PORTLAND WATER DISTRICT
225 Douglass Street, P.O. Box 3553, Portland, ME 04104-3553
(207) 774-5961 - FAX (207) 761-8325

February 24, 2025

REQUEST FOR BID
This is NOT an order.

All Bids must be submitted
By: 2:00 pm, Mar. 31st, 2025

Sebago Heights Pump Station Controls Upgrade

To Potential Contractors

Thank you for your interest in this Portland Water District (PWD) Request for Bid (RFB). The purpose of this RFB is to establish the vendor who shall perform those services, the rate the PWD shall pay, and the terms and conditions of those services. Bids are subject to the terms & conditions included in this RFB.

Evaluation will be based on price and other relevant considerations, including but not limited to past performance. The PWD will execute an agreement and issue purchase order upon award. Please see Attachment One for a sample of the agreement. Any exceptions to the agreement must be stated in the vendor's bid.

The PWD will be holding a non-mandatory site walk. All questions related to this RFB must be submitted in writing before the deadline listed below. When submitting a question, please include the name of your organization and contact information. The answers to all questions will be provided to all bidders.

Bids must be submitted electronically to wgilbert@pwd.org via an email attachment or link to a secure FTP site. Bids must be received by PWD by deadline listed above and below. Signed copies of Attachment Two and Attachment Three must be included in the bid. Late or incomplete bids will not be accepted.

RFB SCHEDULE & DETAILS

ATTACHMENTS:

Attachment 1: Sample Agreement for Services (executed upon award, do not sign)
Attachment 2: Instructions & Conditions
Attachment 3: Supplementary Conditions
Attachment 4: Bid Sheet Sign and submit with bid **(RETURN WITH BID)**
Attachment 5: Bid Bond Penal Sum Form
Attachment 6: Scope of Work**.**

RFB SCHEDULE:

3/3/25- Email RFB to vendors
3/3/25 to 3/24/25 - Question and answer period, questions sent to wgilbert@pwd.org
Answers to all questions will be shared.
3/17/2025-9:00 AM, non-mandatory pre-bid site visit at 26 Bittersweet Way, Windham, ME 04062.
3/31/25 by 2:00PM - Bids Due. Bids will be publicly opened and read aloud. Bidders may attend in person at our Nixon conference room located at 225 Douglass St. Portland, ME 04102.

Project Complete: Substantial completion shall be within 350 calendar days following notice to proceed. Once mobilization has been achieved, work shall be completed within 180 days."

POINT OF CONTACT:

All questions and bid must be submitted to contact listed below

Please use email for all questions.

Portland Water District
Wesley Gilbert, Purchasing Agent
225 Douglass Street
Portland, ME 04102
(e)wgilbert@pwd.org
(t) 207.523.5203

AGREEMENT BETWEEN OWNER AND CONTRACTOR FOR CONSTRUCTION CONTRACT (STIPULATED PRICE)

This Agreement is by and between Portland Water District ("Owner") and

__________________________________ ("Contractor").

Terms used in this Agreement have the meanings stated in the General Conditions and the Supplementary Conditions.

Owner and Contractor hereby agree as follows:

ARTICLE 1—WORK

1.01 **CONTRACTOR SHALL COMPLETE ALL WORK AS SPECIFIED OR INDICATED IN THE CONTRACT DOCUMENTS.**

ARTICLE 2—THE PROJECT

2.01 THE SEBAGO HEIGHTS PUMP STATION IS A WATER BOOSTER STATION IN WINDHAM THAT IS EXPERIENCING EQUIPMENT FAILURES AND IS IN NEED OF A CONTROLS SYSTEM UPGRADE. THE STATION HAS 3 DOMESTIC PUMPS FOR REGULAR RESIDENTIAL FLOWS AND 3 FIRE PUMPS FOR FIREFIGHTING EFFORTS. THE VFD'S FOR DOMESTIC PUMPS 2 & 3 AND HAVE FAILED, LEAVING NO REDUNDANCY FOR REGULAR RESIDENTIAL FLOW. PWD IS LOOKING TO GET THE CONTROLS SYSTEM REPLACED, INCLUDING:

A. The demolition of the two existing pump control panels
B. Design and implementation of a new Telemetry panel, Domestic Pump control panel, and Emergency Fire Pump control panel
C. Code development, integration, and testing

ARTICLE 3—ENGINEER

3.01 Not used.

ARTICLE 4—CONTRACT TIMES

4.01 *Time is of the Essence*

A. All time limits for Milestones, if any, Substantial Completion, and completion and readiness for final payment as stated in the Contract Documents are of the essence of the Contract.

4.02 Contract Times: Days

A. The Work will be substantially complete within 350 days after the date when the Contract Times commence to run as provided in Paragraph 4.01 of the General Conditions, and completed and ready for final payment in accordance with Paragraph 15.06 of the General Conditions within 395 days after the date when the Contract Times commence to run.

4.05 *Liquidated Damages*

A. Contractor and Owner recognize that time is of the essence as stated in Paragraph 4.01 above and that Owner will suffer financial and other losses if the Work is not completed and Milestones not achieved within the Contract Times, as duly modified. The parties also recognize the delays, expense, and difficulties involved in proving, in a legal or arbitration proceeding, the actual loss suffered by Owner if the Work is not completed on time. Accordingly, instead of requiring any such proof, Owner and Contractor agree that as liquidated damages for delay (but not as a penalty):

1. *Substantial Completion:* Contractor shall pay Owner $1,000 for each day that expires after the time (as duly adjusted pursuant to the Contract) specified above for Substantial Completion, until the Work is substantially complete.

2. *Completion of Remaining Work:* After Substantial Completion, if Contractor shall neglect, refuse, or fail to complete the remaining Work within the Contract Times (as duly adjusted pursuant to the Contract) for completion and readiness for final payment, Contractor shall pay Owner $1,000 for each day that expires after such time until the Work is completed and ready for final payment.

3. *Milestones:* Contractor shall pay Owner $1,000 for each day that expires after the time (as duly adjusted pursuant to the Contract) specified above for achievement of Milestone 1, until Milestone 1 is achieved, or until the time specified for Substantial Completion is reached, at which time the rate indicated in Paragraph 4.05.A.1 will apply, rather than the Milestone rate.

4. Liquidated damages for failing to timely attain Milestones, Substantial Completion, and final completion are not additive, and will not be imposed concurrently.

B. If Owner recovers liquidated damages for a delay in completion by Contractor, then such liquidated damages are Owner's sole and exclusive remedy for such delay, and Owner is precluded from recovering any other damages, whether actual, direct, excess, or consequential, for such delay, except for special damages (if any) specified in this Agreement.

4.06 *Special Damages*

A. Contractor shall reimburse Owner (1) for any fines or penalties imposed on Owner as a direct result of the Contractor's failure to attain Substantial Completion according to the Contract Times, and (2) for the actual costs reasonably incurred by Owner for engineering, construction observation, inspection, and administrative services needed after the time specified in Paragraph 4.02 for Substantial Completion (as duly adjusted pursuant to the Contract), until the Work is substantially complete.

B. After Contractor achieves Substantial Completion, if Contractor shall neglect, refuse, or fail to complete the remaining Work within the Contract Times, Contractor shall reimburse Owner for the actual costs reasonably incurred by Owner for engineering, construction observation, inspection, and administrative services needed after the time specified in Paragraph 4.02 for Work to be completed and ready for final payment (as duly adjusted pursuant to the Contract), until the Work is completed and ready for final payment.

C. The special damages imposed in this paragraph are supplemental to any liquidated damages for delayed completion established in this Agreement.

ARTICLE 5—CONTRACT PRICE

5.01 Owner shall pay Contractor for completion of the Work in accordance with the Contract Documents, the amounts that follow, subject to adjustment under the Contract:

A. For all Work other than Unit Price Work, a lump sum of $___________________.

All specific cash allowances are included in the above price in accordance with Paragraph 13.02 of the General Conditions.

D. For all Work, at the prices stated in Contractor's Bid, attached hereto as an exhibit.

ARTICLE 6—PAYMENT PROCEDURES

6.01 *Submittal and Processing of Payments*

A. Contractor shall submit Applications for Payment in accordance with Article 15 of the General Conditions. Applications for Payment will be processed by Engineer as provided in the General Conditions.

6.02 *Progress Payments; Retainage*

A. Owner shall make progress payments on account of the contract Price on the basis of Contractor's Applications for Payment on or about the final day of each month during performance of the Work as provided in Paragraph 6.02.A.1 below, provided that such Applications for Payment have been submitted in a timely manner and otherwise meet the requirements of the Contract. All such payments will be measured by the Schedule of Values established as provided in the General Conditions (and in the case of Unit Price Work based on the number of units completed) or, in the event there is no Schedule of Values, as provided elsewhere in the Contract.

1. Prior to the Substantial Completion, progress payments will be made in an amount equal to the percentage indicated below but, in each case, less aggregate of payments previously made and less such amounts as Owner may withhold, including but not limited to liquidated damages, in accordance with the Contract

a. 95 percent of Work completed (with the balance being retainage);

b. 95 percent of cost of materials and equipment not incorporated in the Work (with the balance being retainage).

B. Upon Substantial Completion of the entire construction to be provided under the Contract Documents, Owner shall pay an amount sufficient to increase total payments to Contractor to 98 percent of the Work completed, less such amounts set off by Owner pursuant to Paragraph 15.01.E of the General Conditions, and less 150 percent of Engineer's estimate of the value of Work to be completed or corrected as shown on the punch list of items to be completed or corrected prior to final payment.

6.03 *Final Payment*

A. Upon final completion and acceptance of the Work in accordance with Paragraph 15.06 of the General Conditions, Owner shall pay an amount sufficient to increase total payments to Contractor to 98 percent of the Contract Price as recommended by the Engineer as provided in said Paragraph 15.06.

B. Retainage in the amount of 2 percent of the Contract Price shall be withheld by the Owner for the duration of the 1-year Correction Period as outlined in 15.08 of the General Conditions. Upon fulfillment of Contractors obligations as outlined in Paragraph 15.08, Owner shall pay an amount sufficient to increase total payments to Contractor to 100 percent of the Contract Price as recommended by Engineer as provided in Paragraph 15.06.

6.04 *Consent of Surety*

A. Owner will not make final payment, or return or release retainage at Substantial Completion or any other time, unless Contractor submits written consent of the surety to such payment, return, or release.

6.05 *Interest*

A. All amounts not paid when due will bear interest at the maximum legal rate.

ARTICLE 7—CONTRACT DOCUMENTS

7.01 *Contents*

A. The Contract Documents consist of all of the following:

1. This Agreement.
2. Bonds:
    a. Performance bond (together with power of attorney).
    b. Payment bond (together with power of attorney).
3. General Conditions.
4. Supplementary Conditions.
5. Specifications as listed in the table of contents of the project manual (copy of list attached).
6. Drawings (not attached but incorporated by reference) consisting of 40 sheets with each sheet bearing the following general title: Congress Street and Garrison Street Pump Station Upgrades.
8. Addenda (numbers ____to ___, inclusive).

B. The Contract Documents listed in Paragraph 7.01.A are attached to this Agreement (except as expressly noted otherwise above).

C. There are no Contract Documents other than those listed above in this Article 7.

D. The Contract Documents may only be amended, modified, or supplemented as provided in the Contract.

ARTICLE 8—REPRESENTATIONS, CERTIFICATIONS, AND STIPULATIONS

8.01 *Contractor's Representations*

A. In order to induce Owner to enter into this Contract, Contractor makes the following representations:

1. Contractor has examined and carefully studied the Contract Documents, including Addenda.

2. Contractor is familiar with all Laws and Regulations that may affect cost, progress, and performance of the Work.

3. Contractor has carefully studied the reports of explorations and tests of subsurface conditions at or adjacent to the Site and the drawings of physical conditions.

4. Contractor has carefully studied the reports and drawings relating to Hazardous Environmental Conditions, if any, at or adjacent to the Site that have been identified in the Supplementary Conditions, with respect to Technical Data in such reports and drawings.

5. Contractor has considered the information known to Contractor itself; information commonly known to contractors doing business in the locality of the Site; information and observations obtained from visits to the Site; the Contract Documents; and the Technical Data identified in the Supplementary Conditions or by definition, with respect to the effect of such information, observations, and Technical Data on (a) the cost, progress, and performance of the Work; (b) the means, methods, techniques, sequences, and procedures of construction to be employed by Contractor; and (c) Contractor's safety precautions and programs.

6. Based on the information and observations referred to in the preceding paragraph, Contractor agrees that no further examinations, investigations, explorations, tests, studies, or data are necessary for the performance of the Work at the Contract Price, within the Contract Times, and in accordance with the other terms and conditions of the Contract.

7. Contractor is aware of the general nature of work to be performed by Owner and others at the Site that relates to the Work as indicated in the Contract Documents.

8. Contractor has given Engineer written notice of all conflicts, errors, ambiguities, or discrepancies that Contractor has discovered in the Contract Documents, and of discrepancies between Site conditions and the Contract Documents, and the written resolution thereof by Engineer is acceptable to Contractor.

9. The Contract Documents are generally sufficient to indicate and convey understanding of all terms and conditions for performance and furnishing of the Work.

10. Contractor's entry into this Contract constitutes an incontrovertible representation by Contractor that without exception all prices in the Agreement are premised upon performing and furnishing the Work required by the Contract Documents.

8.02 *Contractor's Certifications*

A. Contractor certifies that it has not engaged in corrupt, fraudulent, collusive, or coercive practices in competing for or in executing the Contract. For the purposes of this Paragraph 8.02:

1. "corrupt practice" means the offering, giving, receiving, or soliciting of anything of value likely to influence the action of a public official in the bidding process or in the Contract execution;

2. "fraudulent practice" means an intentional misrepresentation of facts made (a) to influence the bidding process or the execution of the Contract to the detriment of Owner, (b) to establish Bid or Contract prices at artificial non-competitive levels, or (c) to deprive Owner of the benefits of free and open competition;

3. "collusive practice" means a scheme or arrangement between two or more Bidders, with or without the knowledge of Owner, a purpose of which is to establish Bid prices at artificial, non-competitive levels; and

4. "coercive practice" means harming or threatening to harm, directly or indirectly, persons or their property to influence their participation in the bidding process or affect the execution of the Contract.

8.03 *Standard General Conditions*

A. Owner stipulates that if the General Conditions that are made a part of this Contract are EJCDC® C-700, Standard General Conditions for the Construction Contract (2018), published by the Engineers Joint Contract Documents Committee, and if Owner is the party that has furnished said General Conditions, then Owner has plainly shown all modifications to the standard wording of such published document to the Contractor, through a process such as highlighting or "track changes" (redline/strikeout), or in the Supplementary Conditions.

IN WITNESS WHEREOF, Owner and Contractor have signed this Agreement.

This Agreement will be effective on ________________(which is the Effective Date of the Contract).

Owner:	Contractor:
Portland Water District	
(typed or printed name of organization)	*(typed or printed name of organization)*
By: ______________________	By: ______________________
(individual's signature)	*(individual's signature)*
Date: ______________________	Date: ______________________
(date signed)	*(date signed)*
Name: ______________________	Name: ______________________
(typed or printed)	*(typed or printed)*
Title: ______________________	Title: ______________________
(typed or printed)	*(typed or printed)*
	*(If **[Type of Entity]** is a corporation, a partnership, or a joint venture, attach evidence of authority to sign.)*
Attest: ______________________	Attest: ______________________
(individual's signature)	*(individual's signature)*
Title: ______________________	Title: ______________________
(typed or printed)	*(typed or printed)*
Address for giving notices:	Address for giving notices:
225 Douglass Street	
PO Box 3553	
Portland, ME 04104-3553	
Designated Representative:	Designated Representative:
Name: ______________________	Name: ______________________
(typed or printed)	*(typed or printed)*
Title: ______________________	Title: ______________________
(typed or printed)	*(typed or printed)*
Address:	Address:
225 Douglass St.	
PO Box 3553	
Portland, ME 04104-3553	
Phone: ______________________	Phone: ______________________
Email: ______________________	Email: ______________________
*(If **[Type of Entity]** is a corporation, attach evidence of authority to sign. If **[Type of Entity]** is a public body, attach evidence of authority to sign and resolution or other documents authorizing execution of this Agreement.)*	License No.: ______________________ *(where applicable)*
	State: ______________________

STANDARD GENERAL CONDITIONS OF THE CONSTRUCTION CONTRACT

TABLE OF CONTENTS

Page

STANDARD GENERAL CONDITIONS
OF THE CONSTRUCTION CONTRACT

ARTICLE 1—DEFINITIONS AND TERMINOLOGY

1.01 *Defined Terms*

A. Wherever used in the Bidding Requirements or Contract Documents, a term printed with initial capital letters, including the term's singular and plural forms, will have the meaning indicated in the definitions below. In addition to terms specifically defined, terms with initial capital letters in the Contract Documents include references to identified articles and paragraphs, and the titles of other documents or forms.

1. *Addenda*—Written or graphic instruments issued prior to the opening of Bids which clarify, correct, or change the Bidding Requirements or the proposed Contract Documents.

2. *Agreement*—The written instrument, executed by Owner and Contractor, that sets forth the Contract Price and Contract Times, identifies the parties and the Engineer, and designates the specific items that are Contract Documents.

3. *Application for Payment*—The document prepared by Contractor, in a form acceptable to Engineer, to request progress or final payments, and which is to be accompanied by such supporting documentation as is required by the Contract Documents.

4. *Bid*—The offer of a Bidder submitted on the prescribed form setting forth the prices for the Work to be performed.

5. *Bidder*—An individual or entity that submits a Bid to Owner.

6. *Bidding Documents*—The Bidding Requirements, the proposed Contract Documents, and all Addenda.

7. *Bidding Requirements*—The Advertisement or invitation to bid, Instructions to Bidders, Bid Bond or other Bid security, if any, the Bid Form, and the Bid with any attachments.

8. *Change Order*—A document which is signed by Contractor and Owner and authorizes an addition, deletion, or revision in the Work or an adjustment in the Contract Price or the Contract Times, or other revision to the Contract, issued on or after the Effective Date of the Contract.

9. *Change Proposal*—A written request by Contractor, duly submitted in compliance with the procedural requirements set forth herein, seeking an adjustment in Contract Price or Contract Times; contesting an initial decision by Engineer concerning the requirements of the Contract Documents or the acceptability of Work under the Contract Documents; challenging a set-off against payments due; or seeking other relief with respect to the terms of the Contract.

10. *Claim*

    a. A demand or assertion by Owner directly to Contractor, duly submitted in compliance with the procedural requirements set forth herein, seeking an adjustment of Contract Price or Contract Times; contesting an initial decision by Engineer concerning the requirements of the Contract Documents or the acceptability of Work under the Contract Documents; contesting Engineer's decision regarding a Change Proposal; seeking resolution of a contractual issue that Engineer has declined to address; or seeking other relief with respect to the terms of the Contract.

b. A demand or assertion by Contractor directly to Owner, duly submitted in compliance with the procedural requirements set forth herein, contesting Engineer's decision regarding a Change Proposal, or seeking resolution of a contractual issue that Engineer has declined to address.

c. A demand or assertion by Owner or Contractor, duly submitted in compliance with the procedural requirements set forth herein, made pursuant to Paragraph 12.01.A.4, concerning disputes arising after Engineer has issued a recommendation of final payment.

d. A demand for money or services by a third party is not a Claim.

11. *Constituent of Concern*—Asbestos, petroleum, radioactive materials, polychlorinated biphenyls (PCBs), lead-based paint (as defined by the HUD/EPA standard), hazardous waste, and any substance, product, waste, or other material of any nature whatsoever that is or becomes listed, regulated, or addressed pursuant to Laws and Regulations regulating, relating to, or imposing liability or standards of conduct concerning, any hazardous, toxic, or dangerous waste, substance, or material.

12. *Contract*—The entire and integrated written contract between Owner and Contractor concerning the Work.

13. *Contract Documents*—Those items so designated in the Agreement, and which together comprise the Contract.

14. *Contract Price*—The money that Owner has agreed to pay Contractor for completion of the Work in accordance with the Contract Documents.

15. *Contract Times*—The number of days or the dates by which Contractor shall: (a) achieve Milestones, if any; (b) achieve Substantial Completion; and (c) complete the Work.

16. *Contractor*—The individual or entity with which Owner has contracted for performance of the Work.

17. *Cost of the Work*—See Paragraph 13.01 for definition.

18. *Drawings*—The part of the Contract that graphically shows the scope, extent, and character of the Work to be performed by Contractor.

19. *Effective Date of the Contract*—The date, indicated in the Agreement, on which the Contract becomes effective.

20. *Electronic Document*—Any Project-related correspondence, attachments to correspondence, data, documents, drawings, information, or graphics, including but not limited to Shop Drawings and other Submittals, that are in an electronic or digital format.

21. *Electronic Means*—Electronic mail (email), upload/download from a secure Project website, or other communications methods that allow: (a) the transmission or communication of Electronic Documents; (b) the documentation of transmissions, including sending and receipt; (c) printing of the transmitted Electronic Document by the

recipient; (d) the storage and archiving of the Electronic Document by sender and recipient; and (e) the use by recipient of the Electronic Document for purposes permitted by this Contract. Electronic Means does not include the use of text messaging, or of Facebook, Twitter, Instagram, or similar social media services for transmission of Electronic Documents.

22. *Engineer*—The individual or entity named as such in the Agreement.

23. *Field Order*—A written order issued by Engineer which requires minor changes in the Work but does not change the Contract Price or the Contract Times.

24. *Hazardous Environmental Condition*—The presence at the Site of Constituents of Concern in such quantities or circumstances that may present a danger to persons or property exposed thereto.

    a. The presence at the Site of materials that are necessary for the execution of the Work, or that are to be incorporated into the Work, and that are controlled and contained pursuant to industry practices, Laws and Regulations, and the requirements of the Contract, is not a Hazardous Environmental Condition.

    b. The presence of Constituents of Concern that are to be removed or remediated as part of the Work is not a Hazardous Environmental Condition.

    c. The presence of Constituents of Concern as part of the routine, anticipated, and obvious working conditions at the Site, is not a Hazardous Environmental Condition.

25. *Laws and Regulations; Laws or Regulations*—Any and all applicable laws, statutes, rules, regulations, ordinances, codes, and binding decrees, resolutions, and orders of any and all governmental bodies, agencies, authorities, and courts having jurisdiction.

26. *Liens*—Charges, security interests, or encumbrances upon Contract-related funds, real property, or personal property.

27. *Milestone*—A principal event in the performance of the Work that the Contract requires Contractor to achieve by an intermediate completion date, or by a time prior to Substantial Completion of all the Work.

28. *Notice of Award*—The written notice by Owner to a Bidder of Owner's acceptance of the Bid.

29. *Notice to Proceed*—A written notice by Owner to Contractor fixing the date on which the Contract Times will commence to run and on which Contractor shall start to perform the Work.

30. *Owner*—The individual or entity with which Contractor has contracted regarding the Work, and which has agreed to pay Contractor for the performance of the Work, pursuant to the terms of the Contract.

31. *Progress Schedule*—A schedule, prepared and maintained by Contractor, describing the sequence and duration of the activities comprising Contractor's plan to accomplish the Work within the Contract Times.

32. *Project*—The total undertaking to be accomplished for Owner by engineers, contractors, and others, including planning, study, design, construction, testing, commissioning, and start-up, and of which the Work to be performed under the Contract Documents is a part.

33. *Resident Project Representative*—The authorized representative of Engineer assigned to assist Engineer at the Site. As used herein, the term Resident Project Representative (RPR) includes any assistants or field staff of Resident Project Representative.

34. *Samples*—Physical examples of materials, equipment, or workmanship that are representative of some portion of the Work and that establish the standards by which such portion of the Work will be judged.

35. *Schedule of Submittals*—A schedule, prepared and maintained by Contractor, of required submittals and the time requirements for Engineer's review of the submittals.

36. *Schedule of Values*—A schedule, prepared and maintained by Contractor, allocating portions of the Contract Price to various portions of the Work and used as the basis for reviewing Contractor's Applications for Payment.

37. *Shop Drawings*—All drawings, diagrams, illustrations, schedules, and other data or information that are specifically prepared or assembled by or for Contractor and submitted by Contractor to illustrate some portion of the Work. Shop Drawings, whether approved or not, are not Drawings and are not Contract Documents.

38. *Site*—Lands or areas indicated in the Contract Documents as being furnished by Owner upon which the Work is to be performed, including rights-of-way and easements, and such other lands or areas furnished by Owner which are designated for the use of Contractor.

39. *Specifications*—The part of the Contract that consists of written requirements for materials, equipment, systems, standards, and workmanship as applied to the Work, and certain administrative requirements and procedural matters applicable to the Work.

40. *Subcontractor*—An individual or entity having a direct contract with Contractor or with any other Subcontractor for the performance of a part of the Work.

41. *Submittal*—A written or graphic document, prepared by or for Contractor, which the Contract Documents require Contractor to submit to Engineer, or that is indicated as a Submittal in the Schedule of Submittals accepted by Engineer. Submittals may include Shop Drawings and Samples; schedules; product data; Owner-delegated designs; sustainable design information; information on special procedures; testing plans; results of tests and evaluations, source quality-control testing and inspections, and field or Site quality-control testing and inspections; warranties and certifications; Suppliers' instructions and reports; records of delivery of spare parts and tools; operations and maintenance data; Project photographic documentation; record documents; and other such documents required by the Contract Documents. Submittals, whether or not approved or accepted by Engineer, are not Contract Documents. Change Proposals, Change Orders, Claims, notices, Applications for Payment, and requests for interpretation or clarification are not Submittals.

42. *Substantial Completion*—The time at which the Work (or a specified part thereof) has progressed to the point where, in the opinion of Engineer, the Work (or a specified part thereof) is sufficiently complete, in accordance with the Contract Documents, so that the Work (or a specified part thereof) can be utilized for the purposes for which it is intended. The terms "substantially complete" and "substantially completed" as applied to all or part of the Work refer to Substantial Completion of such Work.

43. *Successful Bidder*—The Bidder to which the Owner makes an award of contract.

44. *Supplementary Conditions*—The part of the Contract that amends or supplements these General Conditions.

45. *Supplier*—A manufacturer, fabricator, supplier, distributor, or vendor having a direct contract with Contractor or with any Subcontractor to furnish materials or equipment to be incorporated in the Work by Contractor or a Subcontractor.

46. *Technical Data*

    a. Those items expressly identified as Technical Data in the Supplementary Conditions, with respect to either (1) existing subsurface conditions at or adjacent to the Site, or existing physical conditions at or adjacent to the Site including existing surface or subsurface structures (except Underground Facilities) or (2) Hazardous Environmental Conditions at the Site.

    b. If no such express identifications of Technical Data have been made with respect to conditions at the Site, then Technical Data is defined, with respect to conditions at the Site under Paragraphs 5.03, 5.04, and 5.06, as the data contained in boring logs, recorded measurements of subsurface water levels, assessments of the condition of subsurface facilities, laboratory test results, and other factual, objective information regarding conditions at the Site that are set forth in any geotechnical, environmental, or other Site or facilities conditions report prepared for the Project and made available to Contractor.

    c. Information and data regarding the presence or location of Underground Facilities are not intended to be categorized, identified, or defined as Technical Data, and instead Underground Facilities are shown or indicated on the Drawings.

47. *Underground Facilities*—All active or not-in-service underground lines, pipelines, conduits, ducts, encasements, cables, wires, manholes, vaults, tanks, tunnels, or other such facilities or systems at the Site, including but not limited to those facilities or systems that produce, transmit, distribute, or convey telephone or other communications, cable television, fiber optic transmissions, power, electricity, light, heat, gases, oil, crude oil products, liquid petroleum products, water, steam, waste, wastewater, storm water, other liquids or chemicals, or traffic or other control systems. An abandoned facility or system is not an Underground Facility.

48. *Unit Price Work*—Work to be paid for on the basis of unit prices.

49. *Work*—The entire construction or the various separately identifiable parts thereof required to be provided under the Contract Documents. Work includes and is the result of performing or providing all labor, services, and documentation necessary to produce such construction; furnishing, installing, and incorporating all materials and equipment into such construction; and may include related services such as testing, start-up, and commissioning, all as required by the Contract Documents.

50. *Work Change Directive*—A written directive to Contractor issued on or after the Effective Date of the Contract, signed by Owner and recommended by Engineer, ordering an addition, deletion, or revision in the Work.

1.02 *Terminology*

A. The words and terms discussed in Paragraphs 1.02.B, C, D, and E are not defined terms that require initial capital letters, but, when used in the Bidding Requirements or Contract Documents, have the indicated meaning.

B. *Intent of Certain Terms or Adjectives*: The Contract Documents include the terms "as allowed," "as approved," "as ordered," "as directed" or terms of like effect or import to authorize an exercise of professional judgment by Engineer. In addition, the adjectives "reasonable," "suitable," "acceptable," "proper," "satisfactory," or adjectives of like effect or import are used to describe an action or determination of Engineer as to the Work. It is intended that such exercise of professional judgment, action, or determination will be solely to evaluate, in general, the Work for compliance with the information in the Contract Documents and with the design concept of the Project as a functioning whole as shown or indicated in the Contract Documents (unless there is a specific statement indicating otherwise). The use of any such term or adjective is not intended to and shall not be effective to assign to Engineer any duty or authority to supervise or direct the performance of the Work, or any duty or authority to undertake responsibility contrary to the provisions of Article 10 or any other provision of the Contract Documents.

C. *Day*: The word "day" means a calendar day of 24 hours measured from midnight to the next midnight.

D. *Defective*: The word "defective," when modifying the word "Work," refers to Work that is unsatisfactory, faulty, or deficient in that it:

1. does not conform to the Contract Documents;

2. does not meet the requirements of any applicable inspection, reference standard, test, or approval referred to in the Contract Documents; or

3. has been damaged prior to Engineer's recommendation of final payment (unless responsibility for the protection thereof has been assumed by Owner at Substantial Completion in accordance with Paragraph 15.03 or Paragraph 15.04).

E. *Furnish, Install, Perform, Provide*

1. The word "furnish," when used in connection with services, materials, or equipment, means to supply and deliver said services, materials, or equipment to the Site (or some other specified location) ready for use or installation and in usable or operable condition.

2. The word "install," when used in connection with services, materials, or equipment, means to put into use or place in final position said services, materials, or equipment complete and ready for intended use.

3. The words "perform" or "provide," when used in connection with services, materials, or equipment, means to furnish and install said services, materials, or equipment complete and ready for intended use.

4. If the Contract Documents establish an obligation of Contractor with respect to specific services, materials, or equipment, but do not expressly use any of the four words "furnish," "install," "perform," or "provide," then Contractor shall furnish and install said services, materials, or equipment complete and ready for intended use.

F. *Contract Price or Contract Times*: References to a change in "Contract Price or Contract Times" or "Contract Times or Contract Price" or similar, indicate that such change applies to (1) Contract Price, (2) Contract Times, or (3) both Contract Price and Contract Times, as warranted, even if the term "or both" is not expressed.

G. Unless stated otherwise in the Contract Documents, words or phrases that have a well-known technical or construction industry or trade meaning are used in the Contract Documents in accordance with such recognized meaning.

ARTICLE 2—PRELIMINARY MATTERS

2.01 *Delivery of Performance and Payment Bonds; Evidence of Insurance*

A. *Performance and Payment Bonds*: When Contractor delivers the signed counterparts of the Agreement to Owner, Contractor shall also deliver to Owner the performance bond and payment bond (if the Contract requires Contractor to furnish such bonds).

B. *Evidence of Contractor's Insurance*: When Contractor delivers the signed counterparts of the Agreement to Owner, Contractor shall also deliver to Owner, with copies to each additional insured (as identified in the Contract), the certificates, endorsements, and other evidence of insurance required to be provided by Contractor in accordance with Article 6, except to the extent the Supplementary Conditions expressly establish other dates for delivery of specific insurance policies.

C. *Evidence of Owner's Insurance*: After receipt of the signed counterparts of the Agreement and all required bonds and insurance documentation, Owner shall promptly deliver to Contractor, with copies to each additional insured (as identified in the Contract), the certificates and other evidence of insurance required to be provided by Owner under Article 6.

2.02 *Copies of Documents*

A. Owner shall furnish to Contractor four printed copies of the Contract (including one fully signed counterpart of the Agreement), and one copy in electronic portable document format (PDF). Additional printed copies will be furnished upon request at the cost of reproduction.

B. Owner shall maintain and safeguard at least one original printed record version of the Contract, including Drawings and Specifications signed and sealed by Engineer and other design professionals. Owner shall make such original printed record version of the Contract available to Contractor for review. Owner may delegate the responsibilities under this provision to Engineer.

2.03 *Before Starting Construction*

A. *Preliminary Schedules*: Within 10 days after the Effective Date of the Contract (or as otherwise required by the Contract Documents), Contractor shall submit to Engineer for timely review:

1. a preliminary Progress Schedule indicating the times (numbers of days or dates) for starting and completing the various stages of the Work, including any Milestones specified in the Contract;

2. a preliminary Schedule of Submittals; and

3. a preliminary Schedule of Values for all of the Work which includes quantities and prices of items which when added together equal the Contract Price and subdivides the Work

into component parts in sufficient detail to serve as the basis for progress payments during performance of the Work. Such prices will include an appropriate amount of overhead and profit applicable to each item of Work.

2.04 *Preconstruction Conference; Designation of Authorized Representatives*

A. Before any Work at the Site is started, a conference attended by Owner, Contractor, Engineer, and others as appropriate will be held to establish a working understanding among the parties as to the Work, and to discuss the schedules referred to in Paragraph 2.03.A, procedures for handling Shop Drawings, Samples, and other Submittals, processing Applications for Payment, electronic or digital transmittals, and maintaining required records.

B. At this conference Owner and Contractor each shall designate, in writing, a specific individual to act as its authorized representative with respect to the services and responsibilities under the Contract. Such individuals shall have the authority to transmit and receive information, render decisions relative to the Contract, and otherwise act on behalf of each respective party.

2.05 *Acceptance of Schedules*

A. At least 10 days before submission of the first Application for Payment a conference, attended by Contractor, Engineer, and others as appropriate, will be held to review the schedules submitted in accordance with Paragraph 2.03.A. No progress payment will be made to Contractor until acceptable schedules are submitted to Engineer.

1. The Progress Schedule will be acceptable to Engineer if it provides an orderly progression of the Work to completion within the Contract Times. Such acceptance will not impose on Engineer responsibility for the Progress Schedule, for sequencing, scheduling, or progress of the Work, nor interfere with or relieve Contractor from Contractor's full responsibility therefor.

2. Contractor's Schedule of Submittals will be acceptable to Engineer if it provides a workable arrangement for reviewing and processing the required submittals.

3. Contractor's Schedule of Values will be acceptable to Engineer as to form and substance if it provides a reasonable allocation of the Contract Price to the component parts of the Work.

4. If a schedule is not acceptable, Contractor will have an additional 10 days to revise and resubmit the schedule.

2.06 *Electronic Transmittals*

A. Except as otherwise stated elsewhere in the Contract, the Owner, Engineer, and Contractor may send, and shall accept, Electronic Documents transmitted by Electronic Means.

B. If the Contract does not establish protocols for Electronic Means, then Owner, Engineer, and Contractor shall jointly develop such protocols.

C. Subject to any governing protocols for Electronic Means, when transmitting Electronic Documents by Electronic Means, the transmitting party makes no representations as to long-term compatibility, usability, or readability of the Electronic Documents resulting from the recipient's use of software application packages, operating systems, or computer hardware differing from those used in the drafting or transmittal of the Electronic Documents.

ARTICLE 3—CONTRACT DOCUMENTS: INTENT, REQUIREMENTS, REUSE

3.01 *Intent*

A. The Contract Documents are complementary; what is required by one Contract Document is as binding as if required by all.

B. It is the intent of the Contract Documents to describe a functionally complete Project (or part thereof) to be constructed in accordance with the Contract Documents.

C. Unless otherwise stated in the Contract Documents, if there is a discrepancy between the electronic versions of the Contract Documents (including any printed copies derived from such electronic versions) and the printed record version, the printed record version will govern.

D. The Contract supersedes prior negotiations, representations, and agreements, whether written or oral.

E. Engineer will issue clarifications and interpretations of the Contract Documents as provided herein.

F. Any provision or part of the Contract Documents held to be void or unenforceable under any Law or Regulation will be deemed stricken, and all remaining provisions will continue to be valid and binding upon Owner and Contractor, which agree that the Contract Documents will be reformed to replace such stricken provision or part thereof with a valid and enforceable provision that comes as close as possible to expressing the intention of the stricken provision.

G. Nothing in the Contract Documents creates:

1. any contractual relationship between Owner or Engineer and any Subcontractor, Supplier, or other individual or entity performing or furnishing any of the Work, for the benefit of such Subcontractor, Supplier, or other individual or entity; or

2. any obligation on the part of Owner or Engineer to pay or to see to the payment of any money due any such Subcontractor, Supplier, or other individual or entity, except as may otherwise be required by Laws and Regulations.

3.02 *Reference Standards*

A. *Standards Specifications, Codes, Laws and Regulations*

1. Reference in the Contract Documents to standard specifications, manuals, reference standards, or codes of any technical society, organization, or association, or to Laws or Regulations, whether such reference be specific or by implication, means the standard specification, manual, reference standard, code, or Laws or Regulations in effect at the time of opening of Bids (or on the Effective Date of the Contract if there were no Bids), except as may be otherwise specifically stated in the Contract Documents.

2. No provision of any such standard specification, manual, reference standard, or code, and no instruction of a Supplier, will be effective to change the duties or responsibilities of Owner, Contractor, or Engineer from those set forth in the part of the Contract Documents prepared by or for Engineer. No such provision or instruction shall be effective to assign to Owner or Engineer any duty or authority to supervise or direct the performance of the Work, or any duty or authority to undertake responsibility

inconsistent with the provisions of the part of the Contract Documents prepared by or for Engineer.

3.03 *Reporting and Resolving Discrepancies*

A. *Reporting Discrepancies*

1. *Contractor's Verification of Figures and Field Measurements*: Before undertaking each part of the Work, Contractor shall carefully study the Contract Documents, and check and verify pertinent figures and dimensions therein, particularly with respect to applicable field measurements. Contractor shall promptly report in writing to Engineer any conflict, error, ambiguity, or discrepancy that Contractor discovers, or has actual knowledge of, and shall not proceed with any Work affected thereby until the conflict, error, ambiguity, or discrepancy is resolved by a clarification or interpretation by Engineer, or by an amendment or supplement to the Contract issued pursuant to Paragraph 11.01.

2. *Contractor's Review of Contract Documents*: If, before or during the performance of the Work, Contractor discovers any conflict, error, ambiguity, or discrepancy within the Contract Documents, or between the Contract Documents and (a) any applicable Law or Regulation, (b) actual field conditions, (c) any standard specification, manual, reference standard, or code, or (d) any instruction of any Supplier, then Contractor shall promptly report it to Engineer in writing. Contractor shall not proceed with the Work affected thereby (except in an emergency as required by Paragraph 7.15) until the conflict, error, ambiguity, or discrepancy is resolved, by a clarification or interpretation by Engineer, or by an amendment or supplement to the Contract issued pursuant to Paragraph 11.01.

3. Contractor shall not be liable to Owner or Engineer for failure to report any conflict, error, ambiguity, or discrepancy in the Contract Documents unless Contractor had actual knowledge thereof.

B. *Resolving Discrepancies*

1. Except as may be otherwise specifically stated in the Contract Documents, the provisions of the part of the Contract Documents prepared by or for Engineer take precedence in resolving any conflict, error, ambiguity, or discrepancy between such provisions of the Contract Documents and:

   a. the provisions of any standard specification, manual, reference standard, or code, or the instruction of any Supplier (whether or not specifically incorporated by reference as a Contract Document); or

   b. the provisions of any Laws or Regulations applicable to the performance of the Work (unless such an interpretation of the provisions of the Contract Documents would result in violation of such Law or Regulation).

3.04 *Requirements of the Contract Documents*

A. During the performance of the Work and until final payment, Contractor and Owner shall submit to the Engineer in writing all matters in question concerning the requirements of the Contract Documents (sometimes referred to as requests for information or interpretation—RFIs), or relating to the acceptability of the Work under the Contract Documents, as soon as possible after such matters arise. Engineer will be the initial interpreter of the requirements of the Contract Documents, and judge of the acceptability of the Work.

B. Engineer will, with reasonable promptness, render a written clarification, interpretation, or decision on the issue submitted, or initiate an amendment or supplement to the Contract Documents. Engineer's written clarification, interpretation, or decision will be final and binding on Contractor, unless it appeals by submitting a Change Proposal, and on Owner, unless it appeals by filing a Claim.

C. If a submitted matter in question concerns terms and conditions of the Contract Documents that do not involve (1) the performance or acceptability of the Work under the Contract Documents, (2) the design (as set forth in the Drawings, Specifications, or otherwise), or (3) other engineering or technical matters, then Engineer will promptly notify Owner and Contractor in writing that Engineer is unable to provide a decision or interpretation. If Owner and Contractor are unable to agree on resolution of such a matter in question, either party may pursue resolution as provided in Article 12.

3.05 *Reuse of Documents*

A. Contractor and its Subcontractors and Suppliers shall not:

1. have or acquire any title to or ownership rights in any of the Drawings, Specifications, or other documents (or copies of any thereof) prepared by or bearing the seal of Engineer or its consultants, including electronic media versions, or reuse any such Drawings, Specifications, other documents, or copies thereof on extensions of the Project or any other project without written consent of Owner and Engineer and specific written verification or adaptation by Engineer; or

2. have or acquire any title or ownership rights in any other Contract Documents, reuse any such Contract Documents for any purpose without Owner's express written consent, or violate any copyrights pertaining to such Contract Documents.

B. The prohibitions of this Paragraph 3.05 will survive final payment, or termination of the Contract. Nothing herein precludes Contractor from retaining copies of the Contract Documents for record purposes.

ARTICLE 4—COMMENCEMENT AND PROGRESS OF THE WORK

4.01 *Commencement of Contract Times; Notice to Proceed*

A. The Contract Times will commence to run on the 30th day after the Effective Date of the Contract or, if a Notice to Proceed is given, on the day indicated in the Notice to Proceed. A Notice to Proceed may be given at any time within 30 days after the Effective Date of the Contract. In no event will the Contract Times commence to run later than the 60th day after the day of Bid opening or the 30th day after the Effective Date of the Contract, whichever date is earlier.

4.02 *Starting the Work*

A. Contractor shall start to perform the Work on the date when the Contract Times commence to run. No Work may be done at the Site prior to such date.

4.03 *Reference Points*

A. Owner shall provide engineering surveys to establish reference points for construction which in Engineer's judgment are necessary to enable Contractor to proceed with the Work. Contractor shall be responsible for laying out the Work, shall protect and preserve the established reference points and property monuments, and shall make no changes or relocations without the prior written approval of Owner. Contractor shall report to Engineer whenever any reference point or property monument is lost or destroyed or requires relocation because of necessary changes in grades or locations, and shall be responsible for the accurate replacement or relocation of such reference points or property monuments by professionally qualified personnel.

4.04 *Progress Schedule*

A. Contractor shall adhere to the Progress Schedule established in accordance with Paragraph 2.05 as it may be adjusted from time to time as provided below.

1. Contractor shall submit to Engineer for acceptance (to the extent indicated in Paragraph 2.05) proposed adjustments in the Progress Schedule that will not result in changing the Contract Times.

2. Proposed adjustments in the Progress Schedule that will change the Contract Times must be submitted in accordance with the requirements of Article 11.

B. Contractor shall carry on the Work and adhere to the Progress Schedule during all disputes or disagreements with Owner. No Work will be delayed or postponed pending resolution of any disputes or disagreements, or during any appeal process, except as permitted by Paragraph 16.04, or as Owner and Contractor may otherwise agree in writing.

4.05 *Delays in Contractor's Progress*

A. If Owner, Engineer, or anyone for whom Owner is responsible, delays, disrupts, or interferes with the performance or progress of the Work, then Contractor shall be entitled to an equitable adjustment in Contract Price or Contract Times.

B. Contractor shall not be entitled to an adjustment in Contract Price or Contract Times for delay, disruption, or interference caused by or within the control of Contractor. Delay, disruption, and interference attributable to and within the control of a Subcontractor or Supplier shall be deemed to be within the control of Contractor.

C. If Contractor's performance or progress is delayed, disrupted, or interfered with by unanticipated causes not the fault of and beyond the control of Owner, Contractor, and those for which they are responsible, then Contractor shall be entitled to an equitable adjustment in Contract Times. Such an adjustment will be Contractor's sole and exclusive remedy for the delays, disruption, and interference described in this paragraph. Causes of delay, disruption, or interference that may give rise to an adjustment in Contract Times under this paragraph include but are not limited to the following:

1. Severe and unavoidable natural catastrophes such as fires, floods, epidemics, and earthquakes;

2. Abnormal weather conditions;

3. Acts or failures to act of third-party utility owners or other third-party entities (other than those third-party utility owners or other third-party entities performing other work at or adjacent to the Site as arranged by or under contract with Owner, as contemplated in Article 8); and

4. Acts of war or terrorism.

D. Contractor's entitlement to an adjustment of Contract Times or Contract Price is limited as follows:

1. Contractor's entitlement to an adjustment of the Contract Times is conditioned on the delay, disruption, or interference adversely affecting an activity on the critical path to completion of the Work, as of the time of the delay, disruption, or interference.

2. Contractor shall not be entitled to an adjustment in Contract Price for any delay, disruption, or interference if such delay is concurrent with a delay, disruption, or interference caused by or within the control of Contractor. Such a concurrent delay by Contractor shall not preclude an adjustment of Contract Times to which Contractor is otherwise entitled.

3. Adjustments of Contract Times or Contract Price are subject to the provisions of Article 11.

E. Each Contractor request or Change Proposal seeking an increase in Contract Times or Contract Price must be supplemented by supporting data that sets forth in detail the following:

1. The circumstances that form the basis for the requested adjustment;

2. The date upon which each cause of delay, disruption, or interference began to affect the progress of the Work;

3. The date upon which each cause of delay, disruption, or interference ceased to affect the progress of the Work;

4. The number of days' increase in Contract Times claimed as a consequence of each such cause of delay, disruption, or interference; and

5. The impact on Contract Price, in accordance with the provisions of Paragraph 11.07.

Contractor shall also furnish such additional supporting documentation as Owner or Engineer may require including, where appropriate, a revised progress schedule indicating all the activities affected by the delay, disruption, or interference, and an explanation of the effect of the delay, disruption, or interference on the critical path to completion of the Work.

F. Delays, disruption, and interference to the performance or progress of the Work resulting from the existence of a differing subsurface or physical condition, an Underground Facility that was not shown or indicated by the Contract Documents, or not shown or indicated with reasonable accuracy, and those resulting from Hazardous Environmental Conditions, are governed by Article 5, together with the provisions of Paragraphs 4.05.D and 4.05.E.

G. Paragraph 8.03 addresses delays, disruption, and interference to the performance or progress of the Work resulting from the performance of certain other work at or adjacent to the Site.

ARTICLE 5—SITE; SUBSURFACE AND PHYSICAL CONDITIONS; HAZARDOUS ENVIRONMENTAL CONDITIONS

5.01 *Availability of Lands*

A. Owner shall furnish the Site. Owner shall notify Contractor in writing of any encumbrances or restrictions not of general application but specifically related to use of the Site with which Contractor must comply in performing the Work.

B. Upon reasonable written request, Owner shall furnish Contractor with a current statement of record legal title and legal description of the lands upon which permanent improvements are to be made and Owner's interest therein as necessary for giving notice of or filing a mechanic's or construction lien against such lands in accordance with applicable Laws and Regulations.

C. Contractor shall provide for all additional lands and access thereto that may be required for temporary construction facilities or storage of materials and equipment.

5.02 *Use of Site and Other Areas*

A. *Limitation on Use of Site and Other Areas*

1. Contractor shall confine construction equipment, temporary construction facilities, the storage of materials and equipment, and the operations of workers to the Site, adjacent areas that Contractor has arranged to use through construction easements or otherwise, and other adjacent areas permitted by Laws and Regulations, and shall not unreasonably encumber the Site and such other adjacent areas with construction equipment or other materials or equipment. Contractor shall assume full responsibility for (a) damage to the Site; (b) damage to any such other adjacent areas used for Contractor's operations; (c) damage to any other adjacent land or areas, or to improvements, structures, utilities, or similar facilities located at such adjacent lands or areas; and (d) for injuries and losses sustained by the owners or occupants of any such land or areas; provided that such damage or injuries result from the performance of the Work or from other actions or conduct of the Contractor or those for which Contractor is responsible.

2. If a damage or injury claim is made by the owner or occupant of any such land or area because of the performance of the Work, or because of other actions or conduct of the Contractor or those for which Contractor is responsible, Contractor shall (a) take immediate corrective or remedial action as required by Paragraph 7.13, or otherwise; (b) promptly attempt to settle the claim as to all parties through negotiations with such owner or occupant, or otherwise resolve the claim by arbitration or other dispute resolution proceeding, or in a court of competent jurisdiction; and (c) to the fullest extent permitted by Laws and Regulations, indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them, from and against any such claim, and against all costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to any claim or action, legal or equitable, brought by any such owner or occupant against Owner, Engineer, or any other party indemnified hereunder to the extent caused directly or indirectly, in whole or in part by, or based upon, Contractor's performance of the Work, or because of other actions or conduct of the Contractor or those for which Contractor is responsible.

B. *Removal of Debris During Performance of the Work*: During the progress of the Work the Contractor shall keep the Site and other adjacent areas free from accumulations of waste materials, rubbish, and other debris. Removal and disposal of such waste materials, rubbish, and other debris will conform to applicable Laws and Regulations.

C. *Cleaning*: Prior to Substantial Completion of the Work Contractor shall clean the Site and the Work and make it ready for utilization by Owner. At the completion of the Work Contractor shall remove from the Site and adjacent areas all tools, appliances, construction equipment and machinery, and surplus materials and shall restore to original condition all property not designated for alteration by the Contract Documents.

D. *Loading of Structures*: Contractor shall not load nor permit any part of any structure to be loaded in any manner that will endanger the structure, nor shall Contractor subject any part of the Work or adjacent structures or land to stresses or pressures that will endanger them.

5.03 *Subsurface and Physical Conditions*

A. *Reports and Drawings*: The Supplementary Conditions identify:

1. Those reports of explorations and tests of subsurface conditions at or adjacent to the Site that contain Technical Data;

2. Those drawings of existing physical conditions at or adjacent to the Site, including those drawings depicting existing surface or subsurface structures at or adjacent to the Site (except Underground Facilities), that contain Technical Data; and

3. Technical Data contained in such reports and drawings.

B. *Underground Facilities*: Underground Facilities are shown or indicated on the Drawings, pursuant to Paragraph 5.05, and not in the drawings referred to in Paragraph 5.03.A. Information and data regarding the presence or location of Underground Facilities are not intended to be categorized, identified, or defined as Technical Data.

C. *Reliance by Contractor on Technical Data*: Contractor may rely upon the accuracy of the Technical Data expressly identified in the Supplementary Conditions with respect to such reports and drawings, but such reports and drawings are not Contract Documents. If no such express identification has been made, then Contractor may rely upon the accuracy of the Technical Data as defined in Paragraph 1.01.A.46.b.

D. *Limitations of Other Data and Documents*: Except for such reliance on Technical Data, Contractor may not rely upon or make any claim against Owner or Engineer, or any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors, with respect to:

1. the completeness of such reports and drawings for Contractor's purposes, including, but not limited to, any aspects of the means, methods, techniques, sequences, and procedures of construction to be employed by Contractor, and safety precautions and programs incident thereto;

2. other data, interpretations, opinions, and information contained in such reports or shown or indicated in such drawings;

3. the contents of other Site-related documents made available to Contractor, such as record drawings from other projects at or adjacent to the Site, or Owner's archival documents concerning the Site; or

4. any Contractor interpretation of or conclusion drawn from any Technical Data or any such other data, interpretations, opinions, or information.

5.04 *Differing Subsurface or Physical Conditions*

A. *Notice by Contractor*: If Contractor believes that any subsurface or physical condition that is uncovered or revealed at the Site:

1. is of such a nature as to establish that any Technical Data on which Contractor is entitled to rely as provided in Paragraph 5.03 is materially inaccurate;

2. is of such a nature as to require a change in the Drawings or Specifications;

3. differs materially from that shown or indicated in the Contract Documents; or

4. is of an unusual nature, and differs materially from conditions ordinarily encountered and generally recognized as inherent in work of the character provided for in the Contract Documents;

then Contractor shall, promptly after becoming aware thereof and before further disturbing the subsurface or physical conditions or performing any Work in connection therewith (except in an emergency as required by Paragraph 7.15), notify Owner and Engineer in writing about such condition. Contractor shall not further disturb such condition or perform any Work in connection therewith (except with respect to an emergency) until receipt of a written statement permitting Contractor to do so.

B. *Engineer's Review*: After receipt of written notice as required by the preceding paragraph, Engineer will promptly review the subsurface or physical condition in question; determine whether it is necessary for Owner to obtain additional exploration or tests with respect to the condition; conclude whether the condition falls within any one or more of the differing site condition categories in Paragraph 5.04.A; obtain any pertinent cost or schedule information from Contractor; prepare recommendations to Owner regarding the Contractor's resumption of Work in connection with the subsurface or physical condition in question and the need for any change in the Drawings or Specifications; and advise Owner in writing of Engineer's findings, conclusions, and recommendations.

C. *Owner's Statement to Contractor Regarding Site Condition*: After receipt of Engineer's written findings, conclusions, and recommendations, Owner shall issue a written statement to Contractor (with a copy to Engineer) regarding the subsurface or physical condition in question, addressing the resumption of Work in connection with such condition, indicating whether any change in the Drawings or Specifications will be made, and adopting or rejecting Engineer's written findings, conclusions, and recommendations, in whole or in part.

D. *Early Resumption of Work*: If at any time Engineer determines that Work in connection with the subsurface or physical condition in question may resume prior to completion of Engineer's review or Owner's issuance of its statement to Contractor, because the condition in question has been adequately documented, and analyzed on a preliminary basis, then the Engineer may at its discretion instruct Contractor to resume such Work.

E. *Possible Price and Times Adjustments*

1. Contractor shall be entitled to an equitable adjustment in Contract Price or Contract Times, to the extent that the existence of a differing subsurface or physical condition, or any related delay, disruption, or interference, causes an increase or decrease in

Contractor's cost of, or time required for, performance of the Work; subject, however, to the following:

a. Such condition must fall within any one or more of the categories described in Paragraph 5.04.A;

b. With respect to Work that is paid for on a unit price basis, any adjustment in Contract Price will be subject to the provisions of Paragraph 13.03; and,

c. Contractor's entitlement to an adjustment of the Contract Times is subject to the provisions of Paragraphs 4.05.D and 4.05.E.

2. Contractor shall not be entitled to any adjustment in the Contract Price or Contract Times with respect to a subsurface or physical condition if:

a. Contractor knew of the existence of such condition at the time Contractor made a commitment to Owner with respect to Contract Price and Contract Times by the submission of a Bid or becoming bound under a negotiated contract, or otherwise;

b. The existence of such condition reasonably could have been discovered or revealed as a result of any examination, investigation, exploration, test, or study of the Site and contiguous areas expressly required by the Bidding Requirements or Contract Documents to be conducted by or for Contractor prior to Contractor's making such commitment; or

c. Contractor failed to give the written notice required by Paragraph 5.04.A.

3. If Owner and Contractor agree regarding Contractor's entitlement to and the amount or extent of any adjustment in the Contract Price or Contract Times, then any such adjustment will be set forth in a Change Order.

4. Contractor may submit a Change Proposal regarding its entitlement to or the amount or extent of any adjustment in the Contract Price or Contract Times, no later than 30 days after Owner's issuance of the Owner's written statement to Contractor regarding the subsurface or physical condition in question.

F. *Underground Facilities; Hazardous Environmental Conditions*: Paragraph 5.05 governs rights and responsibilities regarding the presence or location of Underground Facilities. Paragraph 5.06 governs rights and responsibilities regarding Hazardous Environmental Conditions. The provisions of Paragraphs 5.03 and 5.04 are not applicable to the presence or location of Underground Facilities, or to Hazardous Environmental Conditions.

5.05 *Underground Facilities*

A. *Contractor's Responsibilities*: Unless it is otherwise expressly provided in the Supplementary Conditions, the cost of all of the following are included in the Contract Price, and Contractor shall have full responsibility for:

1. reviewing and checking all information and data regarding existing Underground Facilities at the Site;

2. complying with applicable state and local utility damage prevention Laws and Regulations;

3. verifying the actual location of those Underground Facilities shown or indicated in the Contract Documents as being within the area affected by the Work, by exposing such Underground Facilities during the course of construction;

4. coordination of the Work with the owners (including Owner) of such Underground Facilities, during construction; and

5. the safety and protection of all existing Underground Facilities at the Site, and repairing any damage thereto resulting from the Work.

B. *Notice by Contractor*: If Contractor believes that an Underground Facility that is uncovered or revealed at the Site was not shown or indicated on the Drawings, or was not shown or indicated on the Drawings with reasonable accuracy, then Contractor shall, promptly after becoming aware thereof and before further disturbing conditions affected thereby or performing any Work in connection therewith (except in an emergency as required by Paragraph 7.15), notify Owner and Engineer in writing regarding such Underground Facility.

C. *Engineer's Review*: Engineer will:

1. promptly review the Underground Facility and conclude whether such Underground Facility was not shown or indicated on the Drawings, or was not shown or indicated with reasonable accuracy;

2. identify and communicate with the owner of the Underground Facility; prepare recommendations to Owner (and if necessary issue any preliminary instructions to Contractor) regarding the Contractor's resumption of Work in connection with the Underground Facility in question;

3. obtain any pertinent cost or schedule information from Contractor; determine the extent, if any, to which a change is required in the Drawings or Specifications to reflect and document the consequences of the existence or location of the Underground Facility; and

4. advise Owner in writing of Engineer's findings, conclusions, and recommendations.

During such time, Contractor shall be responsible for the safety and protection of such Underground Facility.

D. *Owner's Statement to Contractor Regarding Underground Facility*: After receipt of Engineer's written findings, conclusions, and recommendations, Owner shall issue a written statement to Contractor (with a copy to Engineer) regarding the Underground Facility in question addressing the resumption of Work in connection with such Underground Facility, indicating whether any change in the Drawings or Specifications will be made, and adopting or rejecting Engineer's written findings, conclusions, and recommendations in whole or in part.

E. *Early Resumption of Work*: If at any time Engineer determines that Work in connection with the Underground Facility may resume prior to completion of Engineer's review or Owner's issuance of its statement to Contractor, because the Underground Facility in question and conditions affected by its presence have been adequately documented, and analyzed on a preliminary basis, then the Engineer may at its discretion instruct Contractor to resume such Work.

F. *Possible Price and Times Adjustments*

1. Contractor shall be entitled to an equitable adjustment in the Contract Price or Contract Times, to the extent that any existing Underground Facility at the Site that was not shown

or indicated on the Drawings, or was not shown or indicated with reasonable accuracy, or any related delay, disruption, or interference, causes an increase or decrease in Contractor's cost of, or time required for, performance of the Work; subject, however, to the following:

a. With respect to Work that is paid for on a unit price basis, any adjustment in Contract Price will be subject to the provisions of Paragraph 13.03;

b. Contractor's entitlement to an adjustment of the Contract Times is subject to the provisions of Paragraphs 4.05.D and 4.05.E; and

c. Contractor gave the notice required in Paragraph 5.05.B.

2. If Owner and Contractor agree regarding Contractor's entitlement to and the amount or extent of any adjustment in the Contract Price or Contract Times, then any such adjustment will be set forth in a Change Order.

3. Contractor may submit a Change Proposal regarding its entitlement to or the amount or extent of any adjustment in the Contract Price or Contract Times, no later than 30 days after Owner's issuance of the Owner's written statement to Contractor regarding the Underground Facility in question.

4. The information and data shown or indicated on the Drawings with respect to existing Underground Facilities at the Site is based on information and data (a) furnished by the owners of such Underground Facilities, or by others, (b) obtained from available records, or (c) gathered in an investigation conducted in accordance with the current edition of ASCE 38, Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data, by the American Society of Civil Engineers. If such information or data is incorrect or incomplete, Contractor's remedies are limited to those set forth in this Paragraph 5.05.F.

5.06 *Hazardous Environmental Conditions at Site*

A. *Reports and Drawings*: The Supplementary Conditions identify:

1. those reports known to Owner relating to Hazardous Environmental Conditions that have been identified at or adjacent to the Site;

2. drawings known to Owner relating to Hazardous Environmental Conditions that have been identified at or adjacent to the Site; and

3. Technical Data contained in such reports and drawings.

B. *Reliance by Contractor on Technical Data Authorized*: Contractor may rely upon the accuracy of the Technical Data expressly identified in the Supplementary Conditions with respect to such reports and drawings, but such reports and drawings are not Contract Documents. If no such express identification has been made, then Contractor may rely on the accuracy of the Technical Data as defined in Paragraph 1.01.A.46.b. Except for such reliance on Technical Data, Contractor may not rely upon or make any claim against Owner or Engineer, or any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors, with respect to:

1. the completeness of such reports and drawings for Contractor's purposes, including, but not limited to, any aspects of the means, methods, techniques, sequences and procedures

of construction to be employed by Contractor, and safety precautions and programs incident thereto;

2. other data, interpretations, opinions, and information contained in such reports or shown or indicated in such drawings; or

3. any Contractor interpretation of or conclusion drawn from any Technical Data or any such other data, interpretations, opinions or information.

C. Contractor shall not be responsible for removing or remediating any Hazardous Environmental Condition encountered, uncovered, or revealed at the Site unless such removal or remediation is expressly identified in the Contract Documents to be within the scope of the Work.

D. Contractor shall be responsible for controlling, containing, and duly removing all Constituents of Concern brought to the Site by Contractor, Subcontractors, Suppliers, or anyone else for whom Contractor is responsible, and for any associated costs; and for the costs of removing and remediating any Hazardous Environmental Condition created by the presence of any such Constituents of Concern.

E. If Contractor encounters, uncovers, or reveals a Hazardous Environmental Condition whose removal or remediation is not expressly identified in the Contract Documents as being within the scope of the Work, or if Contractor or anyone for whom Contractor is responsible creates a Hazardous Environmental Condition, then Contractor shall immediately: (1) secure or otherwise isolate such condition; (2) stop all Work in connection with such condition and in any area affected thereby (except in an emergency as required by Paragraph 7.15); and (3) notify Owner and Engineer (and promptly thereafter confirm such notice in writing). Owner shall promptly consult with Engineer concerning the necessity for Owner to retain a qualified expert to evaluate such condition or take corrective action, if any. Promptly after consulting with Engineer, Owner shall take such actions as are necessary to permit Owner to timely obtain required permits and provide Contractor the written notice required by Paragraph 5.06.F. If Contractor or anyone for whom Contractor is responsible created the Hazardous Environmental Condition in question, then Owner may remove and remediate the Hazardous Environmental Condition, and impose a set-off against payments to account for the associated costs.

F. Contractor shall not resume Work in connection with such Hazardous Environmental Condition or in any affected area until after Owner has obtained any required permits related thereto, and delivered written notice to Contractor either (1) specifying that such condition and any affected area is or has been rendered safe for the resumption of Work, or (2) specifying any special conditions under which such Work may be resumed safely.

G. If Owner and Contractor cannot agree as to entitlement to or on the amount or extent, if any, of any adjustment in Contract Price or Contract Times, as a result of such Work stoppage, such special conditions under which Work is agreed to be resumed by Contractor, or any costs or expenses incurred in response to the Hazardous Environmental Condition, then within 30 days of Owner's written notice regarding the resumption of Work, Contractor may submit a Change Proposal, or Owner may impose a set-off. Entitlement to any such adjustment is subject to the provisions of Paragraphs 4.05.D, 4.05.E, 11.07, and 11.08.

H. If, after receipt of such written notice, Contractor does not agree to resume such Work based on a reasonable belief it is unsafe, or does not agree to resume such Work under such special conditions, then Owner may order the portion of the Work that is in the area affected by such condition to be deleted from the Work, following the contractual change procedures in Article 11. Owner may have such deleted portion of the Work performed by Owner's own forces or others in accordance with Article 8.

I. To the fullest extent permitted by Laws and Regulations, Owner shall indemnify and hold harmless Contractor, Subcontractors, and Engineer, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them, from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals, and all court, arbitration, or other dispute resolution costs) arising out of or relating to a Hazardous Environmental Condition, provided that such Hazardous Environmental Condition (1) was not shown or indicated in the Drawings, Specifications, or other Contract Documents, identified as Technical Data entitled to limited reliance pursuant to Paragraph 5.06.B, or identified in the Contract Documents to be included within the scope of the Work, and (2) was not created by Contractor or by anyone for whom Contractor is responsible. Nothing in this Paragraph 5.06.I obligates Owner to indemnify any individual or entity from and against the consequences of that individual's or entity's own negligence.

J. To the fullest extent permitted by Laws and Regulations, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them, from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to the failure to control, contain, or remove a Constituent of Concern brought to the Site by Contractor or by anyone for whom Contractor is responsible, or to a Hazardous Environmental Condition created by Contractor or by anyone for whom Contractor is responsible. Nothing in this Paragraph 5.06.J obligates Contractor to indemnify any individual or entity from and against the consequences of that individual's or entity's own negligence.

K. The provisions of Paragraphs 5.03, 5.04, and 5.05 do not apply to the presence of Constituents of Concern or to a Hazardous Environmental Condition uncovered or revealed at the Site.

ARTICLE 6—BONDS AND INSURANCE

6.01 *Performance, Payment, and Other Bonds*

A. Contractor shall furnish a performance bond and a payment bond, each in an amount at least equal to the Contract Price, as security for the faithful performance and payment of Contractor's obligations under the Contract. These bonds must remain in effect until one year after the date when final payment becomes due or until completion of the correction period specified in Paragraph 15.08, whichever is later, except as provided otherwise by Laws or Regulations, the terms of a prescribed bond form, the Supplementary Conditions, or other provisions of the Contract.

B. Contractor shall also furnish such other bonds (if any) as are required by the Supplementary Conditions or other provisions of the Contract.

C. All bonds must be in the form included in the Bidding Documents or otherwise specified by Owner prior to execution of the Contract, except as provided otherwise by Laws or

Regulations, and must be issued and signed by a surety named in "Companies Holding Certificates of Authority as Acceptable Sureties on Federal Bonds and as Acceptable Reinsuring Companies" as published in Department Circular 570 (as amended and supplemented) by the Bureau of the Fiscal Service, U.S. Department of the Treasury. A bond signed by an agent or attorney-in-fact must be accompanied by a certified copy of that individual's authority to bind the surety. The evidence of authority must show that it is effective on the date the agent or attorney-in-fact signed the accompanying bond.

D. Contractor shall obtain the required bonds from surety companies that are duly licensed or authorized, in the state or jurisdiction in which the Project is located, to issue bonds in the required amounts.

E. If the surety on a bond furnished by Contractor is declared bankrupt or becomes insolvent, or the surety ceases to meet the requirements above, then Contractor shall promptly notify Owner and Engineer in writing and shall, within 20 days after the event giving rise to such notification, provide another bond and surety, both of which must comply with the bond and surety requirements above.

F. If Contractor has failed to obtain a required bond, Owner may exclude the Contractor from the Site and exercise Owner's termination rights under Article 16.

G. Upon request to Owner from any Subcontractor, Supplier, or other person or entity claiming to have furnished labor, services, materials, or equipment used in the performance of the Work, Owner shall provide a copy of the payment bond to such person or entity.

H. Upon request to Contractor from any Subcontractor, Supplier, or other person or entity claiming to have furnished labor, services, materials, or equipment used in the performance of the Work, Contractor shall provide a copy of the payment bond to such person or entity.

6.02 *Insurance—General Provisions*

A. Owner and Contractor shall obtain and maintain insurance as required in this article and in the Supplementary Conditions.

B. All insurance required by the Contract to be purchased and maintained by Owner or Contractor shall be obtained from insurance companies that are duly licensed or authorized in the state or jurisdiction in which the Project is located to issue insurance policies for the required limits and coverages. Unless a different standard is indicated in the Supplementary Conditions, all companies that provide insurance policies required under this Contract shall have an A.M. Best rating of A-VII or better.

C. Alternative forms of insurance coverage, including but not limited to self-insurance and "Occupational Accident and Excess Employer's Indemnity Policies," are not sufficient to meet the insurance requirements of this Contract, unless expressly allowed in the Supplementary Conditions.

D. Contractor shall deliver to Owner, with copies to each additional insured identified in the Contract, certificates of insurance and endorsements establishing that Contractor has obtained and is maintaining the policies and coverages required by the Contract. Upon request by Owner or any other insured, Contractor shall also furnish other evidence of such required insurance, including but not limited to copies of policies, documentation of applicable self-insured retentions (if allowed) and deductibles, full disclosure of all relevant exclusions, and evidence of insurance required to be purchased and maintained by

Subcontractors or Suppliers. In any documentation furnished under this provision, Contractor, Subcontractors, and Suppliers may block out (redact) (1) any confidential premium or pricing information and (2) any wording specific to a project or jurisdiction other than those applicable to this Contract.

E. Owner shall deliver to Contractor, with copies to each additional insured identified in the Contract, certificates of insurance and endorsements establishing that Owner has obtained and is maintaining the policies and coverages required of Owner by the Contract (if any). Upon request by Contractor or any other insured, Owner shall also provide other evidence of such required insurance (if any), including but not limited to copies of policies, documentation of applicable self-insured retentions (if allowed) and deductibles, and full disclosure of all relevant exclusions. In any documentation furnished under this provision, Owner may block out (redact) (1) any confidential premium or pricing information and (2) any wording specific to a project or jurisdiction other than those relevant to this Contract.

F. Failure of Owner or Contractor to demand such certificates or other evidence of the other party's full compliance with these insurance requirements, or failure of Owner or Contractor to identify a deficiency in compliance from the evidence provided, will not be construed as a waiver of the other party's obligation to obtain and maintain such insurance.

G. In addition to the liability insurance required to be provided by Contractor, the Owner, at Owner's option, may purchase and maintain Owner's own liability insurance. Owner's liability policies, if any, operate separately and independently from policies required to be provided by Contractor, and Contractor cannot rely upon Owner's liability policies for any of Contractor's obligations to the Owner, Engineer, or third parties.

H. Contractor shall require:

1. Subcontractors to purchase and maintain worker's compensation, commercial general liability, and other insurance that is appropriate for their participation in the Project, and to name as additional insureds Owner and Engineer (and any other individuals or entities identified in the Supplementary Conditions as additional insureds on Contractor's liability policies) on each Subcontractor's commercial general liability insurance policy; and

2. Suppliers to purchase and maintain insurance that is appropriate for their participation in the Project.

I. If either party does not purchase or maintain the insurance required of such party by the Contract, such party shall notify the other party in writing of such failure to purchase prior to the start of the Work, or of such failure to maintain prior to any change in the required coverage.

J. If Contractor has failed to obtain and maintain required insurance, Contractor's entitlement to enter or remain at the Site will end immediately, and Owner may impose an appropriate set-off against payment for any associated costs (including but not limited to the cost of purchasing necessary insurance coverage), and exercise Owner's termination rights under Article 16.

K. Without prejudice to any other right or remedy, if a party has failed to obtain required insurance, the other party may elect (but is in no way obligated) to obtain equivalent insurance to protect such other party's interests at the expense of the party who was required to provide such coverage, and the Contract Price will be adjusted accordingly.

L. Owner does not represent that insurance coverage and limits established in this Contract necessarily will be adequate to protect Contractor or Contractor's interests. Contractor is responsible for determining whether such coverage and limits are adequate to protect its interests, and for obtaining and maintaining any additional insurance that Contractor deems necessary.

M. The insurance and insurance limits required herein will not be deemed as a limitation on Contractor's liability, or that of its Subcontractors or Suppliers, under the indemnities granted to Owner and other individuals and entities in the Contract or otherwise.

N. All the policies of insurance required to be purchased and maintained under this Contract will contain a provision or endorsement that the coverage afforded will not be canceled, or renewal refused, until at least 10 days prior written notice has been given to the purchasing policyholder. Within three days of receipt of any such written notice, the purchasing policyholder shall provide a copy of the notice to each other insured and Engineer.

6.03 *Contractor's Insurance*

A. *Required Insurance*: Contractor shall purchase and maintain Worker's Compensation, Commercial General Liability, and other insurance pursuant to the specific requirements of the Supplementary Conditions.

B. *General Provisions*: The policies of insurance required by this Paragraph 6.03 as supplemented must:

1. include at least the specific coverages required;
2. be written for not less than the limits provided, or those required by Laws or Regulations, whichever is greater;
3. remain in effect at least until the Work is complete (as set forth in Paragraph 15.06.D), and longer if expressly required elsewhere in this Contract, and at all times thereafter when Contractor may be correcting, removing, or replacing defective Work as a warranty or correction obligation, or otherwise, or returning to the Site to conduct other tasks arising from the Contract;
4. apply with respect to the performance of the Work, whether such performance is by Contractor, any Subcontractor or Supplier, or by anyone directly or indirectly employed by any of them to perform any of the Work, or by anyone for whose acts any of them may be liable; and
5. include all necessary endorsements to support the stated requirements.

C. *Additional Insureds*: The Contractor's commercial general liability, automobile liability, employer's liability, umbrella or excess, pollution liability, and unmanned aerial vehicle liability policies, if required by this Contract, must:

1. include and list as additional insureds Owner and Engineer, and any individuals or entities identified as additional insureds in the Supplementary Conditions;
2. include coverage for the respective officers, directors, members, partners, employees, and consultants of all such additional insureds;
3. afford primary coverage to these additional insureds for all claims covered thereby (including as applicable those arising from both ongoing and completed operations);

4. not seek contribution from insurance maintained by the additional insured; and
5. as to commercial general liability insurance, apply to additional insureds with respect to liability caused in whole or in part by Contractor’s acts or omissions, or the acts and omissions of those working on Contractor’s behalf, in the performance of Contractor’s operations.

6.04 *Builder’s Risk and Other Property Insurance*

A. *Builder’s Risk*: Unless otherwise provided in the Supplementary Conditions, Contractor shall purchase and maintain builder’s risk insurance upon the Work on a completed value basis, in the amount of the Work’s full insurable replacement cost (subject to such deductible amounts as may be provided in the Supplementary Conditions or required by Laws and Regulations). The specific requirements applicable to the builder’s risk insurance are set forth in the Supplementary Conditions.

B. *Property Insurance for Facilities of Owner Where Work Will Occur*: Owner is responsible for obtaining and maintaining property insurance covering each existing structure, building, or facility in which any part of the Work will occur, or to which any part of the Work will attach or be adjoined. Such property insurance will be written on a special perils (all-risk) form, on a replacement cost basis, providing coverage consistent with that required for the builder’s risk insurance, and will be maintained until the Work is complete, as set forth in Paragraph 15.06.D.

C. *Property Insurance for Substantially Complete Facilities*: Promptly after Substantial Completion, and before actual occupancy or use of the substantially completed Work, Owner will obtain property insurance for such substantially completed Work, and maintain such property insurance at least until the Work is complete, as set forth in Paragraph 15.06.D. Such property insurance will be written on a special perils (all-risk) form, on a replacement cost basis, and provide coverage consistent with that required for the builder’s risk insurance. The builder’s risk insurance may terminate upon written confirmation of Owner’s procurement of such property insurance.

D. *Partial Occupancy or Use by Owner*: If Owner will occupy or use a portion or portions of the Work prior to Substantial Completion of all the Work, as provided in Paragraph 15.04, then Owner (directly, if it is the purchaser of the builder’s risk policy, or through Contractor) will provide advance notice of such occupancy or use to the builder’s risk insurer, and obtain an endorsement consenting to the continuation of coverage prior to commencing such partial occupancy or use.

E. *Insurance of Other Property; Additional Insurance*: If the express insurance provisions of the Contract do not require or address the insurance of a property item or interest, then the entity or individual owning such property item will be responsible for insuring it. If Contractor elects to obtain other special insurance to be included in or supplement the builder’s risk or property insurance policies provided under this Paragraph 6.04, it may do so at Contractor’s expense.

6.05 *Property Losses; Subrogation*

A. The builder’s risk insurance policy purchased and maintained in accordance with Paragraph 6.04 (or an installation floater policy if authorized by the Supplementary Conditions), will contain provisions to the effect that in the event of payment of any loss or damage the insurer will have no rights of recovery against any insureds thereunder, or against

Engineer or its consultants, or their officers, directors, members, partners, employees, agents, consultants, or subcontractors.

1. Owner and Contractor waive all rights against each other and the respective officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them, for all losses and damages caused by, arising out of, or resulting from any of the perils, risks, or causes of loss covered by such policies and any other property insurance applicable to the Work; and, in addition, waive all such rights against Engineer, its consultants, all individuals or entities identified in the Supplementary Conditions as builder's risk or installation floater insureds, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them, under such policies for losses and damages so caused.

2. None of the above waivers extends to the rights that any party making such waiver may have to the proceeds of insurance held by Owner or Contractor as trustee or fiduciary, or otherwise payable under any policy so issued.

B. Any property insurance policy maintained by Owner covering any loss, damage, or consequential loss to Owner's existing structures, buildings, or facilities in which any part of the Work will occur, or to which any part of the Work will attach or adjoin; to adjacent structures, buildings, or facilities of Owner; or to part or all of the completed or substantially completed Work, during partial occupancy or use pursuant to Paragraph 15.04, after Substantial Completion pursuant to Paragraph 15.03, or after final payment pursuant to Paragraph 15.06, will contain provisions to the effect that in the event of payment of any loss or damage the insurer will have no rights of recovery against any insureds thereunder, or against Contractor, Subcontractors, or Engineer, or the officers, directors, members, partners, employees, agents, consultants, or subcontractors of each and any of them, and that the insured is allowed to waive the insurer's rights of subrogation in a written contract executed prior to the loss, damage, or consequential loss.

1. Owner waives all rights against Contractor, Subcontractors, and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them, for all losses and damages caused by, arising out of, or resulting from fire or any of the perils, risks, or causes of loss covered by such policies.

C. The waivers in this Paragraph 6.05 include the waiver of rights due to business interruption, loss of use, or other consequential loss extending beyond direct physical loss or damage to Owner's property or the Work caused by, arising out of, or resulting from fire or other insured peril, risk, or cause of loss.

D. Contractor shall be responsible for assuring that each Subcontract contains provisions whereby the Subcontractor waives all rights against Owner, Contractor, all individuals or entities identified in the Supplementary Conditions as insureds, the Engineer and its consultants, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them, for all losses and damages caused by, arising out of, relating to, or resulting from fire or other peril, risk, or cause of loss covered by builder's risk insurance, installation floater, and any other property insurance applicable to the Work.

6.06 *Receipt and Application of Property Insurance Proceeds*

A. Any insured loss under the builder's risk and other policies of property insurance required by Paragraph 6.04 will be adjusted and settled with the named insured that purchased the policy. Such named insured shall act as fiduciary for the other insureds, and give notice to such other insureds that adjustment and settlement of a claim is in progress. Any other insured may state its position regarding a claim for insured loss in writing within 15 days after notice of such claim.

B. Proceeds for such insured losses may be made payable by the insurer either jointly to multiple insureds, or to the named insured that purchased the policy in its own right and as fiduciary for other insureds, subject to the requirements of any applicable mortgage clause. A named insured receiving insurance proceeds under the builder's risk and other policies of insurance required by Paragraph 6.04 shall maintain such proceeds in a segregated account, and distribute such proceeds in accordance with such agreement as the parties in interest may reach, or as otherwise required under the dispute resolution provisions of this Contract or applicable Laws and Regulations.

C. If no other special agreement is reached, Contractor shall repair or replace the damaged Work, using allocated insurance proceeds.

ARTICLE 7—CONTRACTOR'S RESPONSIBILITIES

7.01 *Contractor's Means and Methods of Construction*

A. Contractor shall be solely responsible for the means, methods, techniques, sequences, and procedures of construction.

B. If the Contract Documents note, or Contractor determines, that professional engineering or other design services are needed to carry out Contractor's responsibilities for construction means, methods, techniques, sequences, and procedures, or for Site safety, then Contractor shall cause such services to be provided by a properly licensed design professional, at Contractor's expense. Such services are not Owner-delegated professional design services under this Contract, and neither Owner nor Engineer has any responsibility with respect to (1) Contractor's determination of the need for such services, (2) the qualifications or licensing of the design professionals retained or employed by Contractor, (3) the performance of such services, or (4) any errors, omissions, or defects in such services.

7.02 *Supervision and Superintendence*

A. Contractor shall supervise, inspect, and direct the Work competently and efficiently, devoting such attention thereto and applying such skills and expertise as may be necessary to perform the Work in accordance with the Contract Documents.

B. At all times during the progress of the Work, Contractor shall assign a competent resident superintendent who will not be replaced without written notice to Owner and Engineer except under extraordinary circumstances.

7.03 *Labor; Working Hours*

A. Contractor shall provide competent, suitably qualified personnel to survey and lay out the Work and perform construction as required by the Contract Documents. Contractor shall maintain good discipline and order at the Site.

B. Contractor shall be fully responsible to Owner and Engineer for all acts and omissions of Contractor's employees; of Suppliers and Subcontractors, and their employees; and of any other individuals or entities performing or furnishing any of the Work, just as Contractor is responsible for Contractor's own acts and omissions.

C. Except as otherwise required for the safety or protection of persons or the Work or property at the Site or adjacent thereto, and except as otherwise stated in the Contract Documents, all Work at the Site will be performed during regular working hours, Monday through Friday. Contractor will not perform Work on a Saturday, Sunday, or any legal holiday. Contractor may perform Work outside regular working hours or on Saturdays, Sundays, or legal holidays only with Owner's written consent, which will not be unreasonably withheld.

7.04 *Services, Materials, and Equipment*

A. Unless otherwise specified in the Contract Documents, Contractor shall provide and assume full responsibility for all services, materials, equipment, labor, transportation, construction equipment and machinery, tools, appliances, fuel, power, light, heat, telephone, water, sanitary facilities, temporary facilities, and all other facilities and incidentals necessary for the performance, testing, start up, and completion of the Work, whether or not such items are specifically called for in the Contract Documents.

B. All materials and equipment incorporated into the Work must be new and of good quality, except as otherwise provided in the Contract Documents. All special warranties and guarantees required by the Specifications will expressly run to the benefit of Owner. If required by Engineer, Contractor shall furnish satisfactory evidence (including reports of required tests) as to the source, kind, and quality of materials and equipment.

C. All materials and equipment must be stored, applied, installed, connected, erected, protected, used, cleaned, and conditioned in accordance with instructions of the applicable Supplier, except as otherwise may be provided in the Contract Documents.

7.05 *"Or Equals"*

A. *Contractor's Request; Governing Criteria*: Whenever an item of equipment or material is specified or described in the Contract Documents by using the names of one or more proprietary items or specific Suppliers, the Contract Price has been based upon Contractor furnishing such item as specified. The specification or description of such an item is intended to establish the type, function, appearance, and quality required. Unless the specification or description contains or is followed by words reading that no like, equivalent, or "or equal" item is permitted, Contractor may request that Engineer authorize the use of other items of equipment or material, or items from other proposed Suppliers, under the circumstances described below.

1. If Engineer in its sole discretion determines that an item of equipment or material proposed by Contractor is functionally equal to that named and sufficiently similar so that no change in related Work will be required, Engineer will deem it an "or equal" item. For the purposes of this paragraph, a proposed item of equipment or material will be considered functionally equal to an item so named if:

a. in the exercise of reasonable judgment Engineer determines that the proposed item:

1) is at least equal in materials of construction, quality, durability, appearance, strength, and design characteristics;

2) will reliably perform at least equally well the function and achieve the results imposed by the design concept of the completed Project as a functioning whole;

3) has a proven record of performance and availability of responsive service; and

4) is not objectionable to Owner.

b. Contractor certifies that, if the proposed item is approved and incorporated into the Work:

1) there will be no increase in cost to the Owner or increase in Contract Times; and

2) the item will conform substantially to the detailed requirements of the item named in the Contract Documents.

B. *Contractor's Expense*: Contractor shall provide all data in support of any proposed "or equal" item at Contractor's expense.

C. *Engineer's Evaluation and Determination*: Engineer will be allowed a reasonable time to evaluate each "or-equal" request. Engineer may require Contractor to furnish additional data about the proposed "or-equal" item. Engineer will be the sole judge of acceptability. No "or-equal" item will be ordered, furnished, installed, or utilized until Engineer's review is complete and Engineer determines that the proposed item is an "or-equal," which will be evidenced by an approved Shop Drawing or other written communication. Engineer will advise Contractor in writing of any negative determination.

D. *Effect of Engineer's Determination*: Neither approval nor denial of an "or-equal" request will result in any change in Contract Price. The Engineer's denial of an "or-equal" request will be final and binding, and may not be reversed through an appeal under any provision of the Contract.

E. *Treatment as a Substitution Request*: If Engineer determines that an item of equipment or material proposed by Contractor does not qualify as an "or-equal" item, Contractor may request that Engineer consider the item a proposed substitute pursuant to Paragraph 7.06.

7.06 *Substitutes*

A. *Contractor's Request; Governing Criteria*: Unless the specification or description of an item of equipment or material required to be furnished under the Contract Documents contains or is followed by words reading that no substitution is permitted, Contractor may request that Engineer authorize the use of other items of equipment or material under the circumstances described below. To the extent possible such requests must be made before commencement of related construction at the Site.

1. Contractor shall submit sufficient information as provided below to allow Engineer to determine if the item of material or equipment proposed is functionally equivalent to that named and an acceptable substitute therefor. Engineer will not accept requests for review of proposed substitute items of equipment or material from anyone other than Contractor.

2. The requirements for review by Engineer will be as set forth in Paragraph 7.06.B, as supplemented by the Specifications, and as Engineer may decide is appropriate under the circumstances.

3. Contractor shall make written application to Engineer for review of a proposed substitute item of equipment or material that Contractor seeks to furnish or use. The application:

   a. will certify that the proposed substitute item will:

      1) perform adequately the functions and achieve the results called for by the general design;

      2) be similar in substance to the item specified; and

      3) be suited to the same use as the item specified.

   b. will state:

      1) the extent, if any, to which the use of the proposed substitute item will necessitate a change in Contract Times;

      2) whether use of the proposed substitute item in the Work will require a change in any of the Contract Documents (or in the provisions of any other direct contract with Owner for other work on the Project) to adapt the design to the proposed substitute item; and

      3) whether incorporation or use of the proposed substitute item in connection with the Work is subject to payment of any license fee or royalty.

   c. will identify:

      1) all variations of the proposed substitute item from the item specified; and

      2) available engineering, sales, maintenance, repair, and replacement services.

   d. will contain an itemized estimate of all costs or credits that will result directly or indirectly from use of such substitute item, including but not limited to changes in Contract Price, shared savings, costs of redesign, and claims of other contractors affected by any resulting change.

B. *Engineer's Evaluation and Determination*: Engineer will be allowed a reasonable time to evaluate each substitute request, and to obtain comments and direction from Owner. Engineer may require Contractor to furnish additional data about the proposed substitute item. Engineer will be the sole judge of acceptability. No substitute will be ordered, furnished, installed, or utilized until Engineer's review is complete and Engineer determines that the proposed item is an acceptable substitute. Engineer's determination will be evidenced by a Field Order or a proposed Change Order accounting for the substitution itself and all related impacts, including changes in Contract Price or Contract Times. Engineer will advise Contractor in writing of any negative determination.

C. *Special Guarantee*: Owner may require Contractor to furnish at Contractor's expense a special performance guarantee or other surety with respect to any substitute.

D. *Reimbursement of Engineer's Cost*: Engineer will record Engineer's costs in evaluating a substitute proposed or submitted by Contractor. Whether or not Engineer approves a substitute so proposed or submitted by Contractor, Contractor shall reimburse Owner for the reasonable charges of Engineer for evaluating each such proposed substitute. Contractor shall also reimburse Owner for the reasonable charges of Engineer for making changes in the Contract Documents (or in the provisions of any other direct contract with Owner) resulting from the acceptance of each proposed substitute.

E. *Contractor's Expense*: Contractor shall provide all data in support of any proposed substitute at Contractor's expense.

F. *Effect of Engineer's Determination*: If Engineer approves the substitution request, Contractor shall execute the proposed Change Order and proceed with the substitution. The Engineer's denial of a substitution request will be final and binding, and may not be reversed through an appeal under any provision of the Contract. Contractor may challenge the scope of reimbursement costs imposed under Paragraph 7.06.D, by timely submittal of a Change Proposal.

7.07 *Concerning Subcontractors and Suppliers*

A. Contractor may retain Subcontractors and Suppliers for the performance of parts of the Work. Such Subcontractors and Suppliers must be acceptable to Owner. The Contractor's retention of a Subcontractor or Supplier for the performance of parts of the Work will not relieve Contractor's obligation to Owner to perform and complete the Work in accordance with the Contract Documents.

B. Contractor shall retain specific Subcontractors and Suppliers for the performance of designated parts of the Work if required by the Contract to do so.

C. Subsequent to the submittal of Contractor's Bid or final negotiation of the terms of the Contract, Owner may not require Contractor to retain any Subcontractor or Supplier to furnish or perform any of the Work against which Contractor has reasonable objection.

D. Prior to entry into any binding subcontract or purchase order, Contractor shall submit to Owner the identity of the proposed Subcontractor or Supplier (unless Owner has already deemed such proposed Subcontractor or Supplier acceptable during the bidding process or otherwise). Such proposed Subcontractor or Supplier shall be deemed acceptable to Owner unless Owner raises a substantive, reasonable objection within 5 days.

E. Owner may require the replacement of any Subcontractor or Supplier. Owner also may require Contractor to retain specific replacements; provided, however, that Owner may not require a replacement to which Contractor has a reasonable objection. If Contractor has submitted the identity of certain Subcontractors or Suppliers for acceptance by Owner, and Owner has accepted it (either in writing or by failing to make written objection thereto), then Owner may subsequently revoke the acceptance of any such Subcontractor or Supplier so identified solely on the basis of substantive, reasonable objection after due investigation. Contractor shall submit an acceptable replacement for the rejected Subcontractor or Supplier.

F. If Owner requires the replacement of any Subcontractor or Supplier retained by Contractor to perform any part of the Work, then Contractor shall be entitled to an adjustment in Contract Price or Contract Times, with respect to the replacement; and Contractor shall initiate a Change Proposal for such adjustment within 30 days of Owner's requirement of replacement.

G. No acceptance by Owner of any such Subcontractor or Supplier, whether initially or as a replacement, will constitute a waiver of the right of Owner to the completion of the Work in accordance with the Contract Documents.

H. On a monthly basis, Contractor shall submit to Engineer a complete list of all Subcontractors and Suppliers having a direct contract with Contractor, and of all other Subcontractors and Suppliers known to Contractor at the time of submittal.

I. Contractor shall be solely responsible for scheduling and coordinating the work of Subcontractors and Suppliers.

J. The divisions and sections of the Specifications and the identifications of any Drawings do not control Contractor in dividing the Work among Subcontractors or Suppliers, or in delineating the Work to be performed by any specific trade.

K. All Work performed for Contractor by a Subcontractor or Supplier must be pursuant to an appropriate contractual agreement that specifically binds the Subcontractor or Supplier to the applicable terms and conditions of the Contract for the benefit of Owner and Engineer.

L. Owner may furnish to any Subcontractor or Supplier, to the extent practicable, information about amounts paid to Contractor for Work performed for Contractor by the Subcontractor or Supplier.

M. Contractor shall restrict all Subcontractors and Suppliers from communicating with Engineer or Owner, except through Contractor or in case of an emergency, or as otherwise expressly allowed in this Contract.

7.08 *Patent Fees and Royalties*

A. Contractor shall pay all license fees and royalties and assume all costs incident to the use in the performance of the Work or the incorporation in the Work of any invention, design, process, product, or device which is the subject of patent rights or copyrights held by others. If an invention, design, process, product, or device is specified in the Contract Documents for use in the performance of the Work and if, to the actual knowledge of Owner or Engineer, its use is subject to patent rights or copyrights calling for the payment of any license fee or royalty to others, the existence of such rights will be disclosed in the Contract Documents.

B. To the fullest extent permitted by Laws and Regulations, Owner shall indemnify and hold harmless Contractor, and its officers, directors, members, partners, employees, agents, consultants, and subcontractors, from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals, and all court or arbitration or other dispute resolution costs) arising out of or relating to any infringement of patent rights or copyrights incident to the use in the performance of the Work or resulting from the incorporation in the Work of any invention, design, process, product, or device specified in the Contract Documents, but not identified as being subject to payment of any license fee or royalty to others required by patent rights or copyrights.

C. To the fullest extent permitted by Laws and Regulations, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them, from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to any infringement of patent rights or copyrights incident to the use in the performance of the Work or resulting from the incorporation in the Work of any invention, design, process, product, or device not specified in the Contract Documents.

7.09 *Permits*

A. Unless otherwise provided in the Contract Documents, Contractor shall obtain and pay for all construction permits, licenses, and certificates of occupancy. Owner shall assist Contractor, when necessary, in obtaining such permits and licenses. Contractor shall pay all governmental charges and inspection fees necessary for the prosecution of the Work which are applicable at the time of the submission of Contractor's Bid (or when Contractor became bound under a negotiated contract). Owner shall pay all charges of utility owners for connections for providing permanent service to the Work.

7.10 *Taxes*

A. Contractor shall pay all sales, consumer, use, and other similar taxes required to be paid by Contractor in accordance with the Laws and Regulations of the place of the Project which are applicable during the performance of the Work.

7.11 *Laws and Regulations*

A. Contractor shall give all notices required by and shall comply with all Laws and Regulations applicable to the performance of the Work. Neither Owner nor Engineer shall be responsible for monitoring Contractor's compliance with any Laws or Regulations.

B. If Contractor performs any Work or takes any other action knowing or having reason to know that it is contrary to Laws or Regulations, Contractor shall bear all resulting costs and losses, and shall indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants, and subcontractors of each and any of them, from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such Work or other action. It is not Contractor's responsibility to make certain that the Work described in the Contract Documents is in accordance with Laws and Regulations, but this does not relieve Contractor of its obligations under Paragraph 3.03.

C. Owner or Contractor may give written notice to the other party of any changes after the submission of Contractor's Bid (or after the date when Contractor became bound under a negotiated contract) in Laws or Regulations having an effect on the cost or time of performance of the Work, including but not limited to changes in Laws or Regulations having an effect on procuring permits and on sales, use, value-added, consumption, and other similar taxes. If Owner and Contractor are unable to agree on entitlement to or on the amount or extent, if any, of any adjustment in Contract Price or Contract Times resulting from such changes, then within 30 days of such written notice Contractor may submit a Change Proposal, or Owner may initiate a Claim.

7.12 *Record Documents*

A. Contractor shall maintain in a safe place at the Site one printed record copy of all Drawings, Specifications, Addenda, Change Orders, Work Change Directives, Field Orders, written interpretations and clarifications, and approved Shop Drawings. Contractor shall keep such record documents in good order and annotate them to show changes made during construction. These record documents, together with all approved Samples, will be available to Engineer for reference. Upon completion of the Work, Contractor shall deliver these record documents to Engineer.

7.13 *Safety and Protection*

A. Contractor shall be solely responsible for initiating, maintaining, and supervising all safety precautions and programs in connection with the Work. Such responsibility does not relieve Subcontractors of their responsibility for the safety of persons or property in the performance of their work, nor for compliance with applicable safety Laws and Regulations.

B. Contractor shall designate a qualified and experienced safety representative whose duties and responsibilities are the prevention of Work-related accidents and the maintenance and supervision of safety precautions and programs.

C. Contractor shall take all necessary precautions for the safety of, and shall provide the necessary protection to prevent damage, injury, or loss to:

1. all persons on the Site or who may be affected by the Work;
2. all the Work and materials and equipment to be incorporated therein, whether in storage on or off the Site; and
3. other property at the Site or adjacent thereto, including trees, shrubs, lawns, walks, pavements, roadways, structures, other work in progress, utilities, and Underground Facilities not designated for removal, relocation, or replacement in the course of construction.

D. All damage, injury, or loss to any property referred to in Paragraph 7.13.C.2 or 7.13.C.3 caused, directly or indirectly, in whole or in part, by Contractor, any Subcontractor, Supplier, or any other individual or entity directly or indirectly employed by any of them to perform any of the Work, or anyone for whose acts any of them may be liable, shall be remedied by Contractor at its expense (except damage or loss attributable to the fault of Drawings or Specifications or to the acts or omissions of Owner or Engineer or anyone employed by any of them, or anyone for whose acts any of them may be liable, and not attributable, directly or indirectly, in whole or in part, to the fault or negligence of Contractor or any Subcontractor, Supplier, or other individual or entity directly or indirectly employed by any of them).

E. Contractor shall comply with all applicable Laws and Regulations relating to the safety of persons or property, or to the protection of persons or property from damage, injury, or loss; and shall erect and maintain all necessary safeguards for such safety and protection.

F. Contractor shall notify Owner; the owners of adjacent property; the owners of Underground Facilities and other utilities (if the identity of such owners is known to Contractor); and other contractors and utility owners performing work at or adjacent to the Site, in writing, when Contractor knows that prosecution of the Work may affect them, and shall cooperate with them in the protection, removal, relocation, and replacement of their property or work in progress.

G. Contractor shall comply with the applicable requirements of Owner's safety programs, if any. Any Owner's safety programs that are applicable to the Work are identified or included in the Supplementary Conditions or Specifications.

H. Contractor shall inform Owner and Engineer of the specific requirements of Contractor's safety program with which Owner's and Engineer's employees and representatives must comply while at the Site.

I. Contractor's duties and responsibilities for safety and protection will continue until all the Work is completed, Engineer has issued a written notice to Owner and Contractor in accordance with Paragraph 15.06.C that the Work is acceptable, and Contractor has left the Site (except as otherwise expressly provided in connection with Substantial Completion).

J. Contractor's duties and responsibilities for safety and protection will resume whenever Contractor or any Subcontractor or Supplier returns to the Site to fulfill warranty or correction obligations, or to conduct other tasks arising from the Contract Documents.

7.14 *Hazard Communication Programs*

A. Contractor shall be responsible for coordinating any exchange of safety data sheets (formerly known as material safety data sheets) or other hazard communication information required to be made available to or exchanged between or among employers at the Site in accordance with Laws or Regulations.

7.15 *Emergencies*

A. In emergencies affecting the safety or protection of persons or the Work or property at the Site or adjacent thereto, Contractor is obligated to act to prevent damage, injury, or loss. Contractor shall give Engineer prompt written notice if Contractor believes that any significant changes in the Work or variations from the Contract Documents have been caused by an emergency, or are required as a result of Contractor's response to an emergency. If Engineer determines that a change in the Contract Documents is required because of an emergency or Contractor's response, a Work Change Directive or Change Order will be issued.

7.16 *Submittals*

A. *Shop Drawing and Sample Requirements*

1. Before submitting a Shop Drawing or Sample, Contractor shall:

   a. review and coordinate the Shop Drawing or Sample with other Shop Drawings and Samples and with the requirements of the Work and the Contract Documents;

   b. determine and verify:

      1) all field measurements, quantities, dimensions, specified performance and design criteria, installation requirements, materials, catalog numbers, and similar information with respect to the Submittal;

      2) the suitability of all materials and equipment offered with respect to the indicated application, fabrication, shipping, handling, storage, assembly, and installation pertaining to the performance of the Work; and

      3) all information relative to Contractor's responsibilities for means, methods, techniques, sequences, and procedures of construction, and safety precautions and programs incident thereto;

   c. confirm that the Submittal is complete with respect to all related data included in the Submittal.

2. Each Shop Drawing or Sample must bear a stamp or specific written certification that Contractor has satisfied Contractor's obligations under the Contract Documents with respect to Contractor's review of that Submittal, and that Contractor approves the Submittal.

3. With each Shop Drawing or Sample, Contractor shall give Engineer specific written notice of any variations that the Submittal may have from the requirements of the Contract Documents. This notice must be set forth in a written communication separate from the Submittal; and, in addition, in the case of a Shop Drawing by a specific notation made on the Shop Drawing itself.

B. *Submittal Procedures for Shop Drawings and Samples*: Contractor shall label and submit Shop Drawings and Samples to Engineer for review and approval in accordance with the accepted Schedule of Submittals.

1. *Shop Drawings*

   a. Contractor shall submit the number of copies required in the Specifications.

   b. Data shown on the Shop Drawings must be complete with respect to quantities, dimensions, specified performance and design criteria, materials, and similar data to show Engineer the services, materials, and equipment Contractor proposes to provide, and to enable Engineer to review the information for the limited purposes required by Paragraph 7.16.C.

2. *Samples*

   a. Contractor shall submit the number of Samples required in the Specifications.

   b. Contractor shall clearly identify each Sample as to material, Supplier, pertinent data such as catalog numbers, the use for which intended and other data as Engineer may require to enable Engineer to review the Submittal for the limited purposes required by Paragraph 7.16.C.

3. Where a Shop Drawing or Sample is required by the Contract Documents or the Schedule of Submittals, any related Work performed prior to Engineer's review and approval of the pertinent submittal will be at the sole expense and responsibility of Contractor.

C. *Engineer's Review of Shop Drawings and Samples*

1. Engineer will provide timely review of Shop Drawings and Samples in accordance with the accepted Schedule of Submittals. Engineer's review and approval will be only to determine if the items covered by the Submittals will, after installation or incorporation in the Work, comply with the requirements of the Contract Documents, and be compatible with the design concept of the completed Project as a functioning whole as indicated by the Contract Documents.

2. Engineer's review and approval will not extend to means, methods, techniques, sequences, or procedures of construction, or to safety precautions or programs incident thereto.

3. Engineer's review and approval of a separate item as such will not indicate approval of the assembly in which the item functions.

4. Engineer's review and approval of a Shop Drawing or Sample will not relieve Contractor from responsibility for any variation from the requirements of the Contract Documents unless Contractor has complied with the requirements of Paragraph 7.16.A.3 and Engineer has given written approval of each such variation by specific written notation thereof incorporated in or accompanying the Shop Drawing or Sample. Engineer will

document any such approved variation from the requirements of the Contract Documents in a Field Order or other appropriate Contract modification.

5. Engineer's review and approval of a Shop Drawing or Sample will not relieve Contractor from responsibility for complying with the requirements of Paragraphs 7.16.A and B.

6. Engineer's review and approval of a Shop Drawing or Sample, or of a variation from the requirements of the Contract Documents, will not, under any circumstances, change the Contract Times or Contract Price, unless such changes are included in a Change Order.

7. Neither Engineer's receipt, review, acceptance, or approval of a Shop Drawing or Sample will result in such item becoming a Contract Document.

8. Contractor shall perform the Work in compliance with the requirements and commitments set forth in approved Shop Drawings and Samples, subject to the provisions of Paragraph 7.16.C.4.

D. *Resubmittal Procedures for Shop Drawings and Samples*

1. Contractor shall make corrections required by Engineer and shall return the required number of corrected copies of Shop Drawings and submit, as required, new Samples for review and approval. Contractor shall direct specific attention in writing to revisions other than the corrections called for by Engineer on previous Submittals.

2. Contractor shall furnish required Shop Drawing and Sample submittals with sufficient information and accuracy to obtain required approval of an item with no more than two resubmittals. Engineer will record Engineer's time for reviewing a third or subsequent resubmittal of a Shop Drawing or Sample, and Contractor shall be responsible for Engineer's charges to Owner for such time. Owner may impose a set-off against payments due Contractor to secure reimbursement for such charges.

3. If Contractor requests a change of a previously approved Shop Drawing or Sample, Contractor shall be responsible for Engineer's charges to Owner for its review time, and Owner may impose a set-off against payments due Contractor to secure reimbursement for such charges, unless the need for such change is beyond the control of Contractor.

E. *Submittals Other than Shop Drawings, Samples, and Owner-Delegated Designs*

1. The following provisions apply to all Submittals other than Shop Drawings, Samples, and Owner-delegated designs:

   a. Contractor shall submit all such Submittals to the Engineer in accordance with the Schedule of Submittals and pursuant to the applicable terms of the Contract Documents.

   b. Engineer will provide timely review of all such Submittals in accordance with the Schedule of Submittals and return such Submittals with a notation of either Accepted or Not Accepted. Any such Submittal that is not returned within the time established in the Schedule of Submittals will be deemed accepted.

   c. Engineer's review will be only to determine if the Submittal is acceptable under the requirements of the Contract Documents as to general form and content of the Submittal.

d. If any such Submittal is not accepted, Contractor shall confer with Engineer regarding the reason for the non-acceptance, and resubmit an acceptable document.

2. Procedures for the submittal and acceptance of the Progress Schedule, the Schedule of Submittals, and the Schedule of Values are set forth in Paragraphs 2.03. 2.04, and 2.05.

F. Owner-delegated Designs: Submittals pursuant to Owner-delegated designs are governed by the provisions of Paragraph 7.19.

7.17 *Contractor's General Warranty and Guarantee*

A. Contractor warrants and guarantees to Owner that all Work will be in accordance with the Contract Documents and will not be defective. Engineer is entitled to rely on Contractor's warranty and guarantee.

B. Owner's rights under this warranty and guarantee are in addition to, and are not limited by, Owner's rights under the correction period provisions of Paragraph 15.08. The time in which Owner may enforce its warranty and guarantee rights under this Paragraph 7.17 is limited only by applicable Laws and Regulations restricting actions to enforce such rights; provided, however, that after the end of the correction period under Paragraph 15.08:

1. Owner shall give Contractor written notice of any defective Work within 60 days of the discovery that such Work is defective; and

2. Such notice will be deemed the start of an event giving rise to a Claim under Paragraph 12.01.B, such that any related Claim must be brought within 30 days of the notice.

C. Contractor's warranty and guarantee hereunder excludes defects or damage caused by:

1. abuse, or improper modification, maintenance, or operation, by persons other than Contractor, Subcontractors, Suppliers, or any other individual or entity for whom Contractor is responsible; or

2. normal wear and tear under normal usage.

D. Contractor's obligation to perform and complete the Work in accordance with the Contract Documents is absolute. None of the following will constitute an acceptance of Work that is not in accordance with the Contract Documents, a release of Contractor's obligation to perform the Work in accordance with the Contract Documents, or a release of Owner's warranty and guarantee rights under this Paragraph 7.17:

1. Observations by Engineer;

2. Recommendation by Engineer or payment by Owner of any progress or final payment;

3. The issuance of a certificate of Substantial Completion by Engineer or any payment related thereto by Owner;

4. Use or occupancy of the Work or any part thereof by Owner;

5. Any review and approval of a Shop Drawing or Sample submittal;

6. The issuance of a notice of acceptability by Engineer;

7. The end of the correction period established in Paragraph 15.08;

8. Any inspection, test, or approval by others; or

9. Any correction of defective Work by Owner.

E. If the Contract requires the Contractor to accept the assignment of a contract entered into by Owner, then the specific warranties, guarantees, and correction obligations contained in the assigned contract will govern with respect to Contractor's performance obligations to Owner for the Work described in the assigned contract.

7.18 *Indemnification*

A. To the fullest extent permitted by Laws and Regulations, and in addition to any other obligations of Contractor under the Contract or otherwise, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them, from losses, damages, costs, and judgments (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals, and all court or arbitration or other dispute resolution costs) arising from third-party claims or actions relating to or resulting from the performance or furnishing of the Work, provided that any such claim, action, loss, cost, judgment or damage is attributable to bodily injury, sickness, disease, or death, or to damage to or destruction of tangible property (other than the Work itself), including the loss of use resulting therefrom, but only to the extent caused by any negligent act or omission of Contractor, any Subcontractor, any Supplier, or any individual or entity directly or indirectly employed by any of them to perform any of the Work, or anyone for whose acts any of them may be liable.

B. In any and all claims against Owner or Engineer, or any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors, by any employee (or the survivor or personal representative of such employee) of Contractor, any Subcontractor, any Supplier, or any individual or entity directly or indirectly employed by any of them to perform any of the Work, or anyone for whose acts any of them may be liable, the indemnification obligation under Paragraph 7.18.A will not be limited in any way by any limitation on the amount or type of damages, compensation, or benefits payable by or for Contractor or any such Subcontractor, Supplier, or other individual or entity under workers' compensation acts, disability benefit acts, or other employee benefit acts.

7.19 *Delegation of Professional Design Services*

A. Owner may require Contractor to provide professional design services for a portion of the Work by express delegation in the Contract Documents. Such delegation will specify the performance and design criteria that such services must satisfy, and the Submittals that Contractor must furnish to Engineer with respect to the Owner-delegated design.

B. Contractor shall cause such Owner-delegated professional design services to be provided pursuant to the professional standard of care by a properly licensed design professional, whose signature and seal must appear on all drawings, calculations, specifications, certifications, and Submittals prepared by such design professional. Such design professional must issue all certifications of design required by Laws and Regulations.

C. If a Shop Drawing or other Submittal related to the Owner-delegated design is prepared by Contractor, a Subcontractor, or others for submittal to Engineer, then such Shop Drawing or other Submittal must bear the written approval of Contractor's design professional when submitted by Contractor to Engineer.

D. Owner and Engineer shall be entitled to rely upon the adequacy, accuracy, and completeness of the services, certifications, and approvals performed or provided by the design professionals retained or employed by Contractor under an Owner-delegated design, subject to the professional standard of care and the performance and design criteria stated in the Contract Documents.

E. Pursuant to this Paragraph 7.19, Engineer’s review, approval, and other determinations regarding design drawings, calculations, specifications, certifications, and other Submittals furnished by Contractor pursuant to an Owner-delegated design will be only for the following limited purposes:

1. Checking for conformance with the requirements of this Paragraph 7.19;

2. Confirming that Contractor (through its design professionals) has used the performance and design criteria specified in the Contract Documents; and

3. Establishing that the design furnished by Contractor is consistent with the design concept expressed in the Contract Documents.

F. Contractor shall not be responsible for the adequacy of performance or design criteria specified by Owner or Engineer.

G. Contractor is not required to provide professional services in violation of applicable Laws and Regulations.

ARTICLE 8—OTHER WORK AT THE SITE

8.01 *Other Work*

A. In addition to and apart from the Work under the Contract Documents, the Owner may perform other work at or adjacent to the Site. Such other work may be performed by Owner’s employees, or through contracts between the Owner and third parties. Owner may also arrange to have third-party utility owners perform work on their utilities and facilities at or adjacent to the Site.

B. If Owner performs other work at or adjacent to the Site with Owner’s employees, or through contracts for such other work, then Owner shall give Contractor written notice thereof prior to starting any such other work. If Owner has advance information regarding the start of any third-party utility work that Owner has arranged to take place at or adjacent to the Site, Owner shall provide such information to Contractor.

C. Contractor shall afford proper and safe access to the Site to each contractor that performs such other work, each utility owner performing other work, and Owner, if Owner is performing other work with Owner’s employees, and provide a reasonable opportunity for the introduction and storage of materials and equipment and the execution of such other work.

D. Contractor shall do all cutting, fitting, and patching of the Work that may be required to properly connect or otherwise make its several parts come together and properly integrate with such other work. Contractor shall not endanger any work of others by cutting, excavating, or otherwise altering such work; provided, however, that Contractor may cut or alter others' work with the written consent of Engineer and the others whose work will be affected.

E. If the proper execution or results of any part of Contractor's Work depends upon work performed by others, Contractor shall inspect such other work and promptly report to Engineer in writing any delays, defects, or deficiencies in such other work that render it unavailable or unsuitable for the proper execution and results of Contractor's Work. Contractor's failure to so report will constitute an acceptance of such other work as fit and proper for integration with Contractor's Work except for latent defects and deficiencies in such other work.

F. The provisions of this article are not applicable to work that is performed by third-party utilities or other third-party entities without a contract with Owner, or that is performed without having been arranged by Owner. If such work occurs, then any related delay, disruption, or interference incurred by Contractor is governed by the provisions of Paragraph 4.05.C.3.

8.02 *Coordination*

A. If Owner intends to contract with others for the performance of other work at or adjacent to the Site, to perform other work at or adjacent to the Site with Owner's employees, or to arrange to have utility owners perform work at or adjacent to the Site, the following will be set forth in the Supplementary Conditions or provided to Contractor prior to the start of any such other work:

1. The identity of the individual or entity that will have authority and responsibility for coordination of the activities among the various contractors;
2. An itemization of the specific matters to be covered by such authority and responsibility; and
3. The extent of such authority and responsibilities.

B. Unless otherwise provided in the Supplementary Conditions, Owner shall have sole authority and responsibility for such coordination.

8.03 *Legal Relationships*

A. If, in the course of performing other work for Owner at or adjacent to the Site, the Owner's employees, any other contractor working for Owner, or any utility owner that Owner has arranged to perform work, causes damage to the Work or to the property of Contractor or its Subcontractors, or delays, disrupts, interferes with, or increases the scope or cost of the performance of the Work, through actions or inaction, then Contractor shall be entitled to an equitable adjustment in the Contract Price or the Contract Times. Contractor must submit any Change Proposal seeking an equitable adjustment in the Contract Price or the Contract Times under this paragraph within 30 days of the damaging, delaying, disrupting, or interfering event. The entitlement to, and extent of, any such equitable adjustment will take into account information (if any) regarding such other work that was provided to Contractor in the Contract Documents prior to the submittal of the Bid or the final negotiation of the terms of the Contract, and any remedies available to Contractor under Laws or Regulations concerning utility action or inaction. When applicable, any such equitable adjustment in Contract Price will be conditioned on Contractor assigning to Owner all Contractor's rights against such other contractor or utility owner with respect to the damage, delay, disruption, or interference that is the subject of the adjustment. Contractor's entitlement to an adjustment of the Contract Times or Contract Price is subject to the provisions of Paragraphs 4.05.D and 4.05.E.

B. Contractor shall take reasonable and customary measures to avoid damaging, delaying, disrupting, or interfering with the work of Owner, any other contractor, or any utility owner performing other work at or adjacent to the Site.

1. If Contractor fails to take such measures and as a result damages, delays, disrupts, or interferes with the work of any such other contractor or utility owner, then Owner may impose a set-off against payments due Contractor, and assign to such other contractor or utility owner the Owner's contractual rights against Contractor with respect to the breach of the obligations set forth in this Paragraph 8.03.B.

2. When Owner is performing other work at or adjacent to the Site with Owner's employees, Contractor shall be liable to Owner for damage to such other work, and for the reasonable direct delay, disruption, and interference costs incurred by Owner as a result of Contractor's failure to take reasonable and customary measures with respect to Owner's other work. In response to such damage, delay, disruption, or interference, Owner may impose a set-off against payments due Contractor.

C. If Contractor damages, delays, disrupts, or interferes with the work of any other contractor, or any utility owner performing other work at or adjacent to the Site, through Contractor's failure to take reasonable and customary measures to avoid such impacts, or if any claim arising out of Contractor's actions, inactions, or negligence in performance of the Work at or adjacent to the Site is made by any such other contractor or utility owner against Contractor, Owner, or Engineer, then Contractor shall (1) promptly attempt to settle the claim as to all parties through negotiations with such other contractor or utility owner, or otherwise resolve the claim by arbitration or other dispute resolution proceeding or at law, and (2) indemnify and hold harmless Owner and Engineer, and the officers, directors, members, partners, employees, agents, consultants and subcontractors of each and any of them from and against any such claims, and against all costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such damage, delay, disruption, or interference.

ARTICLE 9—OWNER'S RESPONSIBILITIES

9.01 *Communications to Contractor*

A. Except as otherwise provided in these General Conditions, Owner shall issue all communications to Contractor through Engineer.

9.02 *Replacement of Engineer*

A. Owner may at its discretion appoint an engineer to replace Engineer, provided Contractor makes no reasonable objection to the replacement engineer. The replacement engineer's status under the Contract Documents will be that of the former Engineer.

9.03 *Furnish Data*

A. Owner shall promptly furnish the data required of Owner under the Contract Documents.

9.04 *Pay When Due*

A. Owner shall make payments to Contractor when they are due as provided in the Agreement.

9.05 *Lands and Easements; Reports, Tests, and Drawings*

A. Owner's duties with respect to providing lands and easements are set forth in Paragraph 5.01.

B. Owner's duties with respect to providing engineering surveys to establish reference points are set forth in Paragraph 4.03.

C. Article 5 refers to Owner's identifying and making available to Contractor copies of reports of explorations and tests of conditions at the Site, and drawings of physical conditions relating to existing surface or subsurface structures at the Site.

9.06 *Insurance*

A. Owner's responsibilities, if any, with respect to purchasing and maintaining liability and property insurance are set forth in Article 6.

9.07 *Change Orders*

A. Owner's responsibilities with respect to Change Orders are set forth in Article 11.

9.08 *Inspections, Tests, and Approvals*

A. Owner's responsibility with respect to certain inspections, tests, and approvals is set forth in Paragraph 14.02.B.

9.09 *Limitations on Owner's Responsibilities*

A. The Owner shall not supervise, direct, or have control or authority over, nor be responsible for, Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of Contractor to comply with Laws and Regulations applicable to the performance of the Work. Owner will not be responsible for Contractor's failure to perform the Work in accordance with the Contract Documents.

9.10 *Undisclosed Hazardous Environmental Condition*

A. Owner's responsibility in respect to an undisclosed Hazardous Environmental Condition is set forth in Paragraph 5.06.

9.11 *Evidence of Financial Arrangements*

A. Upon request of Contractor, Owner shall furnish Contractor reasonable evidence that financial arrangements have been made to satisfy Owner's obligations under the Contract (including obligations under proposed changes in the Work).

9.12 *Safety Programs*

A. While at the Site, Owner's employees and representatives shall comply with the specific applicable requirements of Contractor's safety programs of which Owner has been informed.

B. Owner shall furnish copies of any applicable Owner safety programs to Contractor.

ARTICLE 10—ENGINEER'S STATUS DURING CONSTRUCTION

10.01 *Owner's Representative*

A. Engineer will be Owner's representative during the construction period. The duties and responsibilities and the limitations of authority of Engineer as Owner's representative during construction are set forth in the Contract.

10.02 *Visits to Site*

A. Engineer will make visits to the Site at intervals appropriate to the various stages of construction as Engineer deems necessary in order to observe, as an experienced and qualified design professional, the progress that has been made and the quality of the various aspects of Contractor's executed Work. Based on information obtained during such visits and observations, Engineer, for the benefit of Owner, will determine, in general, if the Work is proceeding in accordance with the Contract Documents. Engineer will not be required to make exhaustive or continuous inspections on the Site to check the quality or quantity of the Work. Engineer's efforts will be directed toward providing for Owner a greater degree of confidence that the completed Work will conform generally to the Contract Documents. On the basis of such visits and observations, Engineer will keep Owner informed of the progress of the Work and will endeavor to guard Owner against defective Work.

B. Engineer's visits and observations are subject to all the limitations on Engineer's authority and responsibility set forth in Paragraph 10.07. Particularly, but without limitation, during or as a result of Engineer's visits or observations of Contractor's Work, Engineer will not supervise, direct, control, or have authority over or be responsible for Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of Contractor to comply with Laws and Regulations applicable to the performance of the Work.

10.03 *Resident Project Representative*

A. If Owner and Engineer have agreed that Engineer will furnish a Resident Project Representative to represent Engineer at the Site and assist Engineer in observing the progress and quality of the Work, then the authority and responsibilities of any such Resident Project Representative will be as provided in the Supplementary Conditions, and limitations on the responsibilities thereof will be as provided in the Supplementary Conditions and in Paragraph 10.07.

B. If Owner designates an individual or entity who is not Engineer's consultant, agent, or employee to represent Owner at the Site, then the responsibilities and authority of such individual or entity will be as provided in the Supplementary Conditions.

10.04 *Engineer's Authority*

A. Engineer has the authority to reject Work in accordance with Article 14.

B. Engineer's authority as to Submittals is set forth in Paragraph 7.16.

C. Engineer's authority as to design drawings, calculations, specifications, certifications and other Submittals from Contractor in response to Owner's delegation (if any) to Contractor of professional design services, is set forth in Paragraph 7.19.

D. Engineer's authority as to changes in the Work is set forth in Article 11.

E. Engineer's authority as to Applications for Payment is set forth in Article 15.

10.05 *Determinations for Unit Price Work*

A. Engineer will determine the actual quantities and classifications of Unit Price Work performed by Contractor as set forth in Paragraph 13.03.

10.06 *Decisions on Requirements of Contract Documents and Acceptability of Work*

A. Engineer will render decisions regarding the requirements of the Contract Documents, and judge the acceptability of the Work, pursuant to the specific procedures set forth herein for initial interpretations, Change Proposals, and acceptance of the Work. In rendering such decisions and judgments, Engineer will not show partiality to Owner or Contractor, and will not be liable to Owner, Contractor, or others in connection with any proceedings, interpretations, decisions, or judgments conducted or rendered in good faith.

10.07 *Limitations on Engineer's Authority and Responsibilities*

A. Neither Engineer's authority or responsibility under this Article 10 or under any other provision of the Contract, nor any decision made by Engineer in good faith either to exercise or not exercise such authority or responsibility or the undertaking, exercise, or performance of any authority or responsibility by Engineer, will create, impose, or give rise to any duty in contract, tort, or otherwise owed by Engineer to Contractor, any Subcontractor, any Supplier, any other individual or entity, or to any surety for or employee or agent of any of them.

B. Engineer will not supervise, direct, control, or have authority over or be responsible for Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of Contractor to comply with Laws and Regulations applicable to the performance of the Work. Engineer will not be responsible for Contractor's failure to perform the Work in accordance with the Contract Documents.

C. Engineer will not be responsible for the acts or omissions of Contractor or of any Subcontractor, any Supplier, or of any other individual or entity performing any of the Work.

D. Engineer's review of the final Application for Payment and accompanying documentation, and all maintenance and operating instructions, schedules, guarantees, bonds, certificates of inspection, tests and approvals, and other documentation required to be delivered by Contractor under Paragraph 15.06.A, will only be to determine generally that their content complies with the requirements of, and in the case of certificates of inspections, tests, and approvals, that the results certified indicate compliance with the Contract Documents.

E. The limitations upon authority and responsibility set forth in this Paragraph 10.07 also apply to the Resident Project Representative, if any.

10.08 *Compliance with Safety Program*

A. While at the Site, Engineer's employees and representatives will comply with the specific applicable requirements of Owner's and Contractor's safety programs of which Engineer has been informed.

ARTICLE 11—CHANGES TO THE CONTRACT

11.01 *Amending and Supplementing the Contract*

A. The Contract may be amended or supplemented by a Change Order, a Work Change Directive, or a Field Order.

B. If an amendment or supplement to the Contract includes a change in the Contract Price or the Contract Times, such amendment or supplement must be set forth in a Change Order.

C. All changes to the Contract that involve (1) the performance or acceptability of the Work, (2) the design (as set forth in the Drawings, Specifications, or otherwise), or (3) other engineering or technical matters, must be supported by Engineer's recommendation. Owner and Contractor may amend other terms and conditions of the Contract without the recommendation of the Engineer.

11.02 *Change Orders*

A. Owner and Contractor shall execute appropriate Change Orders covering:

1. Changes in Contract Price or Contract Times which are agreed to by the parties, including any undisputed sum or amount of time for Work actually performed in accordance with a Work Change Directive;

2. Changes in Contract Price resulting from an Owner set-off, unless Contractor has duly contested such set-off;

3. Changes in the Work which are: (a) ordered by Owner pursuant to Paragraph 11.05, (b) required because of Owner's acceptance of defective Work under Paragraph 14.04 or Owner's correction of defective Work under Paragraph 14.07, or (c) agreed to by the parties, subject to the need for Engineer's recommendation if the change in the Work involves the design (as set forth in the Drawings, Specifications, or otherwise) or other engineering or technical matters; and

4. Changes that embody the substance of any final and binding results under: Paragraph 11.03.B, resolving the impact of a Work Change Directive; Paragraph 11.09, concerning Change Proposals; Article 12, Claims; Paragraph 13.02.D, final adjustments resulting from allowances; Paragraph 13.03.D, final adjustments relating to determination of quantities for Unit Price Work; and similar provisions.

B. If Owner or Contractor refuses to execute a Change Order that is required to be executed under the terms of Paragraph 11.02.A, it will be deemed to be of full force and effect, as if fully executed.

11.03 *Work Change Directives*

A. A Work Change Directive will not change the Contract Price or the Contract Times but is evidence that the parties expect that the modification ordered or documented by a Work Change Directive will be incorporated in a subsequently issued Change Order, following negotiations by the parties as to the Work Change Directive's effect, if any, on the Contract Price and Contract Times; or, if negotiations are unsuccessful, by a determination under the terms of the Contract Documents governing adjustments, expressly including Paragraph 11.07 regarding change of Contract Price.

B. If Owner has issued a Work Change Directive and:

1. Contractor believes that an adjustment in Contract Times or Contract Price is necessary, then Contractor shall submit any Change Proposal seeking such an adjustment no later than 30 days after the completion of the Work set out in the Work Change Directive.

2. Owner believes that an adjustment in Contract Times or Contract Price is necessary, then Owner shall submit any Claim seeking such an adjustment no later than 60 days after issuance of the Work Change Directive.

11.04 *Field Orders*

A. Engineer may authorize minor changes in the Work if the changes do not involve an adjustment in the Contract Price or the Contract Times and are compatible with the design concept of the completed Project as a functioning whole as indicated by the Contract Documents. Such changes will be accomplished by a Field Order and will be binding on Owner and also on Contractor, which shall perform the Work involved promptly.

B. If Contractor believes that a Field Order justifies an adjustment in the Contract Price or Contract Times, then before proceeding with the Work at issue, Contractor shall submit a Change Proposal as provided herein.

11.05 *Owner-Authorized Changes in the Work*

A. Without invalidating the Contract and without notice to any surety, Owner may, at any time or from time to time, order additions, deletions, or revisions in the Work. Changes involving the design (as set forth in the Drawings, Specifications, or otherwise) or other engineering or technical matters will be supported by Engineer's recommendation.

B. Such changes in the Work may be accomplished by a Change Order, if Owner and Contractor have agreed as to the effect, if any, of the changes on Contract Times or Contract Price; or by a Work Change Directive. Upon receipt of any such document, Contractor shall promptly proceed with the Work involved; or, in the case of a deletion in the Work, promptly cease construction activities with respect to such deleted Work. Added or revised Work must be performed under the applicable conditions of the Contract Documents.

C. Nothing in this Paragraph 11.05 obligates Contractor to undertake work that Contractor reasonably concludes cannot be performed in a manner consistent with Contractor's safety obligations under the Contract Documents or Laws and Regulations.

11.06 *Unauthorized Changes in the Work*

A. Contractor shall not be entitled to an increase in the Contract Price or an extension of the Contract Times with respect to any work performed that is not required by the Contract Documents, as amended, modified, or supplemented, except in the case of an emergency as provided in Paragraph 7.15 or in the case of uncovering Work as provided in Paragraph 14.05.C.2.

11.07 *Change of Contract Price*

A. The Contract Price may only be changed by a Change Order. Any Change Proposal for an adjustment in the Contract Price must comply with the provisions of Paragraph 11.09. Any Claim for an adjustment of Contract Price must comply with the provisions of Article 12.

B. An adjustment in the Contract Price will be determined as follows:

1. Where the Work involved is covered by unit prices contained in the Contract Documents, then by application of such unit prices to the quantities of the items involved (subject to the provisions of Paragraph 13.03);

2. Where the Work involved is not covered by unit prices contained in the Contract Documents, then by a mutually agreed lump sum (which may include an allowance for overhead and profit not necessarily in accordance with Paragraph 11.07.C.2); or

3. Where the Work involved is not covered by unit prices contained in the Contract Documents and the parties do not reach mutual agreement to a lump sum, then on the basis of the Cost of the Work (determined as provided in Paragraph 13.01) plus a Contractor's fee for overhead and profit (determined as provided in Paragraph 11.07.C).

C. *Contractor's Fee*: When applicable, the Contractor's fee for overhead and profit will be determined as follows:

1. A mutually acceptable fixed fee; or

2. If a fixed fee is not agreed upon, then a fee based on the following percentages of the various portions of the Cost of the Work:

   a. For costs incurred under Paragraphs 13.01.B.1 and 13.01.B.2, the Contractor's fee will be 15 percent;

   b. For costs incurred under Paragraph 13.01.B.3, the Contractor's fee will be 5 percent;

   c. Where one or more tiers of subcontracts are on the basis of Cost of the Work plus a fee and no fixed fee is agreed upon, the intent of Paragraphs 11.07.C.2.a and 11.07.C.2.b is that the Contractor's fee will be based on: (1) a fee of 15 percent of the costs incurred under Paragraphs 13.01.B.1 and 13.01.B.2 by the Subcontractor that actually performs the Work, at whatever tier, and (2) with respect to Contractor itself and to any Subcontractors of a tier higher than that of the Subcontractor that actually performs the Work, a fee of 5 percent of the amount (fee plus underlying costs incurred) attributable to the next lower tier Subcontractor; provided, however, that for any such subcontracted Work the maximum total fee to be paid by Owner will be no greater than 27 percent of the costs incurred by the Subcontractor that actually performs the Work;

   d. No fee will be payable on the basis of costs itemized under Paragraphs 13.01.B.4, 13.01.B.5, and 13.01.C;

   e. The amount of credit to be allowed by Contractor to Owner for any change which results in a net decrease in Cost of the Work will be the amount of the actual net decrease in Cost of the Work and a deduction of an additional amount equal to 5 percent of such actual net decrease in Cost of the Work; and

   f. When both additions and credits are involved in any one change or Change Proposal, the adjustment in Contractor's fee will be computed by determining the sum of the costs in each of the cost categories in Paragraph 13.01.B (specifically, payroll costs, Paragraph 13.01.B.1; incorporated materials and equipment costs, Paragraph 13.01.B.2; Subcontract costs, Paragraph 13.01.B.3; special consultants costs, Paragraph 13.01.B.4; and other costs, Paragraph 13.01.B.5) and applying to each such cost category sum the appropriate fee from Paragraphs 11.07.C.2.a through 11.07.C.2.e, inclusive.

11.08 *Change of Contract Times*

A. The Contract Times may only be changed by a Change Order. Any Change Proposal for an adjustment in the Contract Times must comply with the provisions of Paragraph 11.09. Any Claim for an adjustment in the Contract Times must comply with the provisions of Article 12.

B. Delay, disruption, and interference in the Work, and any related changes in Contract Times, are addressed in and governed by Paragraph 4.05.

11.09 *Change Proposals*

A. *Purpose and Content*: Contractor shall submit a Change Proposal to Engineer to request an adjustment in the Contract Times or Contract Price; contest an initial decision by Engineer concerning the requirements of the Contract Documents or relating to the acceptability of the Work under the Contract Documents; challenge a set-off against payment due; or seek other relief under the Contract. The Change Proposal will specify any proposed change in Contract Times or Contract Price, or other proposed relief, and explain the reason for the proposed change, with citations to any governing or applicable provisions of the Contract Documents. Each Change Proposal will address only one issue, or a set of closely related issues.

B. *Change Proposal Procedures*

1. *Submittal*: Contractor shall submit each Change Proposal to Engineer within 30 days after the start of the event giving rise thereto, or after such initial decision.

2. *Supporting Data*: The Contractor shall submit supporting data, including the proposed change in Contract Price or Contract Time (if any), to the Engineer and Owner within 15 days after the submittal of the Change Proposal.

   a. Change Proposals based on or related to delay, interruption, or interference must comply with the provisions of Paragraphs 4.05.D and 4.05.E.

   b. Change proposals related to a change of Contract Price must include full and detailed accounts of materials incorporated into the Work and labor and equipment used for the subject Work.

   The supporting data must be accompanied by a written statement that the supporting data are accurate and complete, and that any requested time or price adjustment is the entire adjustment to which Contractor believes it is entitled as a result of said event.

3. *Engineer's Initial Review*: Engineer will advise Owner regarding the Change Proposal, and consider any comments or response from Owner regarding the Change Proposal. If in its discretion Engineer concludes that additional supporting data is needed before conducting a full review and making a decision regarding the Change Proposal, then Engineer may request that Contractor submit such additional supporting data by a date specified by Engineer, prior to Engineer beginning its full review of the Change Proposal.

4. *Engineer's Full Review and Action on the Change Proposal*: Upon receipt of Contractor's supporting data (including any additional data requested by Engineer), Engineer will conduct a full review of each Change Proposal and, within 30 days after such receipt of the Contractor's supporting data, either approve the Change Proposal in whole, deny it in whole, or approve it in part and deny it in part. Such actions must be in writing, with a copy provided to Owner and Contractor. If Engineer does not take action on the Change

Proposal within 30 days, then either Owner or Contractor may at any time thereafter submit a letter to the other party indicating that as a result of Engineer's inaction the Change Proposal is deemed denied, thereby commencing the time for appeal of the denial under Article 12.

5. *Binding Decision*: Engineer's decision is final and binding upon Owner and Contractor, unless Owner or Contractor appeals the decision by filing a Claim under Article 12.

C. *Resolution of Certain Change Proposals*: If the Change Proposal does not involve the design (as set forth in the Drawings, Specifications, or otherwise), the acceptability of the Work, or other engineering or technical matters, then Engineer will notify the parties in writing that the Engineer is unable to resolve the Change Proposal. For purposes of further resolution of such a Change Proposal, such notice will be deemed a denial, and Contractor may choose to seek resolution under the terms of Article 12.

D. *Post-Completion*: Contractor shall not submit any Change Proposals after Engineer issues a written recommendation of final payment pursuant to Paragraph 15.06.B.

11.10 *Notification to Surety*

A. If the provisions of any bond require notice to be given to a surety of any change affecting the general scope of the Work or the provisions of the Contract Documents (including, but not limited to, Contract Price or Contract Times), the giving of any such notice will be Contractor's responsibility. The amount of each applicable bond will be adjusted to reflect the effect of any such change.

ARTICLE 12—CLAIMS

12.01 *Claims*

A. *Claims Process*: The following disputes between Owner and Contractor are subject to the Claims process set forth in this article:

1. Appeals by Owner or Contractor of Engineer's decisions regarding Change Proposals;

2. Owner demands for adjustments in the Contract Price or Contract Times, or other relief under the Contract Documents;

3. Disputes that Engineer has been unable to address because they do not involve the design (as set forth in the Drawings, Specifications, or otherwise), the acceptability of the Work, or other engineering or technical matters; and

4. Subject to the waiver provisions of Paragraph 15.07, any dispute arising after Engineer has issued a written recommendation of final payment pursuant to Paragraph 15.06.B.

B. *Submittal of Claim*: The party submitting a Claim shall deliver it directly to the other party to the Contract promptly (but in no event later than 30 days) after the start of the event giving rise thereto; in the case of appeals regarding Change Proposals within 30 days of the decision under appeal. The party submitting the Claim shall also furnish a copy to the Engineer, for its information only. The responsibility to substantiate a Claim rests with the party making the Claim. In the case of a Claim by Contractor seeking an increase in the Contract Times or Contract Price, Contractor shall certify that the Claim is made in good faith, that the supporting data are accurate and complete, and that to the best of Contractor's knowledge and belief the amount of time or money requested accurately reflects the full amount to which Contractor is entitled.

C. *Review and Resolution*: The party receiving a Claim shall review it thoroughly, giving full consideration to its merits. The two parties shall seek to resolve the Claim through the exchange of information and direct negotiations. The parties may extend the time for resolving the Claim by mutual agreement. All actions taken on a Claim will be stated in writing and submitted to the other party, with a copy to Engineer.

D. *Mediation*

1. At any time after initiation of a Claim, Owner and Contractor may mutually agree to mediation of the underlying dispute. The agreement to mediate will stay the Claim submittal and response process.

2. If Owner and Contractor agree to mediation, then after 60 days from such agreement, either Owner or Contractor may unilaterally terminate the mediation process, and the Claim submittal and decision process will resume as of the date of the termination. If the mediation proceeds but is unsuccessful in resolving the dispute, the Claim submittal and decision process will resume as of the date of the conclusion of the mediation, as determined by the mediator.

3. Owner and Contractor shall each pay one-half of the mediator's fees and costs.

E. *Partial Approval*: If the party receiving a Claim approves the Claim in part and denies it in part, such action will be final and binding unless within 30 days of such action the other party invokes the procedure set forth in Article 17 for final resolution of disputes.

F. *Denial of Claim*: If efforts to resolve a Claim are not successful, the party receiving the Claim may deny it by giving written notice of denial to the other party. If the receiving party does not take action on the Claim within 90 days, then either Owner or Contractor may at any time thereafter submit a letter to the other party indicating that as a result of the inaction, the Claim is deemed denied, thereby commencing the time for appeal of the denial. A denial of the Claim will be final and binding unless within 30 days of the denial the other party invokes the procedure set forth in Article 17 for the final resolution of disputes.

G. *Final and Binding Results*: If the parties reach a mutual agreement regarding a Claim, whether through approval of the Claim, direct negotiations, mediation, or otherwise; or if a Claim is approved in part and denied in part, or denied in full, and such actions become final and binding; then the results of the agreement or action on the Claim will be incorporated in a Change Order or other written document to the extent they affect the Contract, including the Work, the Contract Times, or the Contract Price.

ARTICLE 13—COST OF THE WORK; ALLOWANCES; UNIT PRICE WORK

13.01 *Cost of the Work*

A. *Purposes for Determination of Cost of the Work*: The term Cost of the Work means the sum of all costs necessary for the proper performance of the Work at issue, as further defined below. The provisions of this Paragraph 13.01 are used for two distinct purposes:

1. To determine Cost of the Work when Cost of the Work is a component of the Contract Price, under cost-plus-fee, time-and-materials, or other cost-based terms; or

2. When needed to determine the value of a Change Order, Change Proposal, Claim, set-off, or other adjustment in Contract Price. When the value of any such adjustment is determined on the basis of Cost of the Work, Contractor is entitled only to those additional or incremental costs required because of the change in the Work or because of the event giving rise to the adjustment.

B. *Costs Included*: Except as otherwise may be agreed to in writing by Owner, costs included in the Cost of the Work will be in amounts no higher than those commonly incurred in the locality of the Project, will not include any of the costs itemized in Paragraph 13.01.C, and will include only the following items:

1. Payroll costs for employees in the direct employ of Contractor in the performance of the Work under schedules of job classifications agreed upon by Owner and Contractor in advance of the subject Work. Such employees include, without limitation, superintendents, foremen, safety managers, safety representatives, and other personnel employed full time on the Work. Payroll costs for employees not employed full time on the Work will be apportioned on the basis of their time spent on the Work. Payroll costs include, but are not limited to, salaries and wages plus the cost of fringe benefits, which include social security contributions, unemployment, excise, and payroll taxes, workers' compensation, health and retirement benefits, sick leave, and vacation and holiday pay applicable thereto. The expenses of performing Work outside of regular working hours, on Saturday, Sunday, or legal holidays, will be included in the above to the extent authorized by Owner.

2. Cost of all materials and equipment furnished and incorporated in the Work, including costs of transportation and storage thereof, and Suppliers' field services required in connection therewith. All cash discounts accrue to Contractor unless Owner deposits funds with Contractor with which to make payments, in which case the cash discounts will accrue to Owner. All trade discounts, rebates, and refunds and returns from sale of surplus materials and equipment will accrue to Owner, and Contractor shall make provisions so that they may be obtained.

3. Payments made by Contractor to Subcontractors for Work performed by Subcontractors. If required by Owner, Contractor shall obtain competitive bids from subcontractors acceptable to Owner and Contractor and shall deliver such bids to Owner, which will then determine, with the advice of Engineer, which bids, if any, will be acceptable. If any subcontract provides that the Subcontractor is to be paid on the basis of Cost of the Work plus a fee, the Subcontractor's Cost of the Work and fee will be determined in the same manner as Contractor's Cost of the Work and fee as provided in this Paragraph 13.01.

4. Costs of special consultants (including but not limited to engineers, architects, testing laboratories, surveyors, attorneys, and accountants) employed or retained for services specifically related to the Work.

5. Other costs consisting of the following:

   a. The proportion of necessary transportation, travel, and subsistence expenses of Contractor's employees incurred in discharge of duties connected with the Work.

   b. Cost, including transportation and maintenance, of all materials, supplies, equipment, machinery, appliances, office, and temporary facilities at the Site, which are consumed in the performance of the Work, and cost, less market value, of such items used but not consumed which remain the property of Contractor.

1) In establishing included costs for materials such as scaffolding, plating, or sheeting, consideration will be given to the actual or the estimated life of the material for use on other projects; or rental rates may be established on the basis of purchase or salvage value of such items, whichever is less. Contractor will not be eligible for compensation for such items in an amount that exceeds the purchase cost of such item.

c. *Construction Equipment Rental*

1) Rentals of all construction equipment and machinery, and the parts thereof, in accordance with rental agreements approved by Owner as to price (including any surcharge or special rates applicable to overtime use of the construction equipment or machinery), and the costs of transportation, loading, unloading, assembly, dismantling, and removal thereof. All such costs will be in accordance with the terms of said rental agreements. The rental of any such equipment, machinery, or parts must cease when the use thereof is no longer necessary for the Work.

2) Costs for equipment and machinery owned by Contractor or a Contractor-related entity will be paid at a rate shown for such equipment in the equipment rental rate book specified in the Supplementary Conditions. An hourly rate will be computed by dividing the monthly rates by 176. These computed rates will include all operating costs.

3) With respect to Work that is the result of a Change Order, Change Proposal, Claim, set-off, or other adjustment in Contract Price ("changed Work"), included costs will be based on the time the equipment or machinery is in use on the changed Work and the costs of transportation, loading, unloading, assembly, dismantling, and removal when directly attributable to the changed Work. The cost of any such equipment or machinery, or parts thereof, must cease to accrue when the use thereof is no longer necessary for the changed Work.

d. Sales, consumer, use, and other similar taxes related to the Work, and for which Contractor is liable, as imposed by Laws and Regulations.

e. Deposits lost for causes other than negligence of Contractor, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable, and royalty payments and fees for permits and licenses.

f. Losses and damages (and related expenses) caused by damage to the Work, not compensated by insurance or otherwise, sustained by Contractor in connection with the performance of the Work (except losses and damages within the deductible amounts of builder's risk or other property insurance established in accordance with Paragraph 6.04), provided such losses and damages have resulted from causes other than the negligence of Contractor, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable. Such losses include settlements made with the written consent and approval of Owner. No such losses, damages, and expenses will be included in the Cost of the Work for the purpose of determining Contractor's fee.

g. The cost of utilities, fuel, and sanitary facilities at the Site.

h. Minor expenses such as communication service at the Site, express and courier services, and similar petty cash items in connection with the Work.

i. The costs of premiums for all bonds and insurance that Contractor is required by the Contract Documents to purchase and maintain.

C. *Costs Excluded*: The term Cost of the Work does not include any of the following items:

1. Payroll costs and other compensation of Contractor's officers, executives, principals, general managers, engineers, architects, estimators, attorneys, auditors, accountants, purchasing and contracting agents, expediters, timekeepers, clerks, and other personnel employed by Contractor, whether at the Site or in Contractor's principal or branch office for general administration of the Work and not specifically included in the agreed upon schedule of job classifications referred to in Paragraph 13.01.B.1 or specifically covered by Paragraph 13.01.B.4. The payroll costs and other compensation excluded here are to be considered administrative costs covered by the Contractor's fee.

2. The cost of purchasing, renting, or furnishing small tools and hand tools.

3. Expenses of Contractor's principal and branch offices other than Contractor's office at the Site.

4. Any part of Contractor's capital expenses, including interest on Contractor's capital employed for the Work and charges against Contractor for delinquent payments.

5. Costs due to the negligence of Contractor, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable, including but not limited to, the correction of defective Work, disposal of materials or equipment wrongly supplied, and making good any damage to property.

6. Expenses incurred in preparing and advancing Claims.

7. Other overhead or general expense costs of any kind and the costs of any item not specifically and expressly included in Paragraph 13.01.B.

D. *Contractor's Fee*

1. When the Work as a whole is performed on the basis of cost-plus-a-fee, then:

   a. Contractor's fee for the Work set forth in the Contract Documents as of the Effective Date of the Contract will be determined as set forth in the Agreement.

   b. for any Work covered by a Change Order, Change Proposal, Claim, set-off, or other adjustment in Contract Price on the basis of Cost of the Work, Contractor's fee will be determined as follows:

      1) When the fee for the Work as a whole is a percentage of the Cost of the Work, the fee will automatically adjust as the Cost of the Work changes.

      2) When the fee for the Work as a whole is a fixed fee, the fee for any additions or deletions will be determined in accordance with Paragraph 11.07.C.2.

2. When the Work as a whole is performed on the basis of a stipulated sum, or any other basis other than cost-plus-a-fee, then Contractor's fee for any Work covered by a Change

Order, Change Proposal, Claim, set-off, or other adjustment in Contract Price on the basis of Cost of the Work will be determined in accordance with Paragraph 11.07.C.2.

E. *Documentation and Audit*: Whenever the Cost of the Work for any purpose is to be determined pursuant to this Article 13, Contractor and pertinent Subcontractors will establish and maintain records of the costs in accordance with generally accepted accounting practices. Subject to prior written notice, Owner will be afforded reasonable access, during normal business hours, to all Contractor's accounts, records, books, correspondence, instructions, drawings, receipts, vouchers, memoranda, and similar data relating to the Cost of the Work and Contractor's fee. Contractor shall preserve all such documents for a period of three years after the final payment by Owner. Pertinent Subcontractors will afford such access to Owner, and preserve such documents, to the same extent required of Contractor.

13.02 *Allowances*

A. It is understood that Contractor has included in the Contract Price all allowances so named in the Contract Documents and shall cause the Work so covered to be performed for such sums and by such persons or entities as may be acceptable to Owner and Engineer.

B. *Cash Allowances*: Contractor agrees that:

1. the cash allowances include the cost to Contractor (less any applicable trade discounts) of materials and equipment required by the allowances to be delivered at the Site, and all applicable taxes; and

2. Contractor's costs for unloading and handling on the Site, labor, installation, overhead, profit, and other expenses contemplated for the cash allowances have been included in the Contract Price and not in the allowances, and no demand for additional payment for any of the foregoing will be valid.

C. *Owner's Contingency Allowance*: Contractor agrees that an Owner's contingency allowance, if any, is for the sole use of Owner to cover unanticipated costs.

D. Prior to final payment, an appropriate Change Order will be issued as recommended by Engineer to reflect actual amounts due Contractor for Work covered by allowances, and the Contract Price will be correspondingly adjusted.

13.03 *Unit Price Work*

A. Where the Contract Documents provide that all or part of the Work is to be Unit Price Work, initially the Contract Price will be deemed to include for all Unit Price Work an amount equal to the sum of the unit price for each separately identified item of Unit Price Work times the estimated quantity of each item as indicated in the Agreement.

B. The estimated quantities of items of Unit Price Work are not guaranteed and are solely for the purpose of comparison of Bids and determining an initial Contract Price. Payments to Contractor for Unit Price Work will be based on actual quantities.

C. Each unit price will be deemed to include an amount considered by Contractor to be adequate to cover Contractor's overhead and profit for each separately identified item.

D. Engineer will determine the actual quantities and classifications of Unit Price Work performed by Contractor. Engineer will review with Contractor the Engineer's preliminary determinations on such matters before rendering a written decision thereon (by recommendation of an Application for Payment or otherwise). Engineer's written decision thereon will be final and binding (except as modified by Engineer to reflect changed factual conditions or more accurate data) upon Owner and Contractor, and the final adjustment of Contract Price will be set forth in a Change Order, subject to the provisions of the following paragraph.

E. *Adjustments in Unit Price*

1. Contractor or Owner shall be entitled to an adjustment in the unit price with respect to an item of Unit Price Work if:

    a. the quantity of the item of Unit Price Work performed by Contractor differs materially and significantly from the estimated quantity of such item indicated in the Agreement; and

    b. Contractor's unit costs to perform the item of Unit Price Work have changed materially and significantly as a result of the quantity change.

2. The adjustment in unit price will account for and be coordinated with any related changes in quantities of other items of Work, and in Contractor's costs to perform such other Work, such that the resulting overall change in Contract Price is equitable to Owner and Contractor.

3. Adjusted unit prices will apply to all units of that item.

ARTICLE 14—TESTS AND INSPECTIONS; CORRECTION, REMOVAL, OR ACCEPTANCE OF DEFECTIVE WORK

14.01 *Access to Work*

A. Owner, Engineer, their consultants and other representatives and personnel of Owner, independent testing laboratories, and authorities having jurisdiction have access to the Site and the Work at reasonable times for their observation, inspection, and testing. Contractor shall provide them proper and safe conditions for such access and advise them of Contractor's safety procedures and programs so that they may comply with such procedures and programs as applicable.

14.02 *Tests, Inspections, and Approvals*

A. Contractor shall give Engineer timely notice of readiness of the Work (or specific parts thereof) for all required inspections and tests, and shall cooperate with inspection and testing personnel to facilitate required inspections and tests.

B. Owner shall retain and pay for the services of an independent inspector, testing laboratory, or other qualified individual or entity to perform all inspections and tests expressly required by the Contract Documents to be furnished and paid for by Owner, except that costs incurred in connection with tests or inspections of covered Work will be governed by the provisions of Paragraph 14.05.

C. If Laws or Regulations of any public body having jurisdiction require any Work (or part thereof) specifically to be inspected, tested, or approved by an employee or other representative of such public body, Contractor shall assume full responsibility for arranging and obtaining such inspections, tests, or approvals, pay all costs in connection therewith, and furnish Engineer the required certificates of inspection or approval.

D. Contractor shall be responsible for arranging, obtaining, and paying for all inspections and tests required:

1. by the Contract Documents, unless the Contract Documents expressly allocate responsibility for a specific inspection or test to Owner;
2. to attain Owner's and Engineer's acceptance of materials or equipment to be incorporated in the Work;
3. by manufacturers of equipment furnished under the Contract Documents;
4. for testing, adjusting, and balancing of mechanical, electrical, and other equipment to be incorporated into the Work; and
5. for acceptance of materials, mix designs, or equipment submitted for approval prior to Contractor's purchase thereof for incorporation in the Work.

Such inspections and tests will be performed by independent inspectors, testing laboratories, or other qualified individuals or entities acceptable to Owner and Engineer.

E. If the Contract Documents require the Work (or part thereof) to be approved by Owner, Engineer, or another designated individual or entity, then Contractor shall assume full responsibility for arranging and obtaining such approvals.

F. If any Work (or the work of others) that is to be inspected, tested, or approved is covered by Contractor without written concurrence of Engineer, Contractor shall, if requested by Engineer, uncover such Work for observation. Such uncovering will be at Contractor's expense unless Contractor had given Engineer timely notice of Contractor's intention to cover the same and Engineer had not acted with reasonable promptness in response to such notice.

14.03 *Defective Work*

A. *Contractor's Obligation*: It is Contractor's obligation to assure that the Work is not defective.

B. *Engineer's Authority*: Engineer has the authority to determine whether Work is defective, and to reject defective Work.

C. *Notice of Defects*: Prompt written notice of all defective Work of which Owner or Engineer has actual knowledge will be given to Contractor.

D. *Correction, or Removal and Replacement*: Promptly after receipt of written notice of defective Work, Contractor shall correct all such defective Work, whether or not fabricated, installed, or completed, or, if Engineer has rejected the defective Work, remove it from the Project and replace it with Work that is not defective.

E. *Preservation of Warranties*: When correcting defective Work, Contractor shall take no action that would void or otherwise impair Owner's special warranty and guarantee, if any, on said Work.

F. *Costs and Damages*: In addition to its correction, removal, and replacement obligations with respect to defective Work, Contractor shall pay all claims, costs, losses, and damages arising out of or relating to defective Work, including but not limited to the cost of the inspection, testing, correction, removal, replacement, or reconstruction of such defective Work, fines levied against Owner by governmental authorities because the Work is defective, and the costs of repair or replacement of work of others resulting from defective Work. Prior to final payment, if Owner and Contractor are unable to agree as to the measure of such claims, costs, losses, and damages resulting from defective Work, then Owner may impose a reasonable set-off against payments due under Article 15.

14.04 *Acceptance of Defective Work*

A. If, instead of requiring correction or removal and replacement of defective Work, Owner prefers to accept it, Owner may do so (subject, if such acceptance occurs prior to final payment, to Engineer's confirmation that such acceptance is in general accord with the design intent and applicable engineering principles, and will not endanger public safety). Contractor shall pay all claims, costs, losses, and damages attributable to Owner's evaluation of and determination to accept such defective Work (such costs to be approved by Engineer as to reasonableness), and for the diminished value of the Work to the extent not otherwise paid by Contractor. If any such acceptance occurs prior to final payment, the necessary revisions in the Contract Documents with respect to the Work will be incorporated in a Change Order. If the parties are unable to agree as to the decrease in the Contract Price, reflecting the diminished value of Work so accepted, then Owner may impose a reasonable set-off against payments due under Article 15. If the acceptance of defective Work occurs after final payment, Contractor shall pay an appropriate amount to Owner.

14.05 *Uncovering Work*

A. Engineer has the authority to require additional inspection or testing of the Work, whether or not the Work is fabricated, installed, or completed.

B. If any Work is covered contrary to the written request of Engineer, then Contractor shall, if requested by Engineer, uncover such Work for Engineer's observation, and then replace the covering, all at Contractor's expense.

C. If Engineer considers it necessary or advisable that covered Work be observed by Engineer or inspected or tested by others, then Contractor, at Engineer's request, shall uncover, expose, or otherwise make available for observation, inspection, or testing as Engineer may require, that portion of the Work in question, and provide all necessary labor, material, and equipment.

1. If it is found that the uncovered Work is defective, Contractor shall be responsible for all claims, costs, losses, and damages arising out of or relating to such uncovering, exposure, observation, inspection, and testing, and of satisfactory replacement or reconstruction (including but not limited to all costs of repair or replacement of work of others); and pending Contractor's full discharge of this responsibility the Owner shall be entitled to impose a reasonable set-off against payments due under Article 15.

2. If the uncovered Work is not found to be defective, Contractor shall be allowed an increase in the Contract Price or an extension of the Contract Times, directly attributable to such uncovering, exposure, observation, inspection, testing, replacement, and reconstruction. If the parties are unable to agree as to the amount or extent thereof, then Contractor may submit a Change Proposal within 30 days of the determination that the Work is not defective.

14.06 *Owner May Stop the Work*

A. If the Work is defective, or Contractor fails to supply sufficient skilled workers or suitable materials or equipment, or fails to perform the Work in such a way that the completed Work will conform to the Contract Documents, then Owner may order Contractor to stop the Work, or any portion thereof, until the cause for such order has been eliminated; however, this right of Owner to stop the Work will not give rise to any duty on the part of Owner to exercise this right for the benefit of Contractor, any Subcontractor, any Supplier, any other individual or entity, or any surety for, or employee or agent of any of them.

14.07 *Owner May Correct Defective Work*

A. If Contractor fails within a reasonable time after written notice from Engineer to correct defective Work, or to remove and replace defective Work as required by Engineer, then Owner may, after 7 days' written notice to Contractor, correct or remedy any such deficiency.

B. In exercising the rights and remedies under this Paragraph 14.07, Owner shall proceed expeditiously. In connection with such corrective or remedial action, Owner may exclude Contractor from all or part of the Site, take possession of all or part of the Work and suspend Contractor's services related thereto, and incorporate in the Work all materials and equipment stored at the Site or for which Owner has paid Contractor but which are stored elsewhere. Contractor shall allow Owner, Owner's representatives, agents and employees, Owner's other contractors, and Engineer and Engineer's consultants access to the Site to enable Owner to exercise the rights and remedies under this paragraph.

C. All claims, costs, losses, and damages incurred or sustained by Owner in exercising the rights and remedies under this Paragraph 14.07 will be charged against Contractor as set-offs against payments due under Article 15. Such claims, costs, losses and damages will include but not be limited to all costs of repair, or replacement of work of others destroyed or damaged by correction, removal, or replacement of Contractor's defective Work.

D. Contractor shall not be allowed an extension of the Contract Times because of any delay in the performance of the Work attributable to the exercise by Owner of Owner's rights and remedies under this Paragraph 14.07.

ARTICLE 15—PAYMENTS TO CONTRACTOR; SET-OFFS; COMPLETION; CORRECTION PERIOD

15.01 *Progress Payments*

A. *Basis for Progress Payments*: The Schedule of Values established as provided in Article 2 will serve as the basis for progress payments and will be incorporated into a form of Application for Payment acceptable to Engineer. Progress payments for Unit Price Work will be based on the number of units completed during the pay period, as determined under the provisions of Paragraph 13.03. Progress payments for cost-based Work will be based on Cost of the Work completed by Contractor during the pay period.

B. *Applications for Payments*

1. At least 20 days before the date established in the Agreement for each progress payment (but not more often than once a month), Contractor shall submit to Engineer for review an Application for Payment filled out and signed by Contractor covering the Work completed as of the date of the Application and accompanied by such supporting documentation as is required by the Contract Documents.

2. If payment is requested on the basis of materials and equipment not incorporated in the Work but delivered and suitably stored at the Site or at another location agreed to in writing, the Application for Payment must also be accompanied by: (a) a bill of sale, invoice, copies of subcontract or purchase order payments, or other documentation

establishing full payment by Contractor for the materials and equipment; (b) at Owner's request, documentation warranting that Owner has received the materials and equipment free and clear of all Liens; and (c) evidence that the materials and equipment are covered by appropriate property insurance, a warehouse bond, or other arrangements to protect Owner's interest therein, all of which must be satisfactory to Owner.

3. Beginning with the second Application for Payment, each Application must include an affidavit of Contractor stating that all previous progress payments received by Contractor have been applied to discharge Contractor's legitimate obligations associated with prior Applications for Payment.

4. The amount of retainage with respect to progress payments will be as stipulated in the Agreement.

C. *Review of Applications*

1. Engineer will, within 10 days after receipt of each Application for Payment, including each resubmittal, either indicate in writing a recommendation of payment and present the Application to Owner, or return the Application to Contractor indicating in writing Engineer's reasons for refusing to recommend payment. In the latter case, Contractor may make the necessary corrections and resubmit the Application.

2. Engineer's recommendation of any payment requested in an Application for Payment will constitute a representation by Engineer to Owner, based on Engineer's observations of the executed Work as an experienced and qualified design professional, and on Engineer's review of the Application for Payment and the accompanying data and schedules, that to the best of Engineer's knowledge, information and belief:

   a. the Work has progressed to the point indicated;

   b. the quality of the Work is generally in accordance with the Contract Documents (subject to an evaluation of the Work as a functioning whole prior to or upon Substantial Completion, the results of any subsequent tests called for in the Contract Documents, a final determination of quantities and classifications for Unit Price Work under Paragraph 13.03, and any other qualifications stated in the recommendation); and

   c. the conditions precedent to Contractor's being entitled to such payment appear to have been fulfilled in so far as it is Engineer's responsibility to observe the Work.

3. By recommending any such payment Engineer will not thereby be deemed to have represented that:

   a. inspections made to check the quality or the quantity of the Work as it has been performed have been exhaustive, extended to every aspect of the Work in progress, or involved detailed inspections of the Work beyond the responsibilities specifically assigned to Engineer in the Contract; or

   b. there may not be other matters or issues between the parties that might entitle Contractor to be paid additionally by Owner or entitle Owner to withhold payment to Contractor.

4. Neither Engineer's review of Contractor's Work for the purposes of recommending payments nor Engineer's recommendation of any payment, including final payment, will impose responsibility on Engineer:

    a. to supervise, direct, or control the Work;

    b. for the means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto;

    c. for Contractor's failure to comply with Laws and Regulations applicable to Contractor's performance of the Work;

    d. to make any examination to ascertain how or for what purposes Contractor has used the money paid by Owner; or

    e. to determine that title to any of the Work, materials, or equipment has passed to Owner free and clear of any Liens.

5. Engineer may refuse to recommend the whole or any part of any payment if, in Engineer's opinion, it would be incorrect to make the representations to Owner stated in Paragraph 15.01.C.2.

6. Engineer will recommend reductions in payment (set-offs) necessary in Engineer's opinion to protect Owner from loss because:

    a. the Work is defective, requiring correction or replacement;

    b. the Contract Price has been reduced by Change Orders;

    c. Owner has been required to correct defective Work in accordance with Paragraph 14.07, or has accepted defective Work pursuant to Paragraph 14.04;

    d. Owner has been required to remove or remediate a Hazardous Environmental Condition for which Contractor is responsible; or

    e. Engineer has actual knowledge of the occurrence of any of the events that would constitute a default by Contractor and therefore justify termination for cause under the Contract Documents.

D. *Payment Becomes Due*

1. Ten days after presentation of the Application for Payment to Owner with Engineer's recommendation, the amount recommended (subject to any Owner set-offs) will become due, and when due will be paid by Owner to Contractor.

E. *Reductions in Payment by Owner*

1. In addition to any reductions in payment (set-offs) recommended by Engineer, Owner is entitled to impose a set-off against payment based on any of the following:

    a. Claims have been made against Owner based on Contractor's conduct in the performance or furnishing of the Work, or Owner has incurred costs, losses, or damages resulting from Contractor's conduct in the performance or furnishing of the Work, including but not limited to claims, costs, losses, or damages from workplace injuries, adjacent property damage, non-compliance with Laws and Regulations, and patent infringement;

b. Contractor has failed to take reasonable and customary measures to avoid damage, delay, disruption, and interference with other work at or adjacent to the Site;

c. Contractor has failed to provide and maintain required bonds or insurance;

d. Owner has been required to remove or remediate a Hazardous Environmental Condition for which Contractor is responsible;

e. Owner has incurred extra charges or engineering costs related to submittal reviews, evaluations of proposed substitutes, tests and inspections, or return visits to manufacturing or assembly facilities;

f. The Work is defective, requiring correction or replacement;

g. Owner has been required to correct defective Work in accordance with Paragraph 14.07, or has accepted defective Work pursuant to Paragraph 14.04;

h. The Contract Price has been reduced by Change Orders;

i. An event has occurred that would constitute a default by Contractor and therefore justify a termination for cause;

j. Liquidated or other damages have accrued as a result of Contractor's failure to achieve Milestones, Substantial Completion, or final completion of the Work;

k. Liens have been filed in connection with the Work, except where Contractor has delivered a specific bond satisfactory to Owner to secure the satisfaction and discharge of such Liens; or

l. Other items entitle Owner to a set-off against the amount recommended.

2. If Owner imposes any set-off against payment, whether based on its own knowledge or on the written recommendations of Engineer, Owner will give Contractor immediate written notice (with a copy to Engineer) stating the reasons for such action and the specific amount of the reduction, and promptly pay Contractor any amount remaining after deduction of the amount so withheld. Owner shall promptly pay Contractor the amount so withheld, or any adjustment thereto agreed to by Owner and Contractor, if Contractor remedies the reasons for such action. The reduction imposed will be binding on Contractor unless it duly submits a Change Proposal contesting the reduction.

3. Upon a subsequent determination that Owner's refusal of payment was not justified, the amount wrongfully withheld will be treated as an amount due as determined by Paragraph 15.01.D.1 and subject to interest as provided in the Agreement.

15.02 *Contractor's Warranty of Title*

A. Contractor warrants and guarantees that title to all Work, materials, and equipment furnished under the Contract will pass to Owner free and clear of (1) all Liens and other title defects, and (2) all patent, licensing, copyright, or royalty obligations, no later than 7 days after the time of payment by Owner.

15.03 *Substantial Completion*

A. When Contractor considers the entire Work ready for its intended use Contractor shall notify Owner and Engineer in writing that the entire Work is substantially complete and request that Engineer issue a certificate of Substantial Completion. Contractor shall at the same time submit to Owner and Engineer an initial draft of punch list items to be completed or corrected before final payment.

B. Promptly after Contractor's notification, Owner, Contractor, and Engineer shall make an inspection of the Work to determine the status of completion. If Engineer does not consider the Work substantially complete, Engineer will notify Contractor in writing giving the reasons therefor.

C. If Engineer considers the Work substantially complete, Engineer will deliver to Owner a preliminary certificate of Substantial Completion which will fix the date of Substantial Completion. Engineer shall attach to the certificate a punch list of items to be completed or corrected before final payment. Owner shall have 7 days after receipt of the preliminary certificate during which to make written objection to Engineer as to any provisions of the certificate or attached punch list. If, after considering the objections to the provisions of the preliminary certificate, Engineer concludes that the Work is not substantially complete, Engineer will, within 14 days after submission of the preliminary certificate to Owner, notify Contractor in writing that the Work is not substantially complete, stating the reasons therefor. If Owner does not object to the provisions of the certificate, or if despite consideration of Owner's objections Engineer concludes that the Work is substantially complete, then Engineer will, within said 14 days, execute and deliver to Owner and Contractor a final certificate of Substantial Completion (with a revised punch list of items to be completed or corrected) reflecting such changes from the preliminary certificate as Engineer believes justified after consideration of any objections from Owner.

D. At the time of receipt of the preliminary certificate of Substantial Completion, Owner and Contractor will confer regarding Owner's use or occupancy of the Work following Substantial Completion, review the builder's risk insurance policy with respect to the end of the builder's risk coverage, and confirm the transition to coverage of the Work under a permanent property insurance policy held by Owner. Unless Owner and Contractor agree otherwise in writing, Owner shall bear responsibility for security, operation, protection of the Work, property insurance, maintenance, heat, and utilities upon Owner's use or occupancy of the Work.

E. After Substantial Completion the Contractor shall promptly begin work on the punch list of items to be completed or corrected prior to final payment. In appropriate cases Contractor may submit monthly Applications for Payment for completed punch list items, following the progress payment procedures set forth above.

F. Owner shall have the right to exclude Contractor from the Site after the date of Substantial Completion subject to allowing Contractor reasonable access to remove its property and complete or correct items on the punch list.

15.04 *Partial Use or Occupancy*

A. Prior to Substantial Completion of all the Work, Owner may use or occupy any substantially completed part of the Work which has specifically been identified in the Contract Documents, or which Owner, Engineer, and Contractor agree constitutes a separately functioning and usable part of the Work that can be used by Owner for its intended purpose without significant interference with Contractor's performance of the remainder of the Work, subject to the following conditions:

1. At any time, Owner may request in writing that Contractor permit Owner to use or occupy any such part of the Work that Owner believes to be substantially complete. If and when Contractor agrees that such part of the Work is substantially complete, Contractor, Owner, and Engineer will follow the procedures of Paragraph 15.03.A through 15.03.E for that part of the Work.

2. At any time, Contractor may notify Owner and Engineer in writing that Contractor considers any such part of the Work substantially complete and request Engineer to issue a certificate of Substantial Completion for that part of the Work.

3. Within a reasonable time after either such request, Owner, Contractor, and Engineer shall make an inspection of that part of the Work to determine its status of completion. If Engineer does not consider that part of the Work to be substantially complete, Engineer will notify Owner and Contractor in writing giving the reasons therefor. If Engineer considers that part of the Work to be substantially complete, the provisions of Paragraph 15.03 will apply with respect to certification of Substantial Completion of that part of the Work and the division of responsibility in respect thereof and access thereto.

4. No use or occupancy or separate operation of part of the Work may occur prior to compliance with the requirements of Paragraph 6.04 regarding builder's risk or other property insurance.

15.05 *Final Inspection*

A. Upon written notice from Contractor that the entire Work or an agreed portion thereof is complete, Engineer will promptly make a final inspection with Owner and Contractor and will notify Contractor in writing of all particulars in which this inspection reveals that the Work, or agreed portion thereof, is incomplete or defective. Contractor shall immediately take such measures as are necessary to complete such Work or remedy such deficiencies.

15.06 *Final Payment*

A. *Application for Payment*

1. After Contractor has, in the opinion of Engineer, satisfactorily completed all corrections identified during the final inspection and has delivered, in accordance with the Contract Documents, all maintenance and operating instructions, schedules, guarantees, bonds, certificates or other evidence of insurance, certificates of inspection, annotated record documents (as provided in Paragraph 7.12), and other documents, Contractor may make application for final payment.

2. The final Application for Payment must be accompanied (except as previously delivered) by:

    a. all documentation called for in the Contract Documents;

    b. consent of the surety, if any, to final payment;

    c. satisfactory evidence that all title issues have been resolved such that title to all Work, materials, and equipment has passed to Owner free and clear of any Liens or other title defects, or will so pass upon final payment.

d. a list of all duly pending Change Proposals and Claims; and

e. complete and legally effective releases or waivers (satisfactory to Owner) of all Lien rights arising out of the Work, and of Liens filed in connection with the Work.

3. In lieu of the releases or waivers of Liens specified in Paragraph 15.06.A.2 and as approved by Owner, Contractor may furnish receipts or releases in full and an affidavit of Contractor that: (a) the releases and receipts include all labor, services, material, and equipment for which a Lien could be filed; and (b) all payrolls, material and equipment bills, and other indebtedness connected with the Work for which Owner might in any way be responsible, or which might in any way result in liens or other burdens on Owner's property, have been paid or otherwise satisfied. If any Subcontractor or Supplier fails to furnish such a release or receipt in full, Contractor may furnish a bond or other collateral satisfactory to Owner to indemnify Owner against any Lien, or Owner at its option may issue joint checks payable to Contractor and specified Subcontractors and Suppliers.

B. *Engineer's Review of Final Application and Recommendation of Payment*: If, on the basis of Engineer's observation of the Work during construction and final inspection, and Engineer's review of the final Application for Payment and accompanying documentation as required by the Contract Documents, Engineer is satisfied that the Work has been completed and Contractor's other obligations under the Contract have been fulfilled, Engineer will, within 10 days after receipt of the final Application for Payment, indicate in writing Engineer's recommendation of final payment and present the final Application for Payment to Owner for payment. Such recommendation will account for any set-offs against payment that are necessary in Engineer's opinion to protect Owner from loss for the reasons stated above with respect to progress payments. Otherwise, Engineer will return the Application for Payment to Contractor, indicating in writing the reasons for refusing to recommend final payment, in which case Contractor shall make the necessary corrections and resubmit the Application for Payment.

C. *Notice of Acceptability*: In support of its recommendation of payment of the final Application for Payment, Engineer will also give written notice to Owner and Contractor that the Work is acceptable, subject to stated limitations in the notice and to the provisions of Paragraph 15.07.

D. *Completion of Work*: The Work is complete (subject to surviving obligations) when it is ready for final payment as established by the Engineer's written recommendation of final payment and issuance of notice of the acceptability of the Work.

E. *Final Payment Becomes Due*: Upon receipt from Engineer of the final Application for Payment and accompanying documentation, Owner shall set off against the amount recommended by Engineer for final payment any further sum to which Owner is entitled, including but not limited to set-offs for liquidated damages and set-offs allowed under the provisions of this Contract with respect to progress payments. Owner shall pay the resulting balance due to Contractor within 30 days of Owner's receipt of the final Application for Payment from Engineer.

15.07 *Waiver of Claims*

A. By making final payment, Owner waives its claim or right to liquidated damages or other damages for late completion by Contractor, except as set forth in an outstanding Claim, appeal under the provisions of Article 17, set-off, or express reservation of rights by Owner. Owner reserves all other claims or rights after final payment.

B. The acceptance of final payment by Contractor will constitute a waiver by Contractor of all claims and rights against Owner other than those pending matters that have been duly submitted as a Claim, or appealed under the provisions of Article 17.

15.08 *Correction Period*

A. If within one year after the date of Substantial Completion (or such longer period of time as may be prescribed by the Supplementary Conditions or the terms of any applicable special guarantee required by the Contract Documents), Owner gives Contractor written notice that any Work has been found to be defective, or that Contractor's repair of any damages to the Site or adjacent areas has been found to be defective, then after receipt of such notice of defect Contractor shall promptly, without cost to Owner and in accordance with Owner's written instructions:

1. correct the defective repairs to the Site or such adjacent areas;
2. correct such defective Work;
3. remove the defective Work from the Project and replace it with Work that is not defective, if the defective Work has been rejected by Owner, and
4. satisfactorily correct or repair or remove and replace any damage to other Work, to the work of others, or to other land or areas resulting from the corrective measures.

B. Owner shall give any such notice of defect within 60 days of the discovery that such Work or repairs is defective. If such notice is given within such 60 days but after the end of the correction period, the notice will be deemed a notice of defective Work under Paragraph 7.17.B.

C. If, after receipt of a notice of defect within 60 days and within the correction period, Contractor does not promptly comply with the terms of Owner's written instructions, or in an emergency where delay would cause serious risk of loss or damage, Owner may have the defective Work corrected or repaired or may have the rejected Work removed and replaced. Contractor shall pay all costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such correction or repair or such removal and replacement (including but not limited to all costs of repair or replacement of work of others). Contractor's failure to pay such costs, losses, and damages within 10 days of invoice from Owner will be deemed the start of an event giving rise to a Claim under Paragraph 12.01.B, such that any related Claim must be brought within 30 days of the failure to pay.

D. In special circumstances where a particular item of equipment is placed in continuous service before Substantial Completion of all the Work, the correction period for that item may start to run from an earlier date if so provided in the Specifications.

E. Where defective Work (and damage to other Work resulting therefrom) has been corrected or removed and replaced under this paragraph, the correction period hereunder with respect to such Work will be extended for an additional period of one year after such correction or removal and replacement has been satisfactorily completed.

F. Contractor's obligations under this paragraph are in addition to all other obligations and warranties. The provisions of this paragraph are not to be construed as a substitute for, or a waiver of, the provisions of any applicable statute of limitation or repose.

ARTICLE 16—SUSPENSION OF WORK AND TERMINATION

16.01 *Owner May Suspend Work*

A. At any time and without cause, Owner may suspend the Work or any portion thereof for a period of not more than 90 consecutive days by written notice to Contractor and Engineer. Such notice will fix the date on which Work will be resumed. Contractor shall resume the Work on the date so fixed. Contractor shall be entitled to an adjustment in the Contract Price or an extension of the Contract Times directly attributable to any such suspension. Any Change Proposal seeking such adjustments must be submitted no later than 30 days after the date fixed for resumption of Work.

16.02 *Owner May Terminate for Cause*

A. The occurrence of any one or more of the following events will constitute a default by Contractor and justify termination for cause:

1. Contractor's persistent failure to perform the Work in accordance with the Contract Documents (including, but not limited to, failure to supply sufficient skilled workers or suitable materials or equipment, or failure to adhere to the Progress Schedule);
2. Failure of Contractor to perform or otherwise to comply with a material term of the Contract Documents;
3. Contractor's disregard of Laws or Regulations of any public body having jurisdiction; or
4. Contractor's repeated disregard of the authority of Owner or Engineer.

B. If one or more of the events identified in Paragraph 16.02.A occurs, then after giving Contractor (and any surety) 10 days' written notice that Owner is considering a declaration that Contractor is in default and termination of the Contract, Owner may proceed to:

1. declare Contractor to be in default, and give Contractor (and any surety) written notice that the Contract is terminated; and
2. enforce the rights available to Owner under any applicable performance bond.

C. Subject to the terms and operation of any applicable performance bond, if Owner has terminated the Contract for cause, Owner may exclude Contractor from the Site, take possession of the Work, incorporate in the Work all materials and equipment stored at the Site or for which Owner has paid Contractor but which are stored elsewhere, and complete the Work as Owner may deem expedient.

D. Owner may not proceed with termination of the Contract under Paragraph 16.02.B if Contractor within 7 days of receipt of notice of intent to terminate begins to correct its failure to perform and proceeds diligently to cure such failure.

E. If Owner proceeds as provided in Paragraph 16.02.B, Contractor shall not be entitled to receive any further payment until the Work is completed. If the unpaid balance of the Contract Price exceeds the cost to complete the Work, including all related claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals) sustained by Owner, such excess will be paid to Contractor. If the cost to complete the Work including such related claims, costs, losses, and damages exceeds such unpaid balance, Contractor shall pay the difference to Owner. Such claims, costs, losses, and damages incurred by Owner will be reviewed by Engineer as to their reasonableness and, when so approved by Engineer, incorporated in a Change Order. When exercising any rights or remedies under this paragraph, Owner shall not be required to obtain the lowest price for the Work performed.

F. Where Contractor's services have been so terminated by Owner, the termination will not affect any rights or remedies of Owner against Contractor then existing or which may thereafter accrue, or any rights or remedies of Owner against Contractor or any surety under any payment bond or performance bond. Any retention or payment of money due Contractor by Owner will not release Contractor from liability.

G. If and to the extent that Contractor has provided a performance bond under the provisions of Paragraph 6.01.A, the provisions of that bond will govern over any inconsistent provisions of Paragraphs 16.02.B and 16.02.D.

16.03 *Owner May Terminate for Convenience*

A. Upon 7 days' written notice to Contractor and Engineer, Owner may, without cause and without prejudice to any other right or remedy of Owner, terminate the Contract. In such case, Contractor shall be paid for (without duplication of any items):

1. completed and acceptable Work executed in accordance with the Contract Documents prior to the effective date of termination, including fair and reasonable sums for overhead and profit on such Work;

2. expenses sustained prior to the effective date of termination in performing services and furnishing labor, materials, or equipment as required by the Contract Documents in connection with uncompleted Work, plus fair and reasonable sums for overhead and profit on such expenses; and

3. other reasonable expenses directly attributable to termination, including costs incurred to prepare a termination for convenience cost proposal.

B. Contractor shall not be paid for any loss of anticipated profits or revenue, post-termination overhead costs, or other economic loss arising out of or resulting from such termination.

16.04 *Contractor May Stop Work or Terminate*

A. If, through no act or fault of Contractor, (1) the Work is suspended for more than 90 consecutive days by Owner or under an order of court or other public authority, or (2) Engineer fails to act on any Application for Payment within 30 days after it is submitted, or (3) Owner fails for 30 days to pay Contractor any sum finally determined to be due, then Contractor may, upon 7 days' written notice to Owner and Engineer, and provided Owner or Engineer do not remedy such suspension or failure within that time, terminate the contract and recover from Owner payment on the same terms as provided in Paragraph 16.03.

B. In lieu of terminating the Contract and without prejudice to any other right or remedy, if Engineer has failed to act on an Application for Payment within 30 days after it is submitted, or Owner has failed for 30 days to pay Contractor any sum finally determined to be due, Contractor may, 7 days after written notice to Owner and Engineer, stop the Work until payment is made of all such amounts due Contractor, including interest thereon. The provisions of this paragraph are not intended to preclude Contractor from submitting a Change Proposal for an adjustment in Contract Price or Contract Times or otherwise for expenses or damage directly attributable to Contractor's stopping the Work as permitted by this paragraph.

ARTICLE 17—FINAL RESOLUTION OF DISPUTES

17.01 *Methods and Procedures*

A. *Disputes Subject to Final Resolution*: The following disputed matters are subject to final resolution under the provisions of this article:

1. A timely appeal of an approval in part and denial in part of a Claim, or of a denial in full, pursuant to Article 12; and

2. Disputes between Owner and Contractor concerning the Work, or obligations under the Contract Documents, that arise after final payment has been made.

B. *Final Resolution of Disputes*: For any dispute subject to resolution under this article, Owner or Contractor may:

1. elect in writing to invoke the dispute resolution process provided for in the Supplementary Conditions;

2. agree with the other party to submit the dispute to another dispute resolution process; or

3. if no dispute resolution process is provided for in the Supplementary Conditions or mutually agreed to, give written notice to the other party of the intent to submit the dispute to a court of competent jurisdiction.

ARTICLE 18—MISCELLANEOUS

18.01 *Giving Notice*

A. Whenever any provision of the Contract requires the giving of written notice to Owner, Engineer, or Contractor, it will be deemed to have been validly given only if delivered:

1. in person, by a commercial courier service or otherwise, to the recipient's place of business;

2. by registered or certified mail, postage prepaid, to the recipient's place of business; or

3. by e-mail to the recipient, with the words "Formal Notice" or similar in the e-mail's subject line.

18.02 *Computation of Times*

A. When any period of time is referred to in the Contract by days, it will be computed to exclude the first and include the last day of such period. If the last day of any such period falls on a Saturday or Sunday or on a day made a legal holiday by the law of the applicable jurisdiction, such day will be omitted from the computation.

18.03 *Cumulative Remedies*

A. The duties and obligations imposed by these General Conditions and the rights and remedies available hereunder to the parties hereto are in addition to, and are not to be construed in any way as a limitation of, any rights and remedies available to any or all of them which are otherwise imposed or available by Laws or Regulations, by special warranty or guarantee, or by other provisions of the Contract. The provisions of this paragraph will be as effective as if repeated specifically in the Contract Documents in connection with each particular duty, obligation, right, and remedy to which they apply.

18.04 *Limitation of Damages*

A. With respect to any and all Change Proposals, Claims, disputes subject to final resolution, and other matters at issue, neither Owner nor Engineer, nor any of their officers, directors, members, partners, employees, agents, consultants, or subcontractors, shall be liable to Contractor for any claims, costs, losses, or damages sustained by Contractor on or in connection with any other project or anticipated project.

18.05 *No Waiver*

A. A party's non-enforcement of any provision will not constitute a waiver of that provision, nor will it affect the enforceability of that provision or of the remainder of this Contract.

18.06 *Survival of Obligations*

A. All representations, indemnifications, warranties, and guarantees made in, required by, or given in accordance with the Contract, as well as all continuing obligations indicated in the Contract, will survive final payment, completion, and acceptance of the Work or termination of the Contract or of the services of Contractor.

18.07 *Controlling Law*

A. This Contract is to be governed by the law of the state in which the Project is located.

18.08 *Assignment of Contract*

A. Unless expressly agreed to elsewhere in the Contract, no assignment by a party to this Contract of any rights under or interests in the Contract will be binding on the other party without the written consent of the party sought to be bound; and, specifically but without limitation, money that may become due and money that is due may not be assigned without such consent (except to the extent that the effect of this restriction may be limited by law), and unless specifically stated to the contrary in any written consent to an assignment, no assignment will release or discharge the assignor from any duty or responsibility under the Contract.

18.09 *Successors and Assigns*

A. Owner and Contractor each binds itself, its successors, assigns, and legal representatives to the other party hereto, its successors, assigns, and legal representatives in respect to all covenants, agreements, and obligations contained in the Contract Documents.

18.10 *Headings*

A. Article and paragraph headings are inserted for convenience only and do not constitute parts of these General Conditions.

Section 00800

Supplementary Conditions

These Supplementary Conditions amend or supplement EJCDC® C 700, Standard General Conditions of the Construction Contract (2018). The General Conditions remain in full force and effect except as amended.

SC-1.01 Defined Terms

Add the following language to the end of Paragraph 1.01.A.3:
The Application for Payment form to be used on this project is EJCDC No. C-620. The Agency must approve all Applications for Payment before payment is made.

Add the following language to the end of Paragraph 1.01.A.8:
The Change Order form to be used on this project is EJCDC No. C-941. The Agency must approve all Change Orders before they become effective.

Add the following language after the first sentence of Paragraph 1.01.A.38:
The term "Site" may include locations within public streets wherein the OWNER'S utility plant is to be constructed and/or replaced.

SC-2.01 Delivery of Bonds and Evidence of Insurance

Delete Paragraph 2.01.B in its entirety and insert the following in its place:

B. Evidence of Contractor's Insurance: Before any Work at the Site is started, Contractor shall deliver to the Owner, with copies for each additional insured identified in the Supplementary Conditions, certificates of insurance (and other evidence of insurance which any additional insured may reasonably request) which Contractor is required to purchase and maintain in accordance with Article 6.

SC-2.02 Copies of Documents

Delete Paragraph 2.02.A in its entirety and insert the following in its place:

A. Owner shall furnish to Contractor One printed or hard copy of the Drawings and Project Manual and one set in electronic format. Additional copies will be furnished upon request at the cost of reproduction.

SC-2.05 Initial Acceptance of Schedules

Delete Paragraph 2.05.A.3 in its entirety and substitute the following:
3. A preliminary Schedule of Values is required for each lump sum item of the Work for which partial payment may be requested. Each required Schedule of Values shall include quantities and prices of items which when added together equal the Lump Sum Price for that item and subdivides the Work into component parts in sufficient detail to serve as the basis for progress payments during performance of the Work. Such prices will include an appropriate amount of overhead and profit applicable to each item of Work.

SC-5.01 Availability of Lands

Delete Paragraphs 5.01.C in its entirety and insert the following:
C. The CONTRACTOR shall provide at his own expense and without liability to the OWNER any land and access thereto that the CONTRACTOR may desire for temporary construction facilities, or for storage of materials and equipment.

SC-5.04 Differing Subsurface or Physical Conditions

Delete Paragraphs 5.04.A in its entirety and insert the following:
A Notice: If Contractor believes that any subsurface or physical condition at or contiguous to the Site that is uncovered or revealed is of an unusual nature, and differs materially from conditions ordinarily encountered and generally recognized as inherent in work of the character provided for in the Contract Documents then Contractor shall, promptly after becoming aware thereof and before further disturbing the subsurface or physical conditions or performing any Work in connection therewith (except in an emergency as required by Paragraph 7.15.A), notify Owner and Engineer in writing about such condition. Contractor shall not further disturb such condition or

perform any Work in connection therewith (except as aforesaid) until receipt of written order to do so.

SC-5.05 Underground Facilities

Amend Paragraph 5.05B. to read as follows:
If an Underground Facility is uncovered or revealed at or contiguous to the Site which was not shown or indicated in the Contract Documents, Contractor shall, promptly after becoming aware thereof and before further disturbing conditions affected thereby or performing any Work in connection therewith (except in an emergency as required by Paragraph 7.15), identify the owner of such Underground Facility and give written notice to that owner and to Owner and Engineer. Contractor shall be responsible for the safety and protection of such underground facilities.

SC-5.06 Hazardous Environmental Condition

Delete Paragraphs 5.06.A and 5.06.B in their entirety and insert the following:
A. No reports or drawings related to Hazardous Environmental Conditions are known to Owner or Engineer.
B. Not Used.

SC-6.02 Insurance – General Provisions

Modify the first sentence of paragraph A by deleting the words: "Owner and".

Modify the first sentence of paragraph B by deleting the words: "Owner or".

SC- 6.02 Insurance – General Provisions

Delete paragraph 6.02.D in its entirety and substitute the following:

D. Contractor shall deliver to Owner, with copies to each additional insured identified in the Supplementary Conditions, certificates of insurance (and other evidence of insurance requested by Owner or any other additional insured) which Contractor is required by this contract to purchase and maintain.

Delete Paragraph 6.02.G in its entirety.

Delete paragraph 6.02 L. in its entirety and substitute the following:

L. By requiring such insurance and insurance limits herein, Owner does not represent that coverage and limits will necessarily be adequate to protect Contractor, and such coverage and limits shall not be deemed as a limitation on Contractor's liability under the indemnities granted to Owner in the Contract Documents.

SC- 6.03 Contractor's Insurance

Delete paragraph 6.03.B.4. in its entirety and substitute the following:
4. be appropriate for the Work being performed and as required by the Supplemental Conditions, and as will provide protection from claims set forth below which may arise out of or result from Contractor's performance of the Work and Contractor's other obligations under the Contract Documents, whether it is to be performed by Contractor, any Subcontractor or Supplier, or by anyone directly or indirectly employed by any of them to perform any of the Work, or by anyone for whose acts any of them may be liable.

Add the following new paragraph immediately after Paragraph 6.03.C:
D. The limits of liability for the insurance required by Paragraph 6.03 of the General Conditions shall provide coverage for not less than the following amounts or greater where required by Laws and Regulations:

1. Workers' Compensation, and related coverages under Paragraphs 6.03.A and 6.03.B of the General Conditions:
    a. State of Maine Statutory
    b. Applicable Federal: Statutory
    c. Employers Liability: $1,000,000
    d. Policy shall be endorsed to provide a Waiver of Subrogation in favor of Owner.

2. Contractor's General Liability under Paragraphs 6.03.A through 6.03.C of the General Conditions which shall include premises/operations, products/completed operations and personal and advertising injury liability coverages.:

    a. General Aggregate: $2,000,000
    b. Products – Completed Operations Aggregate: 2,000,000
    c. Personal and Advertising Injury: $1,000,000
    d. Each Occurrence (Bodily Injury and Property Damage): $1,000,000

e. Property Damage liability insurance will provide Explosion, Collapse, and Underground coverages where applicable.
f. Coverage shall be included for liability assumed by contract for bodily injury and property damage. There shall be no endorsement or modification of coverage limiting the scope of coverage for liability assumed under a contract
g. As required in paragraph 6.03.C. of the General Conditions, owner shall be named as an additional insured for ongoing and completed operations on a primary and noncontributory basis utilizing ISO forms CG 20 01, CG 20 10 & CG 20 37 or substitutes providing equivalent coverage. Additional insured endorsements shall be attached to each certificate of insurance submitted to Owner.
h. Completed operations coverage, including Owner as an additional insured, shall be maintained for a minimum of three (3) years after project completion.

3.Excess or Umbrella Liability
1) General Aggregate $2,000,000
2) Each Occurrence $2,000,000
3) Coverage shall be follow form and shall as respects to additional insureds and shall be on a primary noncontributory basis.

4. Automobile Liability:

a. Combined Single Limit of $1,000,000 for Bodily Injury and Property Damage

5. Contractors Pollution Liability

a. Contractor shall purchase and maintain in force for the duration of the contract, and for three (3) years after completion of the Project, insurance for pollution liability applicable to bodily injury; property damage, including loss of use of damaged property or of property that has not been physically injured or destroyed; cleanup costs; and defense, including costs and expenses incurred in the investigation, defense, or settlement of claims; all in connection with any loss arising from the performance of the Project.
b. Required Limits:
   1) Each Pollution Incident $2,000,000
   2) Aggregate Limit $2,000,000
c. Coverage shall apply to sudden and non-sudden pollution conditions resulting from the escape or release of smoke, vapors, fumes, acids, alkalis, toxic chemicals, liquids, or gases, waste materials, or other irritants, contaminants, or pollutants.
d. If coverage as required in this paragraph is written on a claims-made basis, the Contractor warrants that any retroactive date applicable to coverage under the policy precedes the effective date of this contract; and that continuous coverage will be maintained or an extended discovery period will be exercised for a period of three (3) years beginning from the time that work under this contract is completed.

SC-6.05 Waiver of Rights

Delete paragraphs 6.05.B and 6.05.C in their entirety.

SC-7.03 Labor; Working Hours

Insert the following Paragraph in their entirety directly after 7.03.C:
D. If the Contractor must Work beyond the regular Work week at anytime, all expenses, including labor costs, of the Engineer and personnel required for inspection or observation shall be deducted monthly from any sums due or which shall become due to the Contractor. A regular work week is defined as 40 hours commencing 7:00 AM and ending at 4:00 PM, Monday through Friday.

SC-7.04 Services Materials and Equipment

Insert the following Paragraphs in their entirety directly after 7.04.C
D. Materials and equipment shall be so stored as to insure the preservation of their quality and fitness for the Work. Stored materials and equipment to be incorporated in the Work shall be located so as to facilitate prompt inspection.

E. No Chattel Mortgages: Materials, supplies, or equipment to be incorporated into the Work shall not be purchased by the Contractor or the Subcontractor subject to a chattel mortgage or under a conditional sale Contract or other agreement by which an interest is retained by the seller.

SC-7.07 Concerning Subcontractors, Suppliers, and Others

Add new paragraphs immediately after Paragraph 7.07.M:

N. The Contractor shall not award Work to Subcontractor(s) in excess of fifty (50) percent of the Contract Price without prior written approval of the Owner.

O. In the event that the Work, Materials or Products of any Subcontractor or Supplier are called into question for any reason, said Subcontractor or Supplier will be required to participate in any dispute resolution process and proceeding between the Contractor and the Owner.

SC-7.010 Taxes

Add a new paragraph immediately after Paragraph 7.10.A:
B. Owner is exempt from payment of sales and compensating use taxes of the State of Maine and of cities and counties thereof on all materials to be incorporated into the Work.

1. Owner will furnish the required certificates of tax exemption to Contractor for use in the purchase of equipment, supplies and materials to be physically incorporated into the Work such that they become a part of the real estate.

2. Owner’s exemption does not apply to construction tools, machinery, equipment, or other property purchased by or leased by Contractor, or to supplies or materials consumed in, but not incorporated into, the Work.

SC-7.11 Laws and Regulations

Delete paragraph 7.11.C in it’s entirety

SC-7.13 Safety and Protection

Add a new paragraph immediately after Paragraph 7.13.J:
K. Confined Space and Lock-out/Tag-out programs: The Contractor is advised that the Owner has clearly established on-going Confined Space and Lock-out/Tag-out programs. Where the Contractor's Work requires confined space entry into existing facilities and/or lock-out/tag-out of existing equipment and electrical controls, the Contractor shall strictly abide by the Owner's programs if they are more stringent than the Contractor's own procedures.

SC-7.16 Shop Drawings and Samples

Delete paragraph 7.16.B.3 in its entirety and insert the following in its place:
3. Portions of the Work requiring a Shop Drawing or sample submission shall not begin until the Shop Drawing or submission has been approved by the Engineer. Where a Shop Drawing or Sample is required by the Contract Documents or the Schedule of Submittals, any related Work performed prior to Engineer’s review and approval of all pertinent submittals will be at the sole risk, expense and responsibility of Contractor.

Add the following paragraph after paragraph 7.16.B.3
4. Each submittal shall be cataloged and identified individually according to the specification section, paragraph, sub paragraph, etc. to which it pertains. Submittals from various specifications shall not be grouped into one submittal pertaining to a larger piece of the Work or the work of a single supplier. For example, submittals for pumps, pipe of various types and fittings that are specified in separate sections of the Contract Documents may not be cataloged and identified as a single submittal pertaining to a pump station or other facility, or as a submittal from a single supplier.

Add the following new paragraphs immediately after new Paragraph 7.16.F:

G. In the event that Contractor requests a substitution for a previously approved item, Contractor shall reimburse Owner for Engineer’s charges for such time unless the need for such substitution is beyond the control of Contractor.

SC-7.17 Contractor’s General Warranty and Guarantee

Delete paragraphs 7.17.C, C.1 and C.2 in their entirety and substitute the following:

C. Contractor’s warranty and guarantee hereunder excludes defects or damage caused by:
1. abuse, modification, or improper maintenance or operation by persons or entities for whom the Contractor is not responsible; or
2. normal wear and tear under normal usage that occurs after Substantial Completion.

SC-9 Owner's Responsibilities

Delete Paragraphs 9.04, 9.05, 9.06, 9.07, 9.08, 9.10 and 9.11 in their entirety and substitute the following:
9.04 Several of the Owner's responsibilities described in various Articles of the General Conditions have been modified by various Supplemental Conditions that will not be specifically enumerated here. Full review of the Supplemental Conditions is necessary to a full understanding of the Owner's Responsibilities under this contract.

SC-10.01 Owner's Representative

Delete Paragraph 10.01.A in its entirety and substitute the following:
A. Engineer will be Owner's representative during the construction period. The duties and responsibilities and the limitations of authority of Engineer as Owner's representative during construction are set forth in the Contract Documents.

SC-10.03 Project Representative

Delete Paragraph 10.03.A in its entirety and substitute the following:
A. Owner will furnish a Resident Project Representative to assist Engineer in providing more extensive observation of the Work. The authority and responsibilities of any such Resident Project Representative and assistants will be as provided in the following paragraph 10.03.B, and limitations on the responsibilities thereof will be as provided in General Condition Paragraph 10.07.

B. Duties, Responsibilities and Limitations of Authority of Resident Project Representative.

1. General
a. Resident Project Representative is Owner's agent, will act as directed by and under the supervision of ENGINEER, and will confer with ENGINEER regarding his actions. Resident Project Representative's dealings in matters pertaining to the on-site work shall in general be only with ENGINEER and Contractor(s), and dealings with subcontractor(s) shall only be through or with the full knowledge of Contractor(s).
b. Resident Project Representative services shall be provided as the progress of construction necessitates.

2. Duties and Responsibilities - Resident Project Representative will:
a. Schedules: Review the progress schedule, schedule of Shop Drawing submissions and schedule of values prepared by Contractor(s) and consult with ENGINEER concerning their acceptability.
b. Conference: Attend preconstruction conferences. Arrange a schedule of progress meetings and other job conferences, as required, in consultation with ENGINEER and notify those expected to attend in advance. Attend meetings and maintain and circulate copies of minutes thereof.
c. Liaison: Serve as ENGINEER's liaison with Contractor(s), working principally through Contractor(s)' superintendent.
d. Shop Drawings and Samples:
1) Receive samples which are furnished at the site by Contractor(s), and notify ENGINEER of their availability for examination.
2) Advise ENGINEER and Contractor(s) or its superintendent immediately of the commencement of any work requiring a Shop Drawing or sample submission, if the submission has not been approved by ENGINEER.
e. Review of Work, Rejection of Defective Work, Inspections and Tests:
1) Conduct on-site observations of the work in progress to assist ENGINEER in determining if the work is proceeding in accordance with the Contract Documents and that completed work will conform to the Contract Documents.
2) Report to ENGINEER whenever he/she believes that any work is unsatisfactory, faulty or defective or does not conform to the Contract Documents, or does not meet the requirements of any inspections, tests or approval required to be made or has been damaged prior to final payment; and advise ENGINEER when he believes work should be corrected or rejected or should be uncovered for observation, or requires special testing, inspection or approval.
3) Verify that tests, equipment and system(s) startup(s) and operating and maintenance inspections are conducted as required by the Contract Documents and in presence of the required personnel, and that Contractor(s) maintains adequate records thereof; observe, record and report to ENGINEER appropriate details relative to the test procedures and startup(s).
4) Accompany visiting inspectors representing public or other agencies having jurisdiction over the Project, record the outcome of these inspections and report to ENGINEER.
f. Interpretation of Contract Documents: Transmit to Contractor(s) ENGINEER's clarifications and interpretations of the Contract Documents.
g. Modifications: Consider and evaluate Contractor(s)' suggestions for modifications in Drawings or Specifications and report them with recommendations to ENGINEER.
h. Records:
1) Maintain at the job site orderly files for correspondence, reports of job conferences, Shop Drawings and samples submissions, reproductions of

original Contract Documents including all Addenda, change orders, field orders, additional Drawings issued subsequent to the execution of the contract(s), ENGINEER's clarifications and interpretations of the Contract Documents, progress reports, and other Project related documents.
2) Keep a diary or log book, recording hours on the job site, weather conditions, data relative to questions of extras or deductions, list of visiting officials and representatives of manufacturers, fabricators, suppliers and distributors, daily activities, decisions, observations in general and specific observations in more detail as in the case of observing test procedures. Send copies to ENGINEER.
3) Record names, addresses and telephone numbers of all Contractors, subcontractors and major suppliers of materials and equipment.
i. Reports:
1) Furnish ENGINEER periodic reports as required of progress of the work and Contractor(s)' compliance with the approved progress schedule and schedule of Shop Drawing submissions.
2) Consult with ENGINEER in advance of scheduled major tests, inspections or start of important phases of the work.
3) Report immediately to ENGINEER upon the occurrence of any accident.
j. Payment Requisitions: Review applications for payment with Contractor(s) for compliance with the established procedure for their submission and forward them with recommendations to ENGINEER, noting particularly their relation to the schedule of values, work completed and materials and equipment delivered at the site but not incorporated in the work.
k. Certificates, Maintenance and Operation Manuals: During the course of the work, verify that certificates, maintenance and operation manuals and other data required to be assembled and furnished by Contractor(s) are applicable to the items actually installed; and deliver this material to ENGINEER for its review and forwarding to OWNER prior to final acceptance of the work.
l. Completion:
1) Before ENGINEER issues a Certificate of Substantial Completion, submit to Contractor(s) a list of observed items requiring completion or correction.
2) Conduct final inspection in the company of ENGINEER, OWNER and Contractor(s) and prepare a final list of items to be completed or corrected.
3) Verify that all items on final list have been completed or corrected and make recommendations to ENGINEER concerning acceptance.
3. Limitations of Authority: Resident Project Representative:
a. Shall not authorize any deviation from the Contract Documents or approve any substitute materials or equipment.
b. Shall not exceed limitations on ENGINEER's authority as set forth in the Contract Documents.
c. Shall not undertake any of the responsibilities of Contractor(s), subcontractor(s) or Contractor(s)' superintendent, or expedite the work.
d. Shall not advise on or issue directions relative to any aspect of the means, methods, techniques, sequences or procedures of construction unless such is specifically called for in the Contract Documents.
e. Shall not advise on or issue directions as to safety precautions and programs in connection with the work.
f. Shall not participate in specialized field or laboratory tests.

Renumber Paragraph 10.03.B to 10.03.C.

SC-12.01 Claims

Add the following two sentences to the end of Paragraph GC-12.01.B:

The parties recognize that the Engineer is an employee of the Owner and as such may also prepare the Owner’s notice of Claim envisioned in this paragraph. This fact shall not otherwise affect the process, responsibilities of the Engineer or the remedies available to the parties as set forth elsewhere in GC-12.01

Delete Paragraph 12.01.C in its entirety and replace it as follows:

C. Review and Resolution: The party receiving a Claim shall review it thoroughly, giving full consideration to its merits. The two parties shall seek to resolve the Claim through the mutual exchange of information and direct negotiations. The time for resolving the claim provided in Paragraph F may be extended by mutual agreement. All actions taken on a Claim shall be stated in writing and submitted to the other party with a copy to the Engineer.

SC-13.03. Unit Price Work

Delete Paragraph 13.03.E.1.a. in its entirety and insert the following in its place:

a. the Bid price of a particular item of Unit Price Work amounts to 10 percent or more of the Contract Price and the variation in the quantity of that particular item of Unit Price Work performed by

Contractor differs by more than 25 percent from the estimated quantity of such item indicated in the Agreement; and

SC-14 Tests and Inspections; Corrections

Add the following sentence to the end of 14.02.F: "For the purpose of this paragraph, the words 'timely notice' shall be construed as to mean not less than 48 hours prior to the event of the work being covered."

Add the following paragraph after 14.05C:
D. Paragraphs A, B, and C, above shall apply only to the situation where work that has been covered by mutual agreement is subsequently determined to require uncovering for further observation.

SC-15.01 Progress Payments

Modify the beginning of the first sentence of 15.01.B.1 to read as follows: "At least 10 days before the date established in the Agreement...."

Delete Paragraph 15.01B.3 in its entirety and substitute the following:
2. Beginning with the second Application for Payment, each Application shall include a lien release or other waiver acceptable to the Owner signed by the appropriate officer of each Subcontractor or Supplier that has provided labor, equipment or material to the Project during the period applicable to the previous Application for Payment.

15.01.D.1 Modify the beginning of the first sentence of 15.01.D.1 to read as follows: "Twenty days after presentation of the Application for Payment...."

15.06.A.3. Delete paragraph 15.06.A.3 in its entirety.

SC-16.03 Owner May Terminate For Convenience

Add a new paragraph following 16.03.A.3:
4. In no event shall the Contractor be entitled to overhead and profit for Work not performed.

SC-16.04 Contractor May Stop Work or Terminate

Add the following paragraph after 16.04.B:
C. The parties recognize that the Engineer is an employee of the Owner and as such will be reviewing and recommending Applications for Payment by the Owner. Therefore, the Owner shall have no less than 60 days after the receipt of an Application for Payment by the Engineer to pay any amount finally determined to be due before the Contractor may invoke the actions contemplated in 16.04.

SC-17 Final Resolution of Disputes

17.01-a new section 17.02 is added to read as follows:

17.02-Alternate Dispute Resolution

A. If a claim is not finally resolved under the provisions of Section 12.01 of the of the General Conditions, the Owner or Contractor may:

1. Give to the other party written notice of intent to submit the claim to a court in Cumberland County, State of Maine, or
2. Agree with the other party to submit the claim to another dispute resolution process.

B. Notwithstanding any applicable statute of limitations, a party giving notice under paragraph SC 17.02 A.1 shall commence an action on the claim within one year of giving such notice. Failure to do so shall result in the Claim being time-barred and Engineer's action or denial shall become final and binding.

SC-18.01 Giving Notice

Delete 18.01.A.1 in its entirety and insert the following in its place:
1. intended for Owner: delivered in person to the individual named in the Agreement as Engineer; if intended for Contractor: given in person to the individual named in the Agreement as Agent for Service or Process.

Delete 18.01.A.2 in its entirety and insert the following in its place:
2. delivered at or sent by registered or certified mail, postage prepaid, to the "Address for Giving Notices" listed in the Agreement.

SC-18.11 Fill on Private Land

Insert 18.11 after 18.10 as follows:
18.11 Fill on Private Land
A. The Contractor shall not deposit any matter on private land for the purpose of fill without written permission of the land owner.

SC-18.12 Operation of Existing Facilities

Insert 18.12 after 18.11 as follows:
18.12 Operation of Existing Facilities
A. No valve, hydrant or other facility of the Portland Water District may be operated by the

CONTRACTOR or his agents. The OWNER will, upon reasonable request of the CONTRACTOR, furnish men and equipment for such activity at no additional cost to the CONTRACTOR.

SC-18.13 Noise Control

Insert 18.13 after 18.12 as follows:
18.13 Noise Control
A. The project area is residential in nature. The CONTRACTOR shall provide adequate exhaust silencers on all equipment and shall generally endeavor to minimize noise throughout the term of construction. This shall be in addition to any applicable ordinance or regulation pertaining to noise.

SC-18.14 Vehicle Idling Policy

Insert 18.14 after 18.13 as follows:
18.14 Vehicle Idling Policy
A. Purpose: Air pollution is a major public health concern in Portland Water District's Service Area. Air pollution can cause or aggravate lung illnesses as well as impose significant economic costs and negative impacts on our quality of life. Exhaust from both on- and off-road vehicles is a source of carbon monoxide, particulate matter, toxic air contaminants, and greenhouse gases. The Portland Water District can play an important role in improving air quality by limiting the amount of time the District vehicles are allowed to idle. As an environmental leader in the water and wastewater fields the District has the responsibility to be a leader by the adoption of effective policies to improve air quality. Under this policy, limitations and guidelines on engine idling are established by the District to reduce the idling of District and Contractor vehicles.

B. Definitions:
1. "Driver" means any person who drives, operates, or is in actual physical control of a vehicle.
2. "Emergency" means a sudden, urgent, usually unforeseen, occurrence.
3. "Equipment Operator" means any person who is in actual physical control of a piece of off-road equipment.
4. "Idling" means the engine is running while the vehicle is stationary or the piece of off-road equipment is not performing work.
5. "Traffic Control Device" means any sign, signal, marking or device placed or erected for the purpose of regulating, warning, or guiding traffic.
6. "Off-road Equipment" means all non-road equipment such as bulldozers, loaders, backhoes, compressors, etc.
7. "Vehicle" means any on-road, self-propelled vehicle that is required to be registered and have a license plate by the Department of Motor Vehicles.

C. Scope: This policy applies to all District and Contractor vehicles regardless of gross vehicle weight rating, all heavy-duty vehicles regardless of the fuel being used, all off-road diesel equipment regardless of horsepower rating, and all off-road equipment regardless of fuel being used, except as provided as specific exceptions stated in the policy.

D. Policy:
1. The driver of a vehicle shall turn off the engine upon stopping at a destination and shall not cause or allow an engine to idle at any location for:
a. More than ten consecutive minutes or
b. A period or periods totaling more than ten minutes in any one hour period.
2. An equipment operator of an off-road piece of equipment shall not cause or allow an engine to idle at any location for:
a. More than ten consecutive minutes or
b. A period or periods totaling more than ten minutes in any one hour period
3. This idling policy does not apply to a vehicle or a piece of equipment for the period or periods during which:
a. idling is necessary while stopped:
1) and the vehicle is being used for a traffic control device (Using strobe lights, light-bars, etc.) to protect employees while working in the street from traffic.
2) for traffic conditions over which the driver has no control, included but not limited to: stopped in a line of traffic, at a railroad crossing, etc.
3) at the direction of a law enforcement officer
b. idling is necessary to determine that the vehicle and / or the off-road equipment is in safe operating condition and equipped as required by all provisions of the law, and that all equipment is in good working order, either as part of the daily vehicle inspection, or as otherwise needed.
c. idling is necessary for the testing, servicing, repairing, and diagnostic purposes.
d. idling is necessary, for a period of 3 minutes or as recommended by the manufacturer, to cool down a turbo- charged vehicle before turning off the vehicle.
e. idling is necessary to accomplish work for which the vehicle / equipment was designed, other than transporting goods, for example: operating a lift, crane, pump, drill, hoist, or other auxiliary equipment other than a heater or air conditioner.
f. idling is necessary to operate defrosters, heaters, air conditioners, or other equipment to prevent a safety hazard such as melting ice on the windshield, but not

solely for the comfort of the driver or passengers for a period not to exceed twenty minutes.

g. idling is necessary solely to recharge a battery or other energy storage unit of a hybrid electric vehicle / equipment.

h. idling is permitted when vehicles are occupied by personnel and being actively used as a work station, i.e. TV truck, using computers, etc.

i. idling is permitted to provide a habitable environment during breaks during extreme weather conditions, hot or cold (above 80 degrees F or below 32 degrees F)

END OF SECTION

BID FORM FOR CONSTRUCTION CONTRACT

The terms used in this Bid with initial capital letters have the meanings stated in the Instructions to Bidders, the General Conditions, and the Supplementary Conditions.

ARTICLE 1—OWNER AND BIDDER

1.01 This Bid is submitted to: **Portland Water District, 225 Douglass St. Portland, ME 04102**

1.02 The undersigned Bidder proposes and agrees, if this Bid is accepted, to enter into an Agreement with Owner in the form included in the Bidding Documents to perform all Work as specified or indicated in the Bidding Documents for the prices and within the times indicated in this Bid and in accordance with the other terms and conditions of the Bidding Documents.

ARTICLE 2—ATTACHMENTS TO THIS BID

2.01 The following documents are submitted with and made a condition of this Bid:

A. Required Bid security;

B. List of Proposed Subcontractors;

C. List of Proposed Suppliers;

D. Evidence of authority to do business in the state of the Project; or a written covenant to obtain such authority within the time for acceptance of Bids;

E. Contractor's license number as evidence of Bidder's State Contractor's License or a covenant by Bidder to obtain said license within the time for acceptance of Bids;

F. Required Bidder Qualification Statement with supporting data; and

ARTICLE 3—BASIS OF BID—LUMP SUM BID AND UNIT PRICES

3.01 *Lump Sum Bids*

Total Bid Price (Total of all Lump Sum and Unit Price Bids)	$

A. Bonds required under Paragraph 6.01 of the General Conditions will be based on the Contract Price.

ARTICLE 4—TIME OF COMPLETION

4.01 Bidder agrees that the Work will be substantially complete and will be completed and ready for final payment in accordance with Paragraph 15.06 of the General Conditions on or before the dates or within the number of calendar days indicated in the Agreement.

4.02 Bidder accepts the provisions of the Agreement as to liquidated damages.

ARTICLE 5—BIDDER'S ACKNOWLEDGEMENTS: ACCEPTANCE PERIOD, INSTRUCTIONS, AND RECEIPT OF ADDENDA

5.01 *Bid Acceptance Period*

A. This Bid will remain subject to acceptance for 60 days after the Bid opening, or for such longer period of time that Bidder may agree to in writing upon request of Owner.

5.02 *Instructions to Bidders*

A. Bidder accepts all of the terms and conditions of the Instructions to Bidders, including without limitation those dealing with the disposition of Bid security.

5.03 *Receipt of Addenda*

A. Bidder hereby acknowledges receipt of the following Addenda: **[Add rows as needed. Bidder is to complete table.]**

Addendum Number	Addendum Date

ARTICLE 6—BIDDER'S REPRESENTATIONS AND CERTIFICATIONS

6.01 *Bidder's Representations*

A. In submitting this Bid, Bidder represents the following:

1. Bidder has examined and carefully studied the Bidding Documents, including Addenda.
2. Bidder has visited the Site, conducted a thorough visual examination of the Site and adjacent areas, and become familiar with the general, local, and Site conditions that may affect cost, progress, and performance of the Work.
3. Bidder is familiar with all Laws and Regulations that may affect cost, progress, and performance of the Work.
4. Bidder has carefully studied the reports of explorations and tests of subsurface conditions at or adjacent to the Site and the drawings of physical conditions relating to existing surface or subsurface structures at the Site that have been identified in the Supplementary Conditions, with respect to the Technical Data in such reports and drawings.
5. Bidder has carefully studied the reports and drawings relating to Hazardous Environmental Conditions, if any, at or adjacent to the Site that have been identified in the Supplementary Conditions, with respect to Technical Data in such reports and drawings.
6. Bidder has considered the information known to Bidder itself; information commonly known to contractors doing business in the locality of the Site; information and observations obtained from visits to the Site; the Bidding Documents; and the Technical Data identified in the Supplementary Conditions or by definition, with respect to the effect of such information, observations, and Technical Data on (a) the cost, progress, and performance of the Work; (b) the means, methods, techniques, sequences, and

procedures of construction to be employed by Bidder, if selected as Contractor; and (c) Bidder's (Contractor's) safety precautions and programs.

7. Based on the information and observations referred to in the preceding paragraph, Bidder agrees that no further examinations, investigations, explorations, tests, studies, or data are necessary for the performance of the Work at the Contract Price, within the Contract Times, and in accordance with the other terms and conditions of the Contract.

8. Bidder is aware of the general nature of work to be performed by Owner and others at the Site that relates to the Work as indicated in the Bidding Documents.

9. Bidder has given Engineer written notice of all conflicts, errors, ambiguities, or discrepancies that Bidder has discovered in the Bidding Documents, and of discrepancies between Site conditions and the Contract Documents, and the written resolution thereof by Engineer is acceptable to Contractor.

10. The Bidding Documents are generally sufficient to indicate and convey understanding of all terms and conditions for performance and furnishing of the Work.

11. The submission of this Bid constitutes an incontrovertible representation by Bidder that without exception the Bid and all prices in the Bid are premised upon performing and furnishing the Work required by the Bidding Documents.

6.02 *Bidder's Certifications*

A. The Bidder certifies the following:

1. This Bid is genuine and not made in the interest of or on behalf of any undisclosed individual or entity and is not submitted in conformity with any collusive agreement or rules of any group, association, organization, or corporation.

2. Bidder has not directly or indirectly induced or solicited any other Bidder to submit a false or sham Bid.

3. Bidder has not solicited or induced any individual or entity to refrain from bidding.

4. Bidder has not engaged in corrupt, fraudulent, collusive, or coercive practices in competing for the Contract. For the purposes of this Paragraph 8.02.A:

   a. Corrupt practice means the offering, giving, receiving, or soliciting of anything of value likely to influence the action of a public official in the bidding process.

   b. Fraudulent practice means an intentional misrepresentation of facts made (a) to influence the bidding process to the detriment of Owner, (b) to establish bid prices at artificial non-competitive levels, or (c) to deprive Owner of the benefits of free and open competition.

   c. Collusive practice means a scheme or arrangement between two or more Bidders, with or without the knowledge of Owner, a purpose of which is to establish bid prices at artificial, non-competitive levels.

   d. Coercive practice means harming or threatening to harm, directly or indirectly, persons or their property to influence their participation in the bidding process or affect the execution of the Contract.

BIDDER hereby submits this Bid as set forth above:

Bidder:

____
(typed or printed name of organization)

By: ____
(individual's signature)

Name: ____
(typed or printed)

Title: ____
(typed or printed)

Date: ____
(typed or printed)

If Bidder is a corporation, a partnership, or a joint venture, attach evidence of authority to sign.

Attest: ____
(individual's signature)

Name: ____
(typed or printed)

Title: ____
(typed or printed)

Date: ____
(typed or printed)

Address for giving notices:

____

____

Bidder's Contact:

Name: ____
(typed or printed)

Title: ____
(typed or printed)

Phone: ____

Email: ____

Address:

____

____

____

Bidder's Contractor License No.: (if applicable) ______________________________

BID BOND (PENAL SUM FORM)

Bidder	**Surety**
Name: **[Full formal name of Bidder]** Address *(principal place of business)*: **[Address of Bidder's principal place of business]**	Name: **[Full formal name of Surety]** Address *(principal place of business)*: **[Address of Surety's principal place of business]**
Owner Name: **[Full formal name of Owner]** Address *(principal place of business)*: **[Address of Owner's principal place of business]**	**Bid** Project *(name and location)*: **[Owner project/contract name, and location of the project]** Bid Due Date: **[Enter date bid is due]**

Bond

Penal Sum: **[Amount]**

Date of Bond: **[Date]**

Surety and Bidder, intending to be legally bound hereby, subject to the terms set forth in this Bid Bond, do each cause this Bid Bond to be duly executed by an authorized officer, agent, or representative.

Bidder	Surety
_________________________ *(Full formal name of Bidder)*	_________________________ *(Full formal name of Surety) (corporate seal)*
By: _________________________ *(Signature)*	By: _________________________ *(Signature) (Attach Power of Attorney)*
Name: _________________________ *(Printed or typed)*	Name: _________________________ *(Printed or typed)*
Title: _________________________	Title: _________________________
Attest: _________________________ *(Signature)*	Attest: _________________________ *(Signature)*
Name: _________________________ *(Printed or typed)*	Name: _________________________ *(Printed or typed)*
Title:	Title:

Notes: (1) Note: Addresses are to be used for giving any required notice. (2) Provide execution by any additional parties, such as joint venturers, if necessary.

1. Bidder and Surety, jointly and severally, bind themselves, their heirs, executors, administrators, successors, and assigns to pay to Owner upon default of Bidder the penal sum set forth on the face of this Bond. Payment of the penal sum is the extent of Bidder's and Surety's liability. Recovery of such penal sum under the terms of this Bond will be Owner's sole and exclusive remedy upon default of Bidder.

2. Default of Bidder occurs upon the failure of Bidder to deliver within the time required by the Bidding Documents (or any extension thereof agreed to in writing by Owner) the executed Agreement required by the Bidding Documents and any performance and payment bonds required by the Bidding Documents.

3. This obligation will be null and void if:

   3.1. Owner accepts Bidder's Bid and Bidder delivers within the time required by the Bidding Documents (or any extension thereof agreed to in writing by Owner) the executed Agreement required by the Bidding Documents and any performance and payment bonds required by the Bidding Documents, or

   3.2. All Bids are rejected by Owner, or

   3.3. Owner fails to issue a Notice of Award to Bidder within the time specified in the Bidding Documents (or any extension thereof agreed to in writing by Bidder and, if applicable, consented to by Surety when required by Paragraph 5 hereof).

4. Payment under this Bond will be due and payable upon default of Bidder and within 30 calendar days after receipt by Bidder and Surety of written notice of default from Owner, which notice will be given with reasonable promptness, identifying this Bond and the Project and including a statement of the amount due.

5. Surety waives notice of any and all defenses based on or arising out of any time extension to issue Notice of Award agreed to in writing by Owner and Bidder, provided that the total time for issuing Notice of Award including extensions does not in the aggregate exceed 120 days from the Bid due date without Surety's written consent.

6. No suit or action will be commenced under this Bond prior to 30 calendar days after the notice of default required in Paragraph 4 above is received by Bidder and Surety, and in no case later than one year after the Bid due date.

7. Any suit or action under this Bond will be commenced only in a court of competent jurisdiction located in the state in which the Project is located.

8. Notices required hereunder must be in writing and sent to Bidder and Surety at their respective addresses shown on the face of this Bond. Such notices may be sent by personal delivery, commercial courier, or by United States Postal Service registered or certified mail, return receipt requested, postage pre-paid, and will be deemed to be effective upon receipt by the party concerned.

9. Surety shall cause to be attached to this Bond a current and effective Power of Attorney evidencing the authority of the officer, agent, or representative who executed this Bond on behalf of Surety to execute, seal, and deliver such Bond and bind the Surety thereby.

10. This Bond is intended to conform to all applicable statutory requirements. Any applicable requirement of any applicable statute that has been omitted from this Bond will be deemed to be included herein as if set forth at length. If any provision of this Bond conflicts with any applicable statute, then the provision of said statute governs and the remainder of this Bond that is not in conflict therewith continues in full force and effect.

11. The term "Bid" as used herein includes a Bid, offer, or proposal as applicable.

Portland Water District
From Sebago Lake to Casco Bay

Scope of Work

From: Portland Water District

Date: 2.28.2025

Subject: Sebago Heights Pump Station Controls Upgrade

Project Background

The Sebago Heights Pump Station is a water booster station in Windham that is experiencing equipment failures and is in need of a controls system upgrade. The station has 3 domestic pumps for regular residential flows and 3 fire pumps for firefighting efforts. The VFD's for domestic pumps 2 & 3 and have failed, leaving no redundancy for regular residential flow.

PWD is seeking a contractor to design and implement a new controls system in accordance with the PWD SCADA Standards, including new Pump Control Panels, one for the domestic pumps and one for the emergency fire pumps, and a new SCADA Telemetry Panel.

Existing Conditions

The process piping and controls are a skid system provided by Lucas Technologies and installed in 2010. The station is currently run through a Maple Systems controller that communicates to PWD's SCADA system through a SLC 5/05. The existing controls are no longer supported and incompatible with PWD standard controls. The existing SCADA and VFD control panels are housed in an onsite building. There are currently two 60"H x 48"W x 12"D panels, one housing telemetry and domestic pump controls/VFD's, and the other housing the fire pump controls/VFD's.

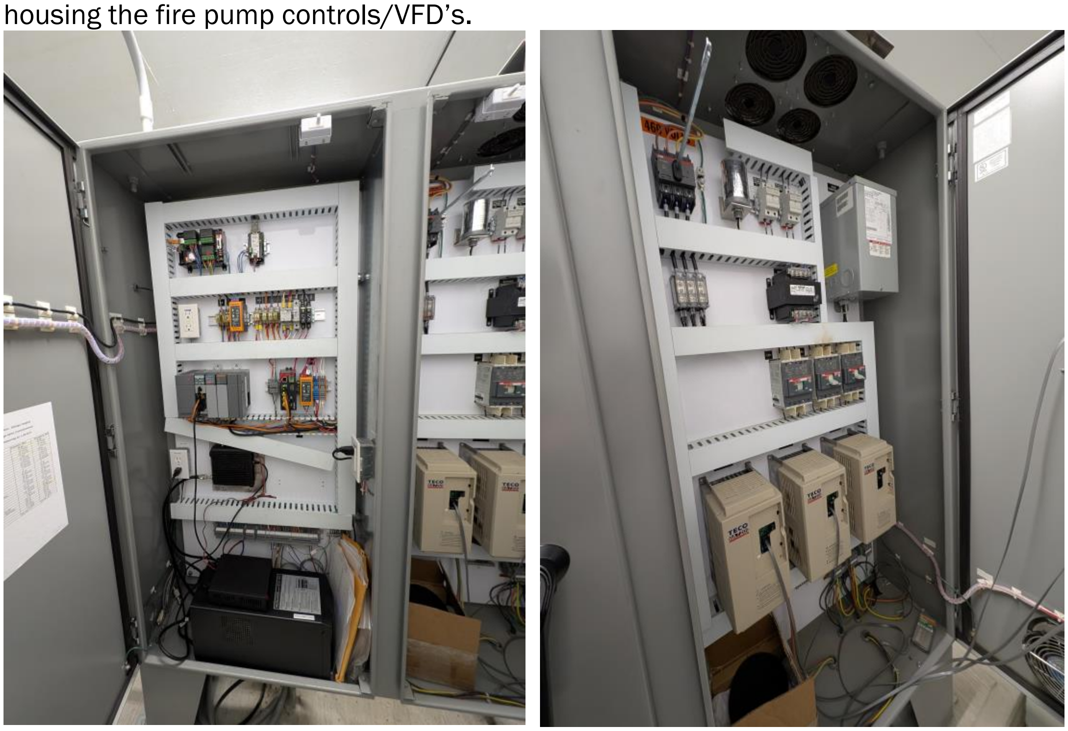


Figure 1. Telemetry and domestic pump control panel

Figure 2. Fire pump control panel

Scope of Work

The contractor shall be responsible for the following:

- Demolition of the existing control/VFD panels
- Design and implementation of a new telemetry panel to be field located with PWD approval
    - Telemetry panel to be equipped with a MicroLogix 1400 that provides station control i.e., reads and writes all inputs and outputs
        - See attached Control Narrative for station operation
    - Telemetry panel to be equipped with PanelView Plus 7 HMI that can be used to monitor and control station
    - Telemetry panel to be built in accordance with PWD's SCADA Standards
- Design and implementation a new domestic pump VFD panel in place of existing
    - Domestic pump VFD panel to house three new Toshiba VFD's sized appropriately for the existing 3 HP domestic pumps
    - Provide local-off-remote switches for each pump
    - Provide a speed potentiometer with a speed percentage readout for each pump
    - Provide a single E-Stop button for all three domestic pumps
    - See attached Control Narrative for additional details on panel design
- Design and provide a new fire pump VFD panel in place of existing
    - Fire pump VFD panel to house three new Toshiba VFD's sized appropriately for the existing 30 HP fire pumps

    - Provide local-off-remote switches for each pump
    - Provide a speed potentiometer with a speed percentage readout for each pump
    - Provide a single E-Stop button all three emergency fire pumps
    - See attached Control Narrative for additional details on panel design
- Develop code based on the existing control scheme
    - See attached Control Narrative for details on station control
- Integrate any control changes into existing OIT and HMI screens
- Integrate newly developed controls into PWD's existing SCADA system
- Perform testing of control panels including FAT, SAT, and SAD per PWD SCADA Standards
- Perform PID function tuning onsite to ensure pumps maintain system pressure setpoint as expected

PWD shall be responsible for the following:

- Temporary bypass of the station during integration of the new control panels

Additional Detail

Additional details about the existing conditions of the station can be found in Appendix A.

Appendix A

LUCAS TECHNOLOGIES

POB 350
Cassadaga, FL 32706

386-218-4984
386-218-4986 fax

www.lucasnow.com

April 17, 2010

REFERENCE: Sebago Heights Booster System

The following is a description of what Lucas Technologies is proposing to consolidate the variable speed / constant pressure pump control system with the standalone SCADA panel planned for the Sebago Heights Booster Station project. Consolidating these controls has the following advantages:

1. Fewer components (cost savings)
2. All of the booster system parameters can be fed to the SCADA PLC via a single Ethernet cable instead of multiple individual hardwired connections (cost savings / improved reliability)
3. Future upgrades (add additional monitoring parameters, upgrade to Ethernet radios, etc) are greatly simplified

Preliminary drawings are attached for the booster control cabinets. Drawing A-3688B shows the AB SLC503 PLC, Esteem 192C radio modem and UPS the customer has requested. If Lucas is provided with the standard PWD Telemetry PLC program (or at the least, the list of registers that the SCADA system interrogates), then integrating into the existing SCADA network should be seamless.

GL 5/05

PWD has used the SLC503 PLC extensively in other applications / locations. However, it should be noted that exactly the same functionality can be achieved with the newer Allen Bradley MicroLogix PLC's. Communication with the SCADA system would be identical, existing programming software is identical and cost is ~5 times less expensive. PWD should give some consideration to upgrading to the MicroLogix unit.

The following parameters will be immediately available to the SCADA system:

- Domestic Flow Rate
- Inlet Pressure
- Outlet Pressure
- Room Temperature
- Domestic Pumps 1-3 Speeds
- Fire Pumps 1-3 Speeds
- Domestic Pumps 1-3 Run, VFD Fault, MMP Trip
- Fire Pumps 1-3 Run, VFD Fault, MMP Trip
- Power Failure
- Domestic And Fire General Alarms
- Phase Fail Alarm
- ATS Position (Normal / Emergency)
- Generator Failed Alarm
- Generator Run Status
- Domestic Control Running
- Fire Control Running

- Fuel Tank Low Level
- Fuel Tank Leak Alarm
- Fire Alarm
- Control Panel Door Open Indicator
- Reset Push Button Indicator
- Domestic Remote On / Off Command
- Fire Remote On / Off Command
- SCADA PLC Health Alarm

This is the "standard" data defined by PWD and it is our understanding that the existing SCADA system is configured to handle this data without a significant amount of work. PLEASE NOTE – The Lucas Technologies booster controller has a much more detailed set of alarms which would also be available in digital form for the PWD SCADA system to use. These include:

- Specific booster system alarms (low suction pressure, high / low discharge pressure, individual pressure sensor faults, etc.)
- Specific VFD faults (overvoltage, undervoltage, phase loss, overload, overheat, etc)
- Flow Total
- Pump power consumption
- Lead / Lag position status for each pump
- Elapsed run times for each pump

Lucas Technologies was provided with a user manual showing screen shots of the current water booster system Panel View 1000 user interface. The Lucas Technologies standard booster system interface incorporates all of these same items (and many more, ex. historical trending graphs). However, since PWD personnel are used to the look and feel of the current screens, Lucas will add a button allowing the user to toggle between the standard Lucas screens and the "classic" PWD screens.

<u>Proposed pump control logic</u>:

Under normal operation, the 3 hp domestic pumps will act in lead / lag / alternate variable speed mode to maintain a constant, user set system pressure.

If domestic flow rate (as measured at the 3" flowmeter) exceeds a user defined limit OR system discharge pressure falls below a user defined limit:

- The fire pumps will be enabled and act in lead / lag / alternate variable speed mode to maintain a constant, user set system pressure. According to specification, this is a higher pressure than the domestic setpoint.

- Since the system pressure in fire mode is higher than the domestic pump setpoint, the domestic pumps will automatically shut down (believing demand is met).

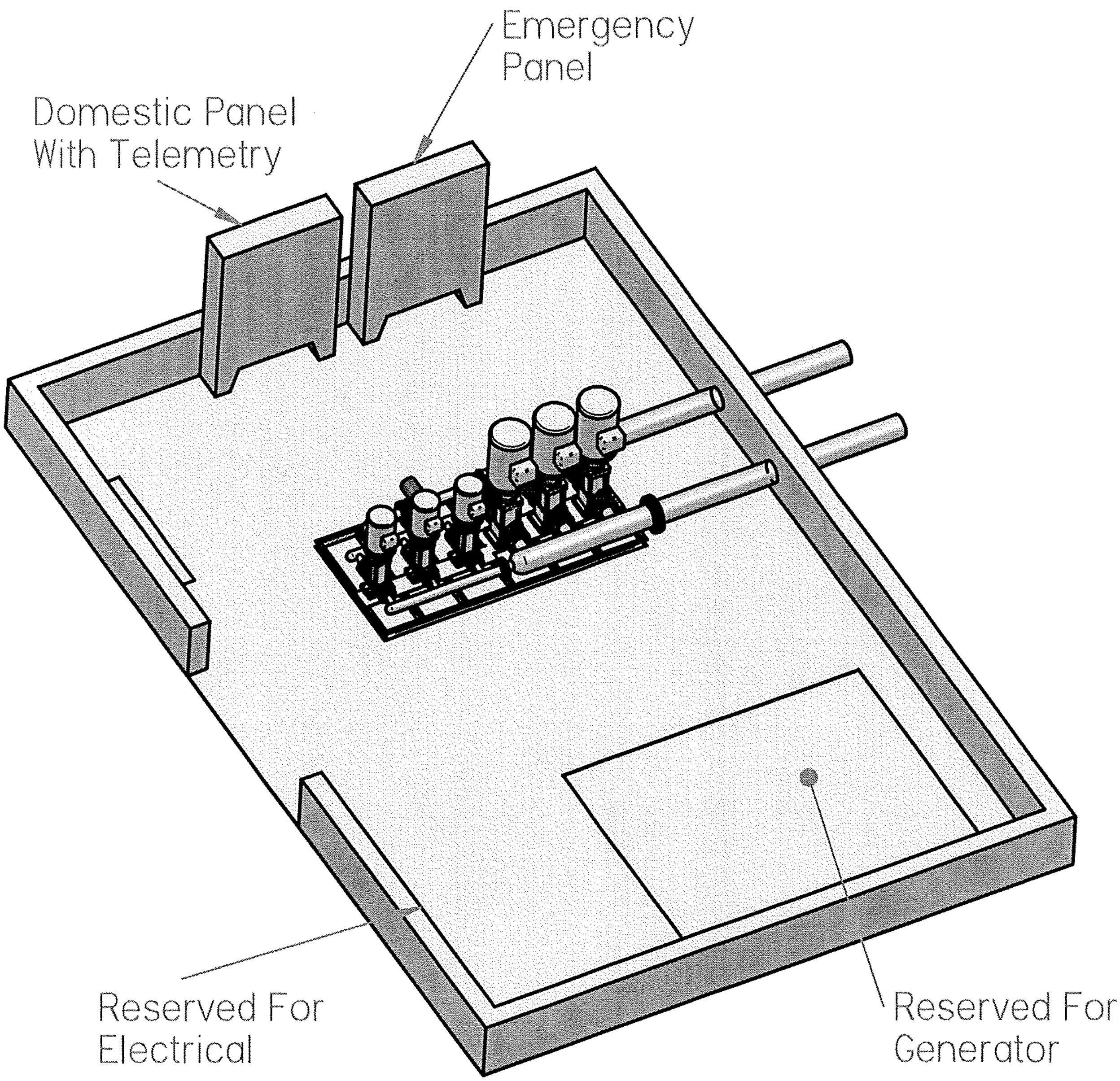
If fire pump speed (as read from the VFD's) falls below a user defined limit for a user defined length of time, it is assumed that flow rate has dropped to the point that the domestic pumps have sufficient flow to meet demand. Therefore, the emergency pumps will be put back into standby mode.

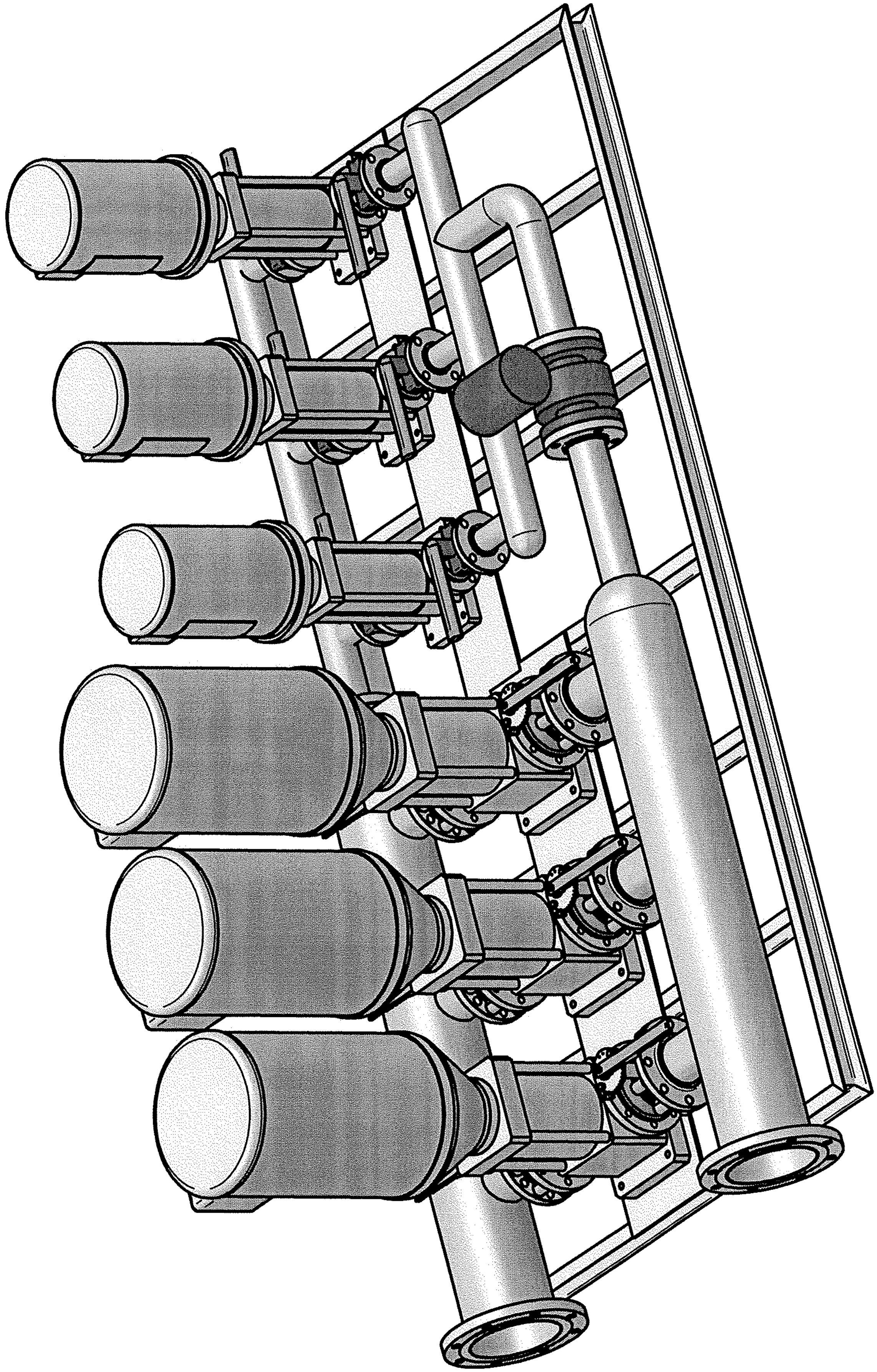
With the fire pumps off, the system pressure will fall. Once it falls below the domestic pump setpoint, they will again become active and maintain constant discharge pressure.

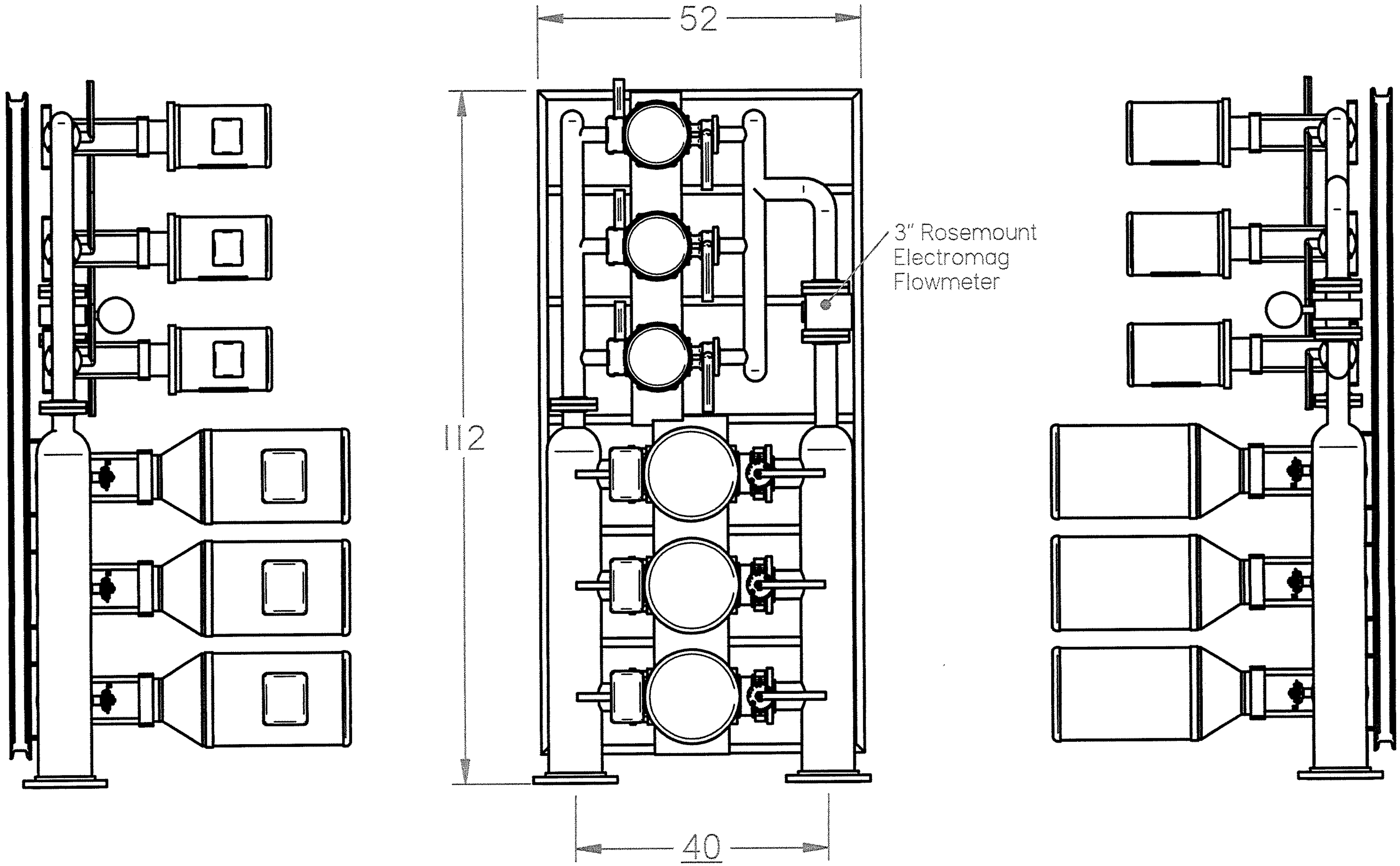
Please let me know if you have any additional questions or concerns.

Best regards,

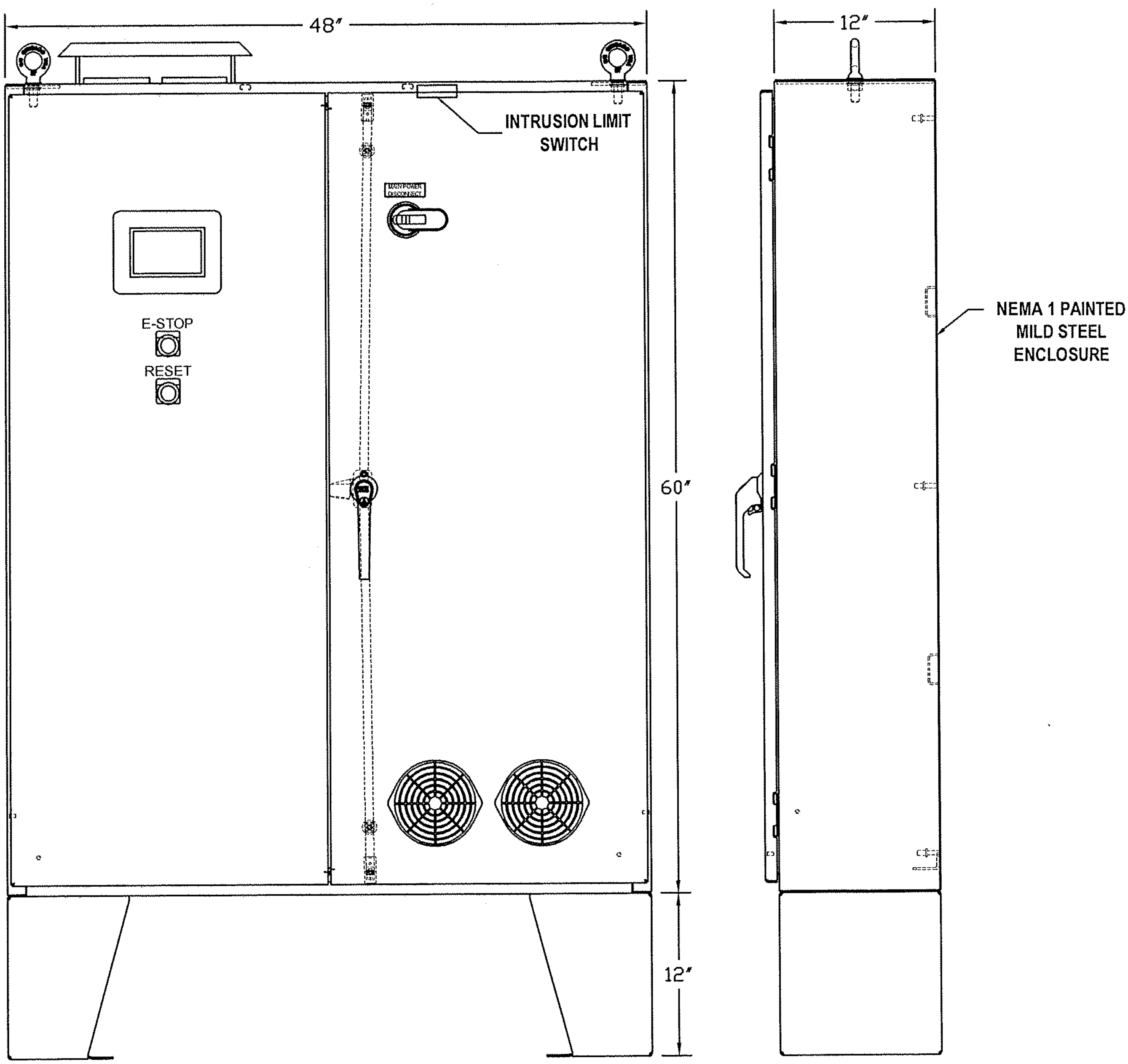
Doug Chappel


Emergency
Panel
Domestic Panel
With Telemetry
Reserved For
Electrical
Reserved For
Generator




52
112
40
3" Rosemount
Electromag
Flowmeter

DOMESTIC PUMP CONTROL+ TELEMETRY / SCADA

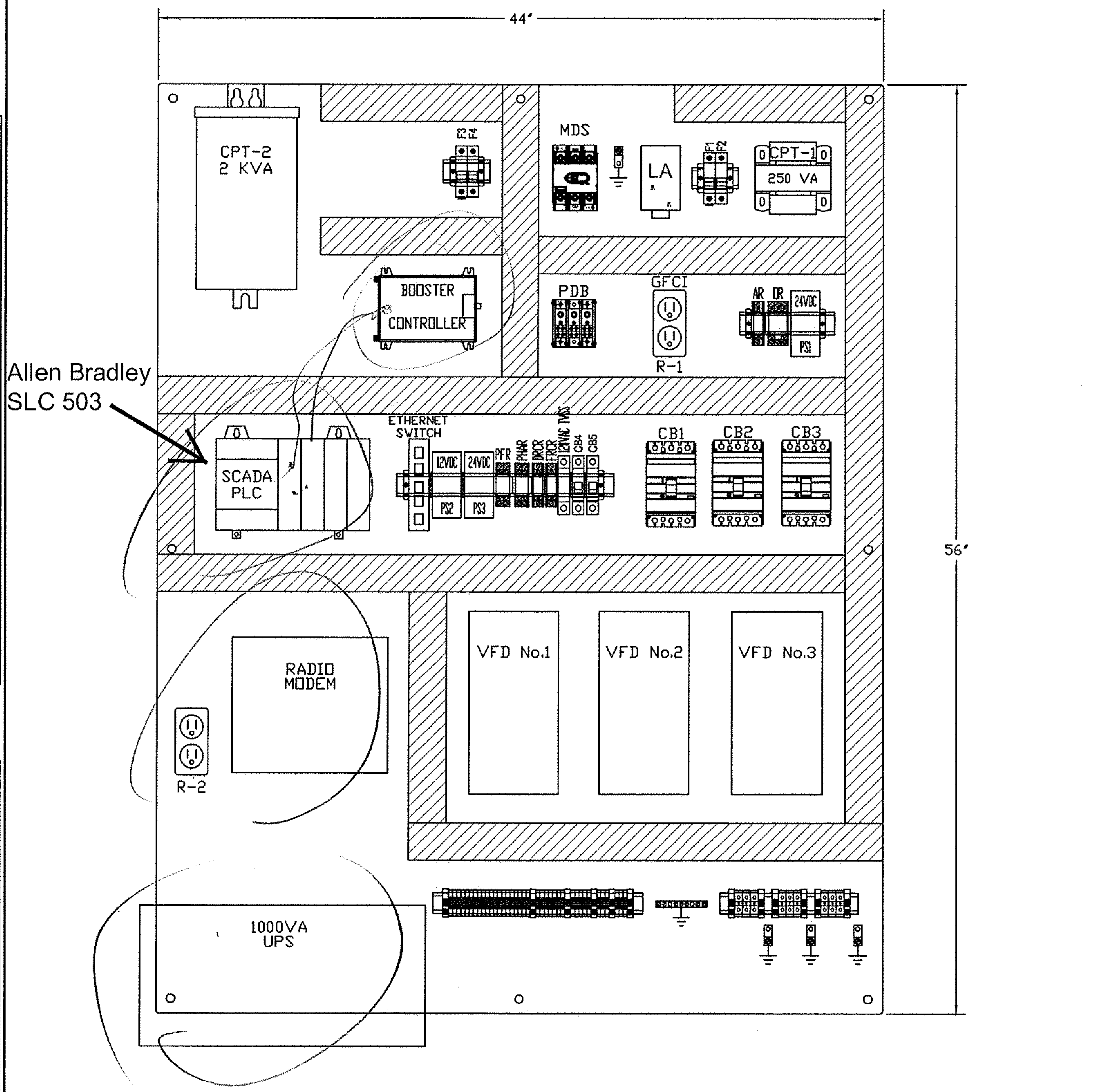


NOTE: ***COMPLETED PUMP CONTROL PANEL ASSEMBLY WILL BE UL LISTED AND LABELED UNDER STANDARD 508A.***

REV	DESCRIPTION	BY	DATE
A	ORIGINAL ISSUE	DL	4-09-10
B			
C			
D			

LUCAS TECHNOLOGIES
510 S. Lakeview Drive
Lake Helen, FL 32744
386-218-4984
www.lucasnow.com

DWG. TITLE	SEBAGO HEIGHTS BOOSTER PUMP CONTROL SYSTEM		
DATE 4-09-10	CSD L.MORRIS	DWG.NO. A-3688B	REV A
DRAWN BY D.LONG	APP'D. L.MORRIS	SHT. L1	CONT. ON SHT. L2



NOTE: ***COMPLETED PUMP CONTROL PANEL ASSEMBLY WILL BE UL LISTED AND LABELED UNDER STANDARD 508A.***

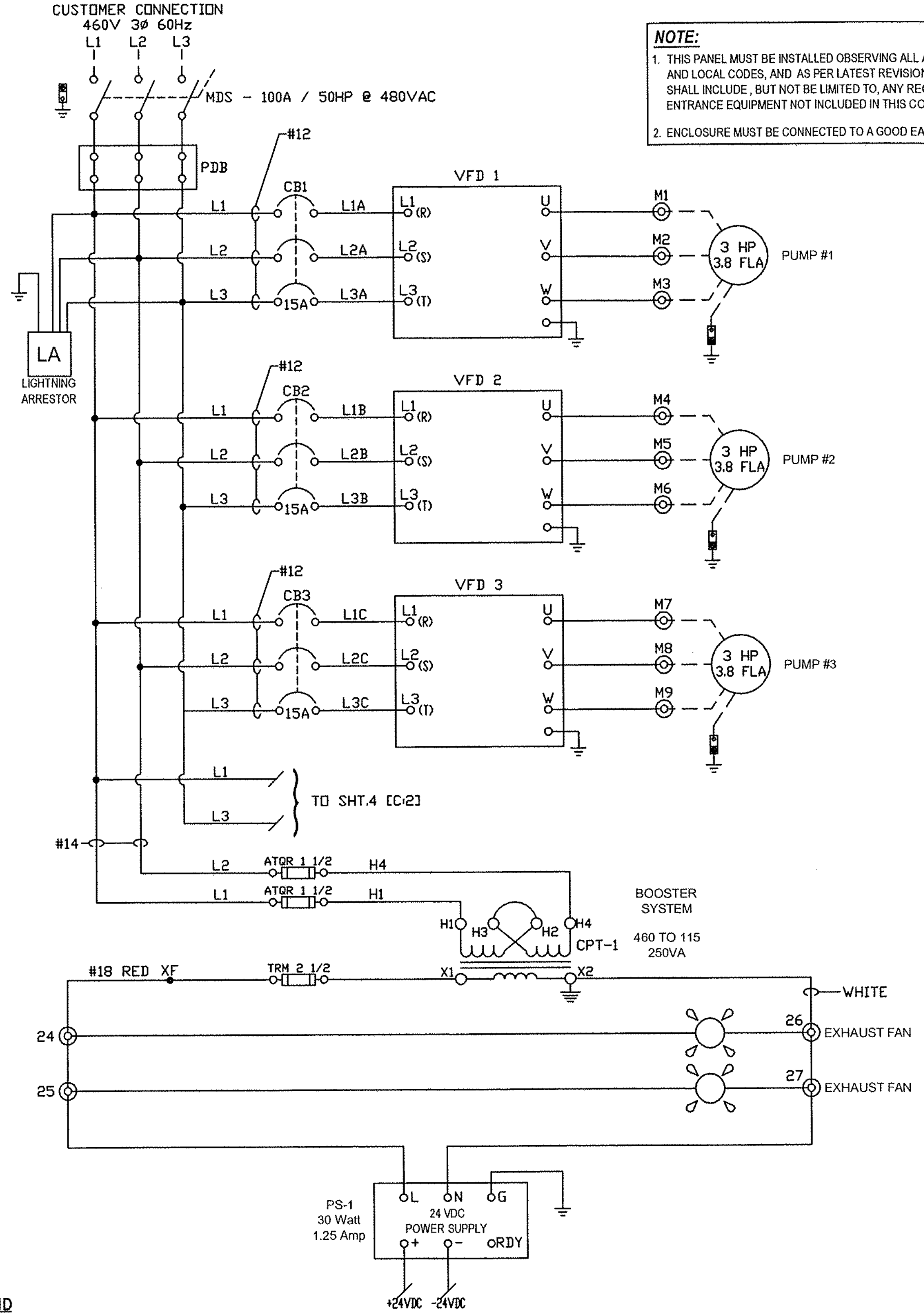
A	ORIGINAL ISSUE	DL	4-09-10
B			
C			
D			

LUCAS TECHNOLOGIES
510 S. Lakeview Drive
Lake Helen, FL 32744
386-218-4984
www.lucasnow.com

DWG. TITLE	SEBAGO HEIGHTS BOOSTER PUMP CONTROL SYSTEM		
DATE 4-09-10	CSD L.MORRIS	DWG.NO. A-3688B	REV A
DRAWN BY D.LONG	APP'D. L.MORRIS	SHT. L2	CONT. ON SHT. SH1

NOTE:

1. THIS PANEL MUST BE INSTALLED OBSERVING ALL APPLICABLE STATE AND LOCAL CODES, AND AS PER LATEST REVISION OF NEC. THIS SHALL INCLUDE, BUT NOT BE LIMITED TO, ANY REQUIL1 SERVICE ENTRANCE EQUIPMENT NOT INCLUDED IN THIS CONTROL PANEL.
2. ENCLOSURE MUST BE CONNECTED TO A GOOD EARTH GROUND.



LEGEND

◎ - INDICATES TERMINAL BLOCK

△ - INDICATES TERMINAL BLOCK IN VFD

– – – – INDICATES FIELD WIRING

⊣⊢ - ALL CONTACTS SHOWN IN THE DE-ENERGIZED STATE

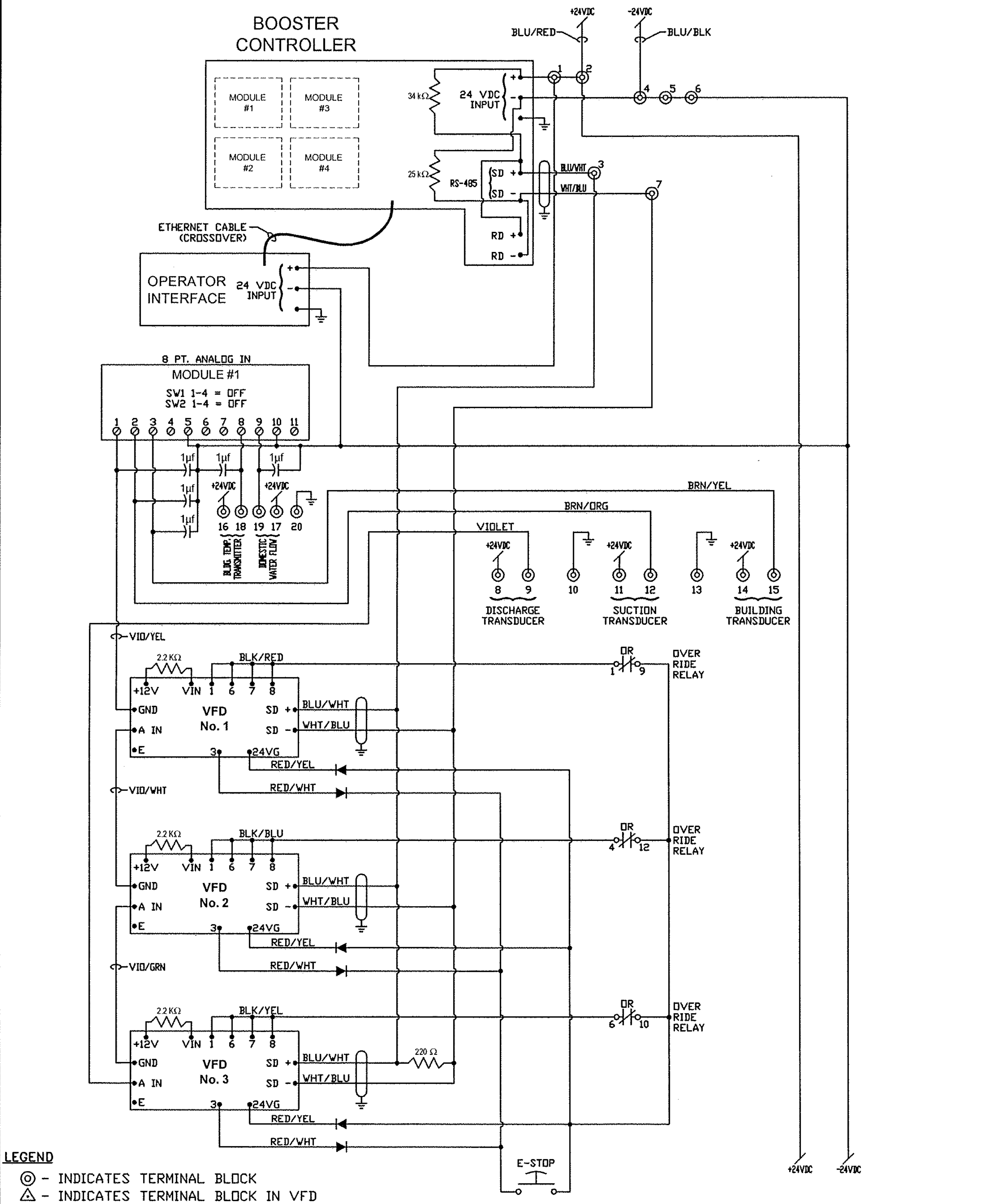
REV	DATE	BY	DESCRIPTION
A	4-09-10	DL	ORIGINAL ISSUE
B			
C			
D			

LUCAS TECHNOLOGIES
510 S. Lakeview Drive
Lake Helen, FL 32744
386-218-4984
www.lucasnow.com

DWG. TITLE: SEBAGO HEIGHTS BOOSTER PUMP CONTROL SYSTEM

DATE	CSD	DWG.NO.	REV
4-09-10	L.MORRIS	A-3688B	A

DRAWN BY	APP'D.	
D.LONG	L.MORRIS	SHT. 1 CONT. ON SHT. 2

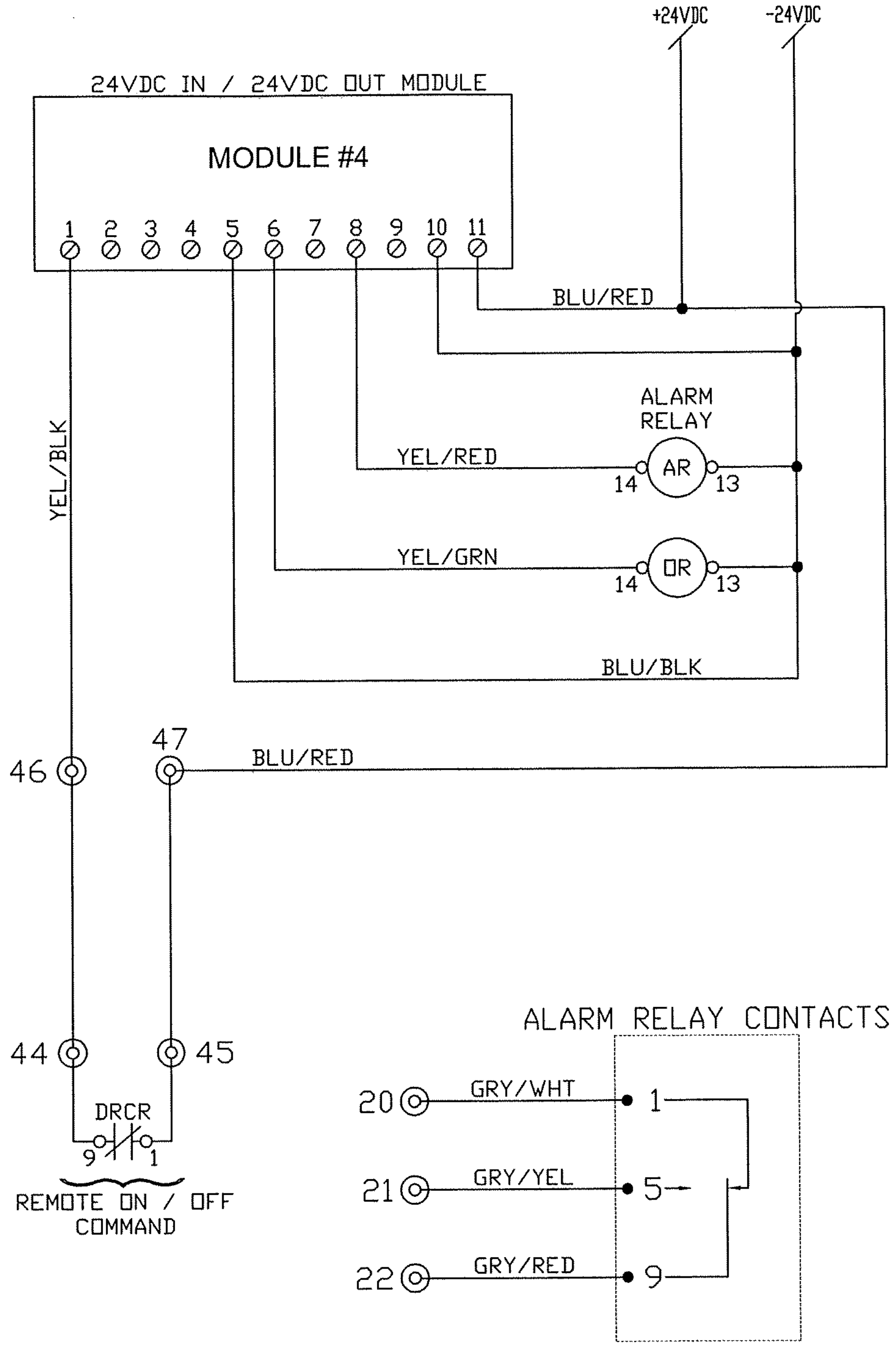


LEGEND
◎ - INDICATES TERMINAL BLOCK
△ - INDICATES TERMINAL BLOCK IN VFD
------ INDICATES FIELD WIRING
-| |- - ALL CONTACTS SHOWN IN THE DE-ENERGIZED STATE

D			
C			
B	ADD GND T/B & CAPS TO INPUTS	DL	4-16-10
A	ORIGINAL ISSUE	DL	4-09-10

LUCAS TECHNOLOGIES
510 S. Lakeview Drive
Lake Helen, FL 32744
386-218-4984
www.lucasnow.com

DWG. TITLE: SEBAGO HEIGHTS BOOSTER PUMP CONTROL SYSTEM			
DATE 4-09-10	CSD L.MORRIS	DWG.NO. A-3688B	REV B
DRAWN BY D.LONG	APP'D. L.MORRIS	SHT. 2	CONT. ON SHT. 3



LEGEND

◎ - INDICATES TERMINAL BLOCK
△ - INDICATES TERMINAL BLOCK IN VFD
— — — - - INDICATES FIELD WIRING
⊣⊢ - ALL CONTACTS SHOWN IN THE DE-ENERGIZED STATE

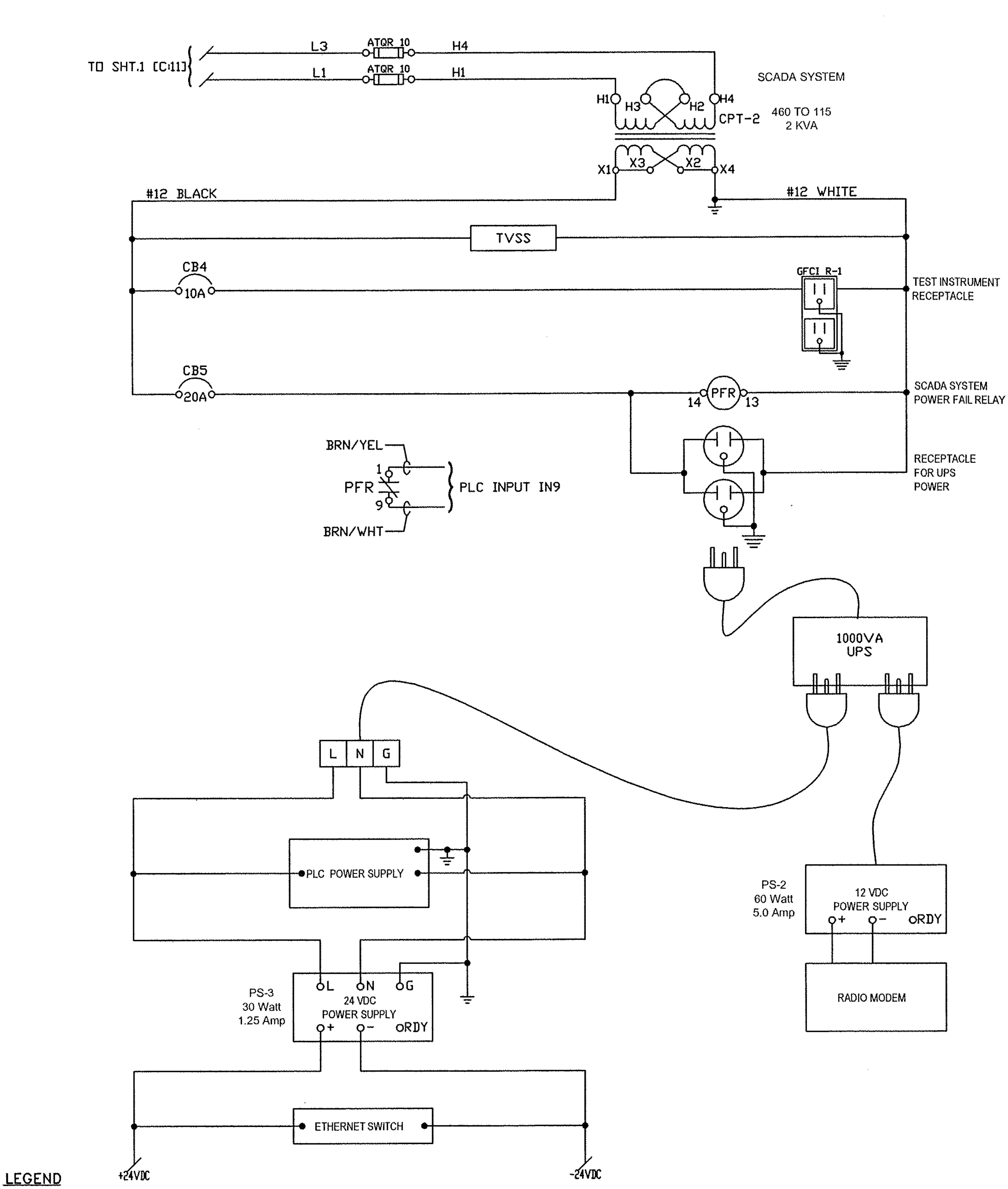
A	ORIGINAL ISSUE	DL	4-09-10
B			
C			
D			

LUCAS TECHNOLOGIES

510 S. Lakeview Drive
Lake Helen, FL 32744
386-218-4984
www.lucasnow.com

DWG. TITLE	SEBAGO HEIGHTS BOOSTER PUMP CONTROL SYSTEM		
DATE 4-09-10	CSD L.MORRIS	DWG.NO. A-3688B	REV A
DRAWN BY D.LONG	APP'D. L.MORRIS	SHT. 3	CONT. ON SHT. 4

A | B | C | D | E | F | G | H | I | J



LEGEND

◎ - INDICATES TERMINAL BLOCK

△ - INDICATES TERMINAL BLOCK IN VFD

– – – – INDICATES FIELD WIRING

o┤├o - ALL CONTACTS SHOWN IN THE DE-ENERGIZED STATE

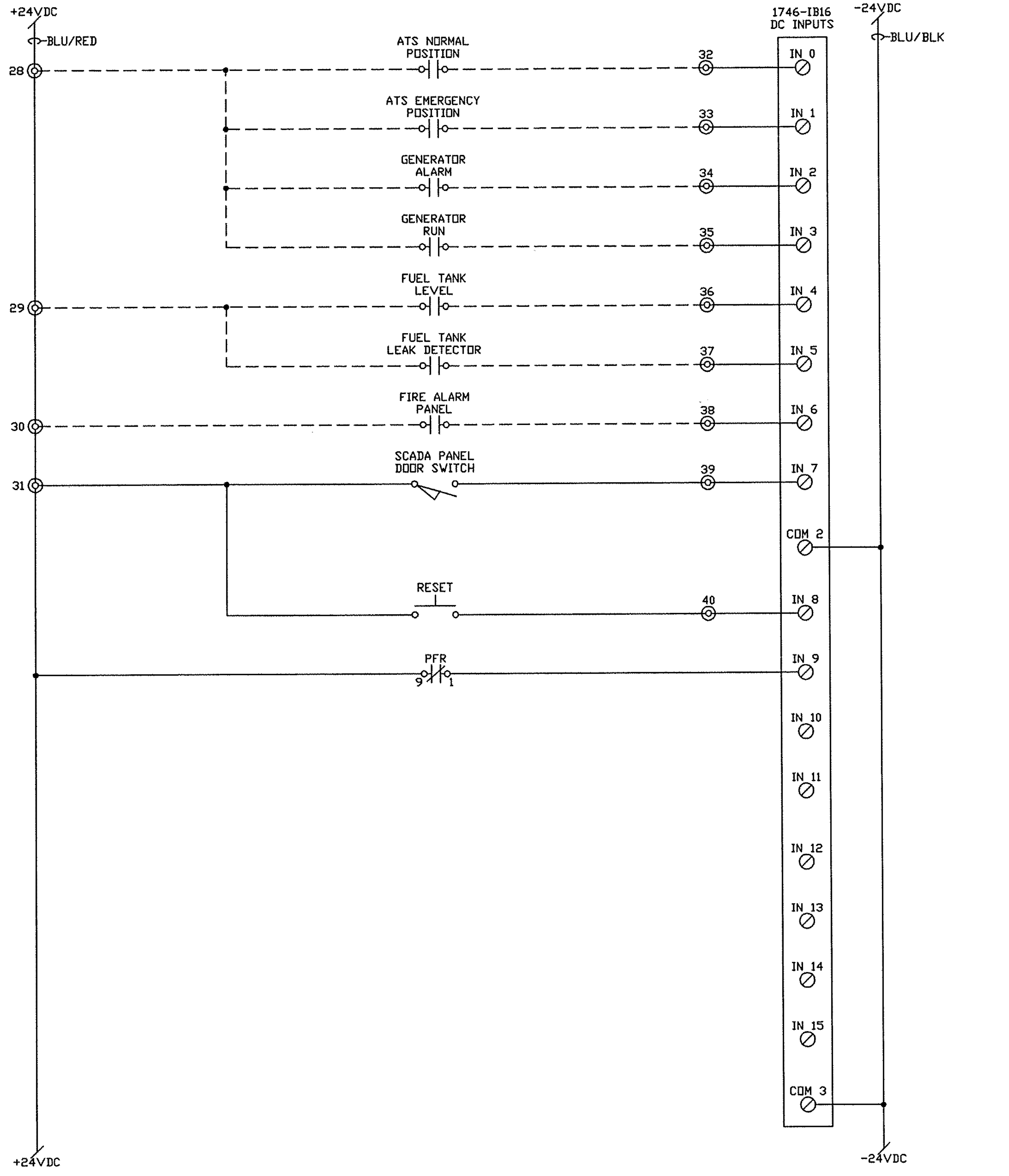
A	ORIGINAL ISSUE	DL 4-09-10
B		
C		
D		

LUCAS TECHNOLOGIES

510 S. Lakeview Drive
Lake Helen, FL 32744
386-218-4984
www.lucasnow.com

DWG. TITLE: SEBAGO HEIGHTS BOOSTER PUMP CONTROL SYSTEM

DATE	CSD	DWG.NO.	REV
4-09-10	L.MORRIS	A-3688B	A
DRAWN BY: D.LONG	APP'D: L.MORRIS	SHT. 4	CONT. ON SHT. 5

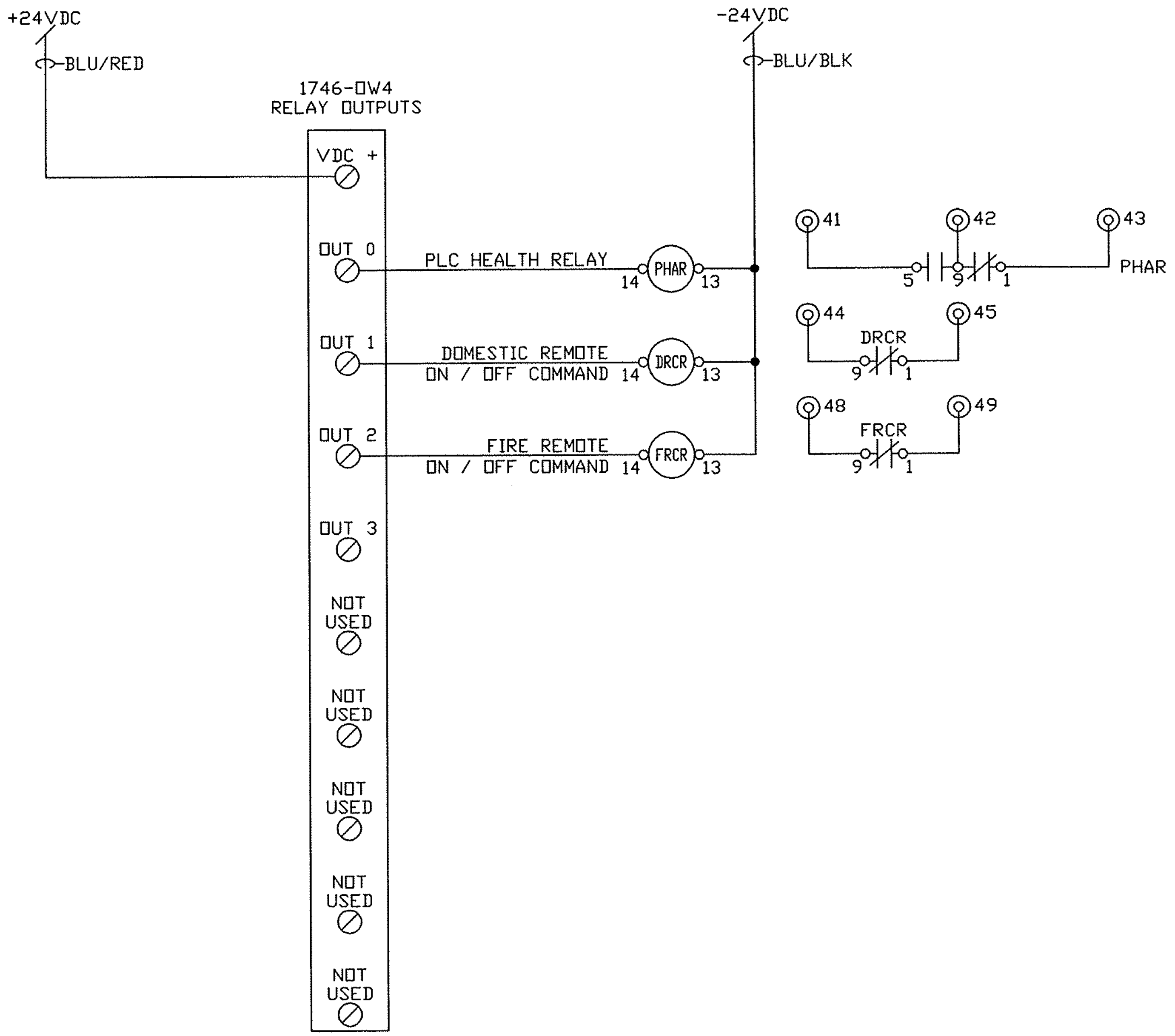


LEGEND
◎ - INDICATES TERMINAL BLOCK
– – – – INDICATES FIELD WIRING
o┤├o - ALL CONTACTS SHOWN IN THE DE-ENERGIZED STATE

D			
C			
B			
A	ORIGINAL ISSUE	DL	4-09-10

LUCAS TECHNOLOGIES
510 S. Lakeview Drive
Lake Helen, FL 32744
386-218-4984
www.lucasnow.com

DWG. TITLE	SEBAGO HEIGHTS BOOSTER PUMP CONTROL SYSTEM		
DATE 4-09-10	CSD L.MORRIS	DWG.NO. A-3688B	REV A
DRAWN BY D.LONG	APP'D. L.MORRIS	SHT. 5	CONT. ON SHT. 6

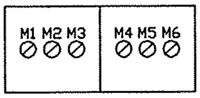


LEGEND
◎ - INDICATES TERMINAL BLOCK
— — — - INDICATES FIELD WIRING
○|├○ - ALL CONTACTS SHOWN IN THE DE-ENERGIZED STATE

B	A	ORIGINAL ISSUE
	DL	4-09-10
D	C	

LUCAS TECHNOLOGIES
510 S. Lakeview Drive
Lake Helen, FL 32744
386-218-4984
www.lucasnow.com

DWG. TITLE	SEBAGO HEIGHTS BOOSTER PUMP CONTROL SYSTEM		
DATE 4-09-10	CSD L.MORRIS	DWG.NO. A-3688B	REV A
DRAWN BY D.LONG	APP'D. L.MORRIS	SHT. 6	CONT. ON SHT. 7

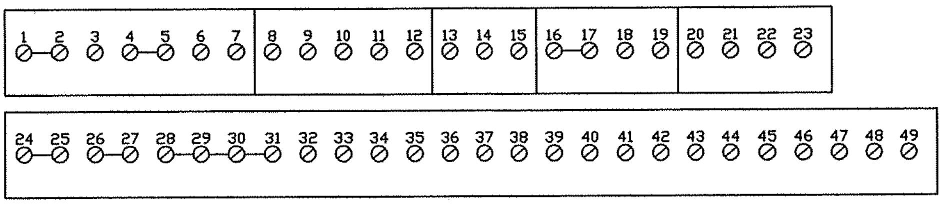


POWER TERMINAL CONNECTIONS

MAIN DISCONNECT SWITCH (MDS) - INCOMING POWER L1 / L2 / L3

PUMP No. 1 MOTOR - M1
PUMP No. 1 MOTOR - M2
PUMP No. 1 MOTOR - M3

PUMP No. 2 MOTOR - M4
PUMP No. 2 MOTOR - M5
PUMP No. 2 MOTOR - M6



CONTROL TERMINAL CONNECTIONS

1 AND 2 - (+) 24 VDC POWER ***FOR INTERNAL CONNECTIONS ONLY***

4, 5 AND 6 - (-) 24 VDC POWER ***FOR INTERNAL CONNECTIONS ONLY***

3 AND 7 - RS 485 CONNECTION ***FOR INTERNAL CONNECTIONS ONLY***

8, 9 AND 10 - DISCHARGE TRANSDUCER CONNECTION

10, 11 AND 12 - SUCTION TRANSDUCER CONNECTION

13, 14 AND 15 - BUILDING TRANSDUCER CONNECTION

16, 18 AND 20 - BUILDING TEMPERATURE TRANSMITTER CONNECTION

17, 19 AND 20 - DOMESTIC WATER FLOW CONNECTION

21 AND 23 - N.C. ALARM RELAY CONNECTION

22 AND 23 - N.O. ALARM RELAY CONNECTION

24 AND 25 - INTERNAL USE ONLY - LINE SIDE CONNECTION FOR FANS

26 AND 27 - INTERNAL USE ONLY - NEUTRAL SIDE CONNECTION FOR FANS

28 AND 32 - ATS NORMAL POSITION PLC INPUT

28 AND 33 - ATS EMERGENCY POSITION PLC INPUT

28 AND 34 - GENERATOR ALARM PLC INPUT

28 AND 35 - GENERATOR RUN PLC INPUT

29 AND 36 - FUEL TANK LEVEL PLC INPUT

29 AND 37 - FUEL TANK LEAK DETECTOR PLC INPUT

30 AND 38 - FIRE ALARM PANEL PLC INPUT

31 AND 39 - SCADA PANEL INTRUSION DOOR SWITCH PLC INPUT

31 AND 40 - SCADA PANEL INTRUSION RESET PLC INPUT

41 AND 42 - PLC HEALTH RELAY N.O. DRY CONTACT

42 AND 43 - PLC HEALTH RELAY N.C. DRY CONTACT

44 AND 45 - DOMESTIC REMOTE ON / OFF COMMAND N.C. CONTACT

46 AND 47 - DOMESTIC REMOTE ON / OFF COMMAND PLC INPUT

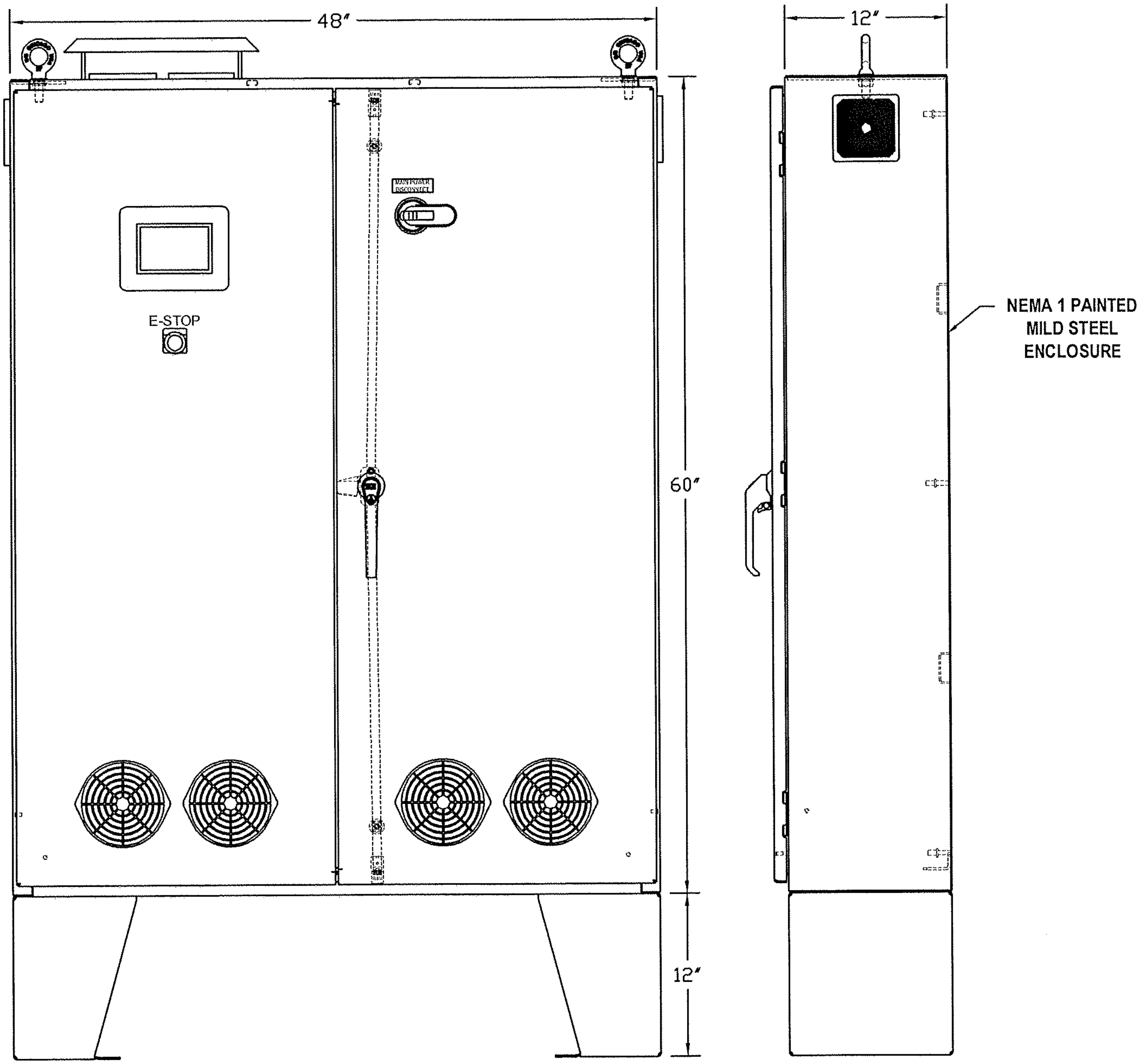
48 AND 49 - FIRE REMOTE ON / OFF COMMAND N.C. CONTACT

A	ORIGINAL ISSUE	DL	4-09-10
B			
C			
D			

LUCAS TECHNOLOGIES
510 S. Lakeview Drive
Lake Helen, FL 32744
386-218-4984
www.lucasnow.com

DWG. TITLE	SEBAGO HEIGHTS BOOSTER PUMP CONTROL SYSTEM		
DATE 4-09-10	CSD L.MORRIS	DWG.NO. A-3688B	REV A
DRAWN BY D.LONG	APP'D. L.MORRIS	SHT. 7	CONT. ON SHT. FL

FIRE PUMP CONTROL

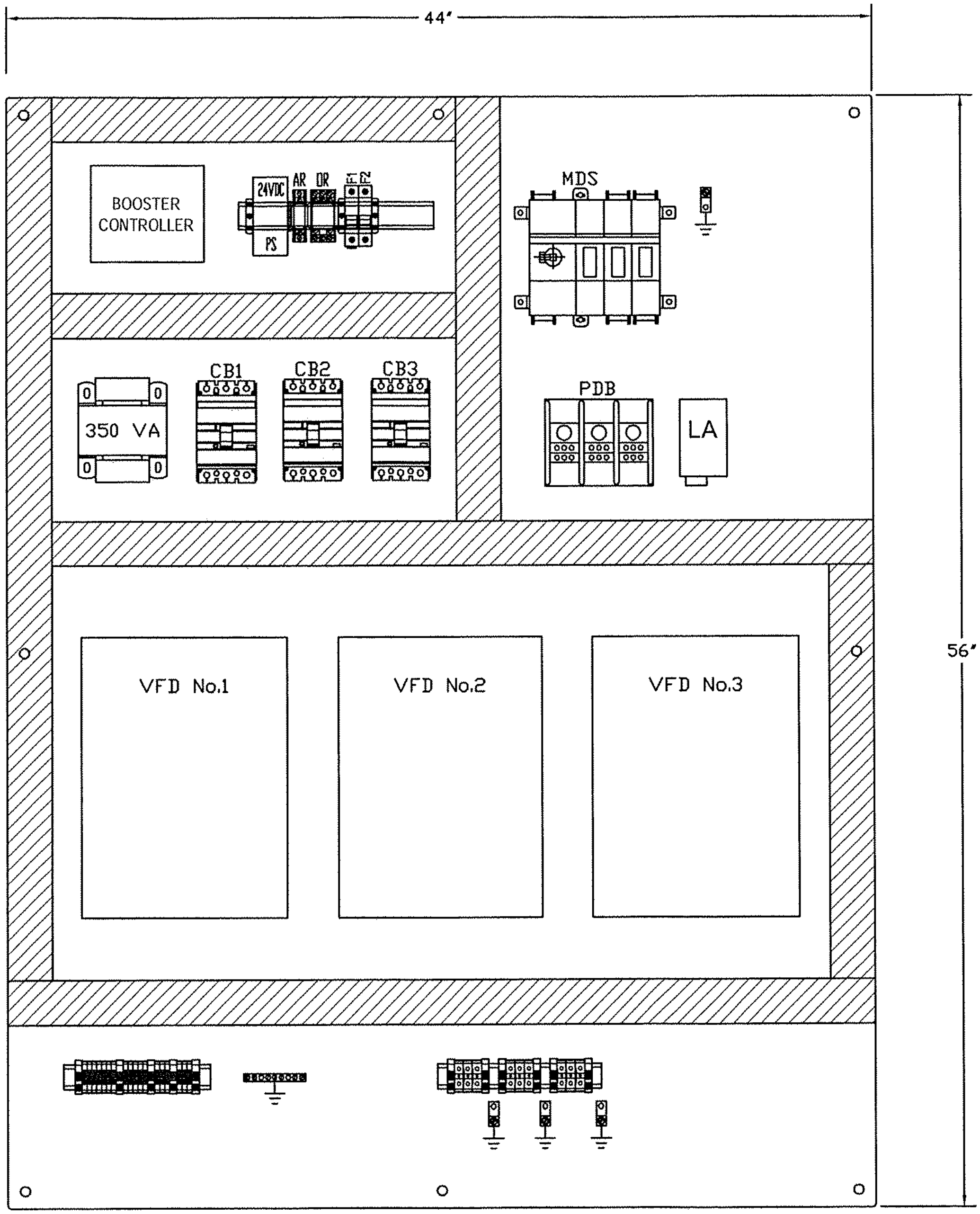


NOTE: ***COMPLETED PUMP CONTROL PANEL ASSEMBLY WILL BE UL LISTED AND LABELED UNDER STANDARD 508A.***

A	ORIGINAL ISSUE	DL	4-09-10
B			
C			
D			

LUCAS TECHNOLOGIES
510 S. Lakeview Drive
Lake Helen, FL 32744
386-218-4984
www.lucasnow.com

DWG. TITLE: SEBAGO HEIGHTS BOOSTER PUMP CONTROL SYSTEM			
DATE: 4-09-10	CSD: L.MORRIS	DWG.NO.: A-3688A	REV: A
DRAWN BY: D.LONG	APP'D.: L.MORRIS	SHT. L1	CONT. ON SHT. L2



NOTE: ***COMPLETED PUMP CONTROL PANEL ASSEMBLY WILL BE UL LISTED AND LABELED UNDER STANDARD 508A.***

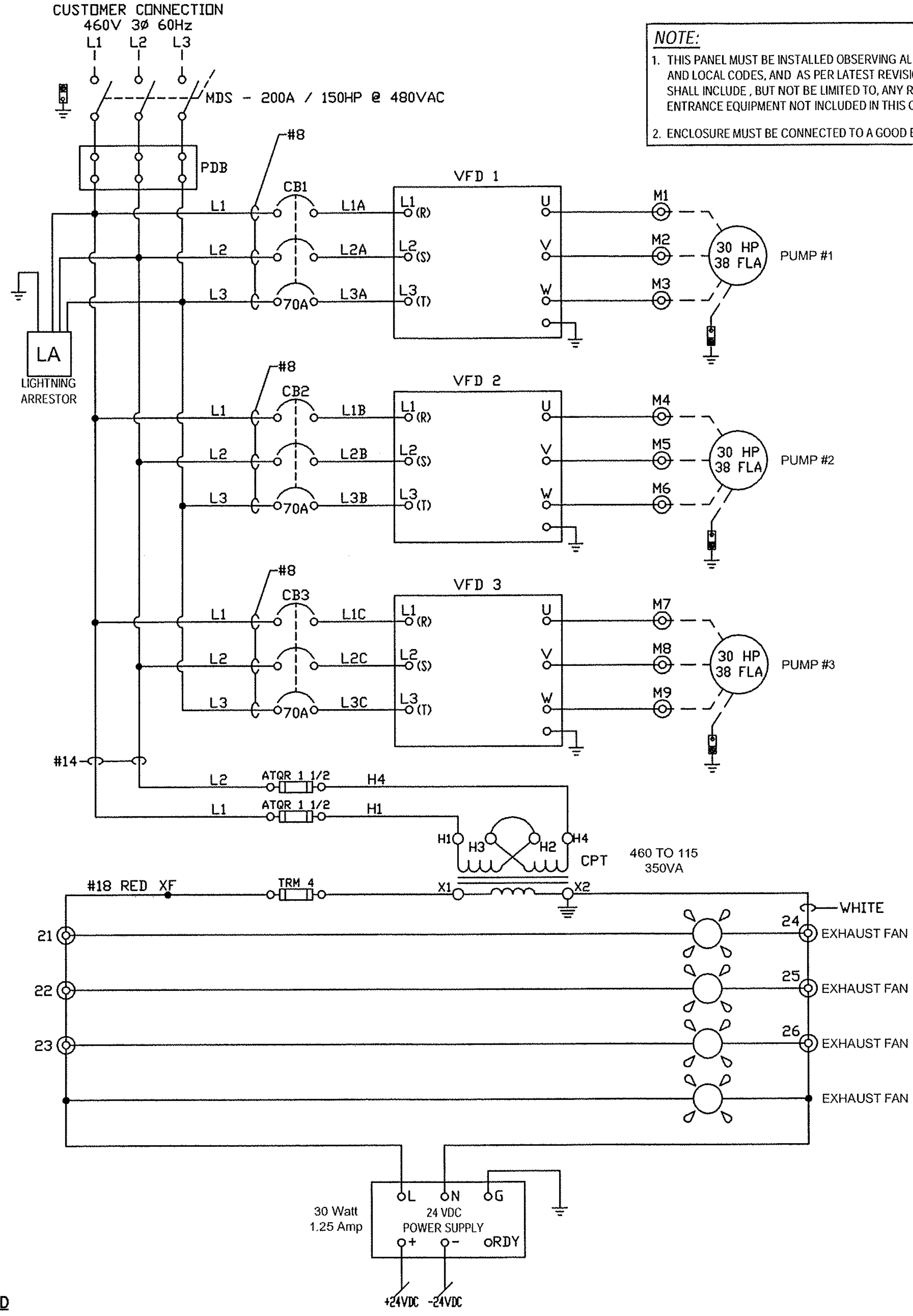
A	ORIGINAL ISSUE	DL	4-09-10
B			
C			
D			

LUCAS TECHNOLOGIES
510 S. Lakeview Drive
Lake Helen, FL 32744
386-218-4984
www.lucasnow.com

DWG. TITLE	SEBAGO HEIGHTS BOOSTER PUMP CONTROL SYSTEM		
DATE 4-09-10	CSD L.MORRIS	DWG.NO. A-3688A	REV A
DRAWN BY D.LONG	APP'D. L.MORRIS	SHT. L2	CONT. ON SHT. SH1

NOTE:

1. THIS PANEL MUST BE INSTALLED OBSERVING ALL APPLICABLE STATE AND LOCAL CODES, AND AS PER LATEST REVISION OF NEC. THIS SHALL INCLUDE, BUT NOT BE LIMITED TO, ANY REQUIL1 SERVICE ENTRANCE EQUIPMENT NOT INCLUDED IN THIS CONTROL PANEL.
2. ENCLOSURE MUST BE CONNECTED TO A GOOD EARTH GROUND.



LEGEND

◎ - INDICATES TERMINAL BLOCK

△ - INDICATES TERMINAL BLOCK IN VFD

– – – – – INDICATES FIELD WIRING

ALL CONTACTS SHOWN IN THE DE-ENERGIZED STATE

A	ORIGINAL ISSUE	DL	4-09-10
B			
C			
D			

LUCAS TECHNOLOGIES

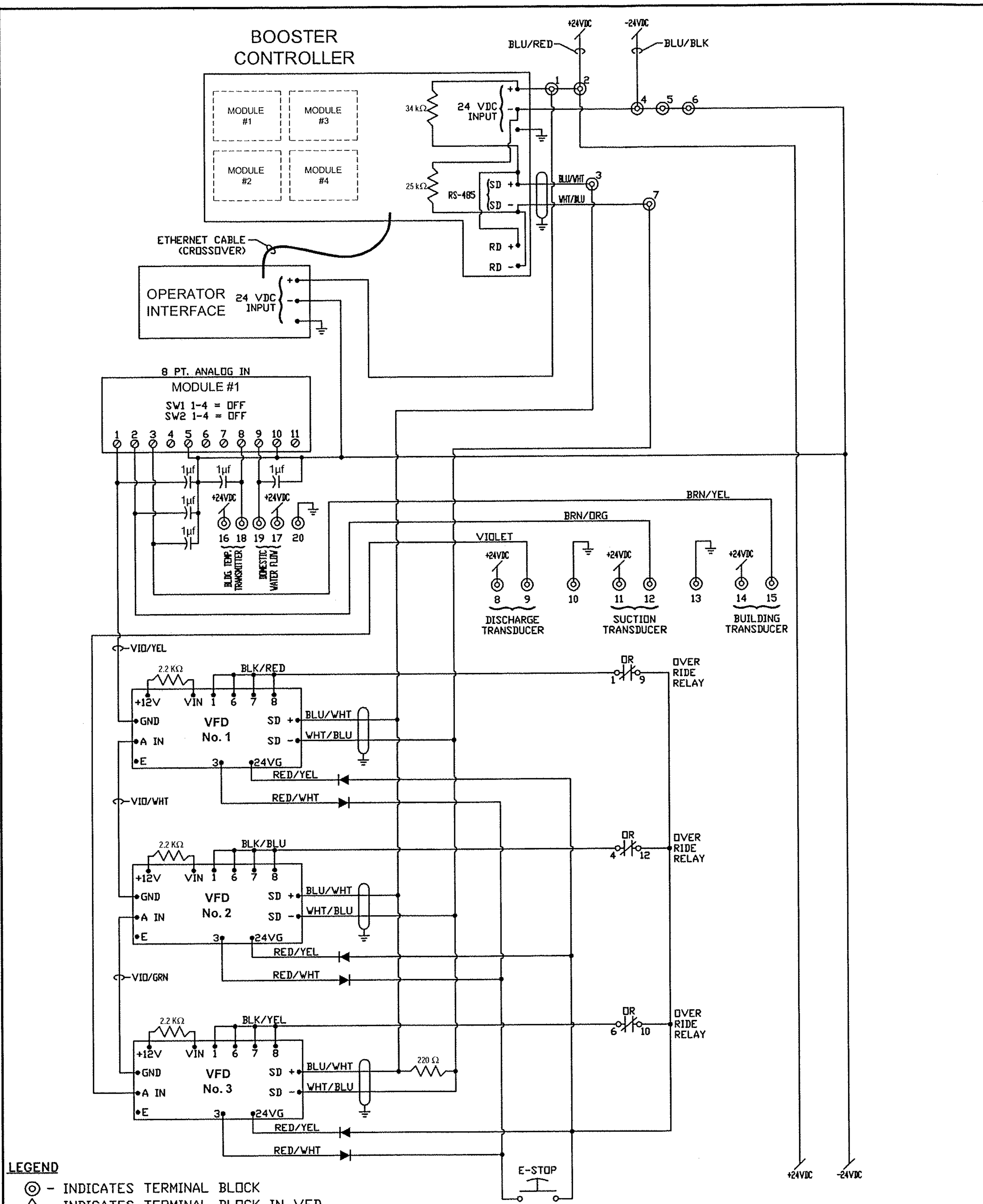
510 S. Lakeview Drive

Lake Helen, FL 32744

386-218-4984

www.lucasnow.com

DWG. TITLE	SEBAGO HEIGHTS BOOSTER PUMP CONTROL SYSTEM		
DATE 4-09-10	CSD L.MORRIS	DWG.NO. A-3688A	REV A
DRAWN BY D.LONG	APP'D. L.MORRIS	SHT. 1	CONT. ON SHT. 2

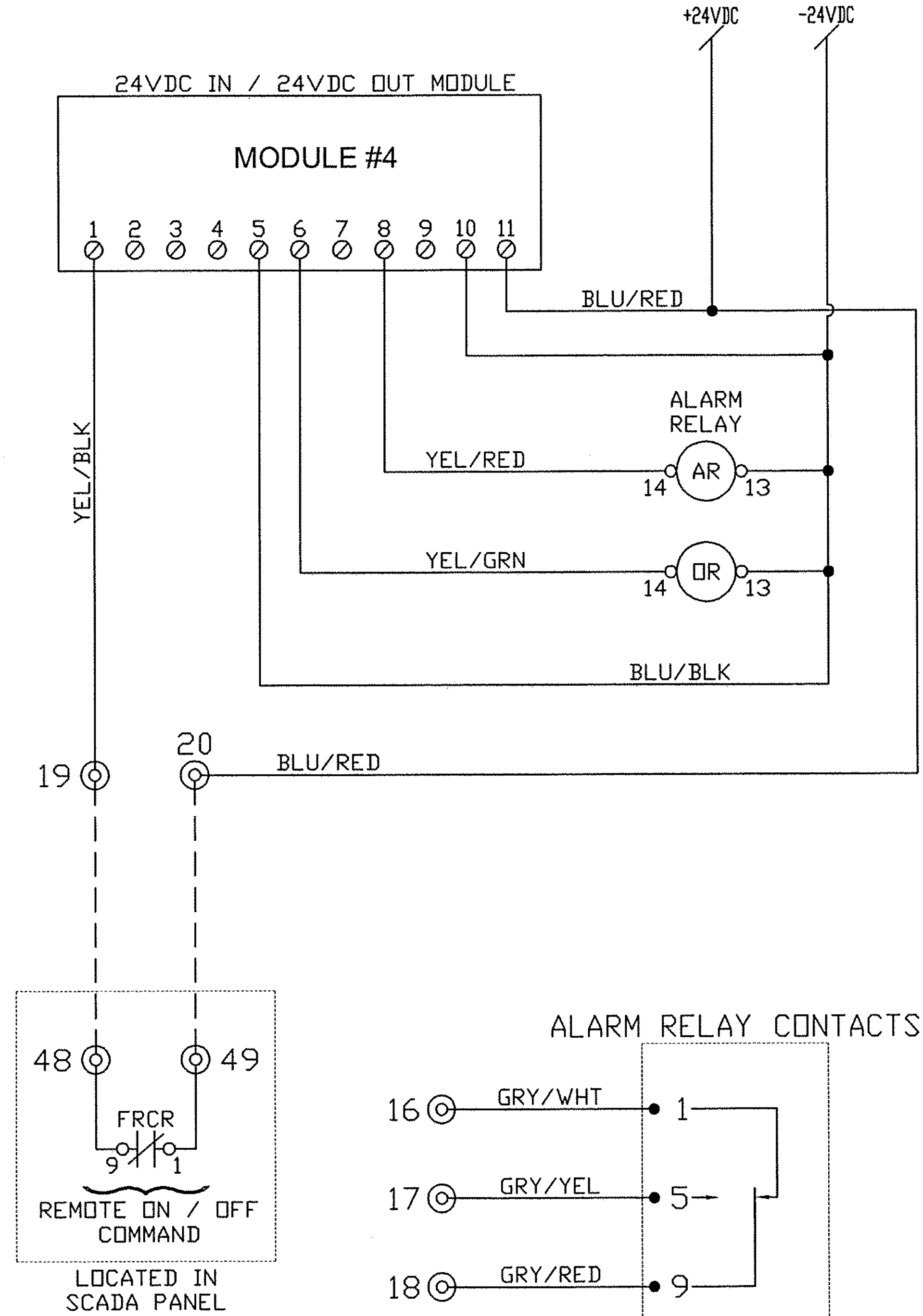


LEGEND
◎ - INDICATES TERMINAL BLOCK
△ - INDICATES TERMINAL BLOCK IN VFD
------ INDICATES FIELD WIRING
⊣⊢ - ALL CONTACTS SHOWN IN THE DE-ENERGIZED STATE

B	A	ORIGINAL ISSUE	DL	4-09-10
D	C			

LUCAS TECHNOLOGIES
510 S. Lakeview Drive
Lake Helen, FL 32744
386-218-4984
www.lucasnow.com

DWG. TITLE	SEBAGO HEIGHTS BOOSTER PUMP CONTROL SYSTEM		
DATE 4-09-10	CSD L.MORRIS	DWG.NO. A-3688A	REV A
DRAWN BY D.LONG	APP'D. L.MORRIS	SHT. 2	CONT. ON SHT. 3



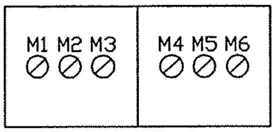
LEGEND

- ◎ - INDICATES TERMINAL BLOCK
- △ - INDICATES TERMINAL BLOCK IN VFD
- — — — INDICATES FIELD WIRING
- ALL CONTACTS SHOWN IN THE DE-ENERGIZED STATE

REV	DATE	BY	DESCRIPTION
A	4-09-10	DL	ORIGINAL ISSUE

LUCAS TECHNOLOGIES
510 S. Lakeview Drive
Lake Helen, FL 32744
386-218-4984
www.lucasnow.com

DWG. TITLE	SEBAGO HEIGHTS BOOSTER PUMP CONTROL SYSTEM		
DATE 4-09-10	CSD L.MORRIS	DWG.NO. A-3688A	REV A
DRAWN BY D.LONG	APP'D. L.MORRIS	SHT. 3	CONT. ON SHT. 4

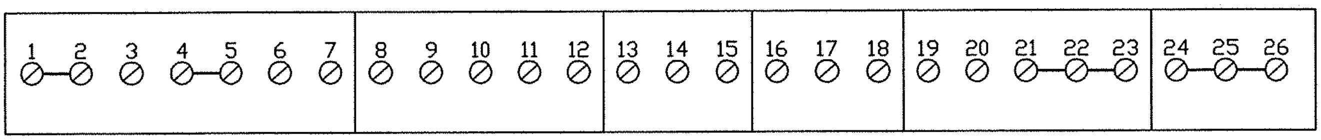


POWER TERMINAL CONNECTIONS

MAIN DISCONNECT SWITCH (MDS) - INCOMING POWER L1 / L2 / L3

PUMP No. 1 MOTOR - M1
PUMP No. 1 MOTOR - M2
PUMP No. 1 MOTOR - M3

PUMP No. 2 MOTOR - M4
PUMP No. 2 MOTOR - M5
PUMP No. 2 MOTOR - M6



CONTROL TERMINAL CONNECTIONS

1 AND 2 - (+) 24 VDC POWER ***FOR INTERNAL CONNECTIONS ONLY***

4, 5 AND 6 - (-) 24 VDC POWER ***FOR INTERNAL CONNECTIONS ONLY***

3 AND 7 - RS 485 CONNECTION ***FOR INTERNAL CONNECTIONS ONLY***

8, 9 AND 10 - DISCHARGE TRANSDUCER CONNECTION

10, 11 AND 12 - SUCTION TRANSDUCER CONNECTION

13, 14 AND 15 - BUILDING TRANSDUCER CONNECTION

16 AND 18 - N.C. ALARM RELAY CONNECTION

17 AND 18 - N.O. ALARM RELAY CONNECTION

19 AND 20 - FIRE REMOTE ON / OFF COMMAND CONNECTION

21, 22 AND 23 - INTERNAL USE ONLY - LINE SIDE CONNECTION FOR FANS

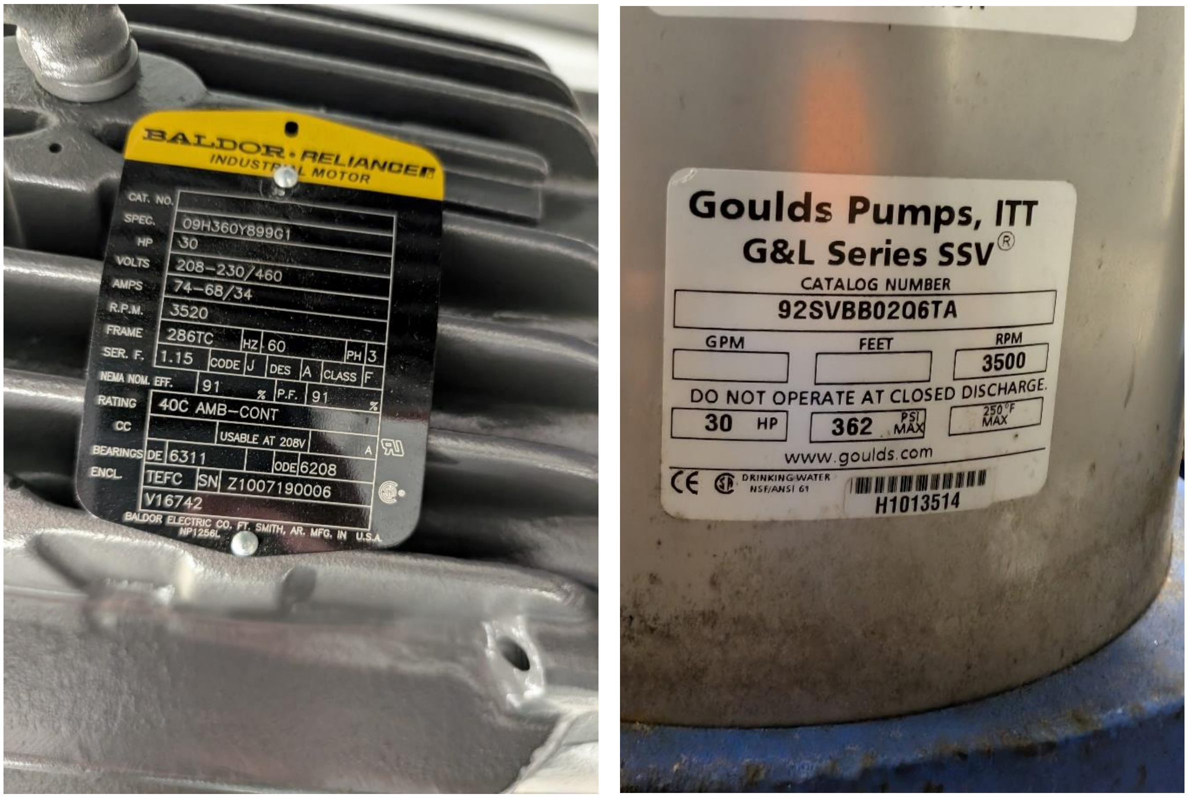
24, 25 AND 26 - INTERNAL USE ONLY - NEUTRAL SIDE CONNECTION FOR FANS

A	ORIGINAL ISSUE	DL	4-09-10
B			
C			
D			

LUCAS TECHNOLOGIES
510 S. Lakeview Drive
Lake Helen, FL 32744
386-218-4984
www.lucasnow.com

DWG. TITLE SEBAGO HEIGHTS BOOSTER PUMP CONTROL SYSTEM

DATE	CSD	DWG.NO.	REV
4-09-10	L.MORRIS	A-3688A	A
DRAWN BY D.LONG	APP'D. L.MORRIS	SHT. 4	CONT. ON SHT. FL



Emergency fire pump nameplates

Domestic pump nameplates

Flowmeter and Transmitter Nameplates

Portland Water District

From Sebago Lake to Casco Bay

SEBAGO HEIGHTS BOOSTER STATION CONTROL NARRATIVE

SECTION **PAGE NO.**

1. GENERAL INFORMATION

1.1 STATION OVERVIEW

The control system at the Sebago Heights Booster Station shall monitor and control the following major pieces of equipment:

Domestic Pumps:

- Three domestic pumps each connected to a variable frequency drive (VFD)
- Domestic pump VFD control panel
- Domestic pump discharge flow meter
- Domestic pump suction pressure transducer
- Domestic pump primary discharge pressure transducer
- Domestic pump secondary discharge pressure transducer

Emergency Fire Pumps:

- Three emergency fire pumps each connected to a variable frequency drive (VFD)
- Emergency fire pump VFD control panel
- Emergency fire pump suction pressure transducer
- Emergency fire pump primary discharge pressure transducer
- Emergency fire pump secondary discharge pressure transducer

Building Monitoring & Control:

- Telemetry panel
- Generator and automatic transfer switch (ATS)
- Station monitoring (building temperature, HVAC, power, security, cyber key access control, radio telemetry)

The following control programs and strategies shall be included:

1. Pump Control Program (CP-01)
2. Flow Monitoring Control Program (CP-02)
3. Pressure Monitoring Control Programs (CP-03)
4. Flow Control Strategy (CS-01)
5. Pressure Control Strategy (CS-02)
6. Station Monitoring (CS-03)

1.2 OIT & HMI DISPLAYS

The Local OIT shall include the following displays:

- Pump Station Overview
- Process Setpoints
- Domestic Pump 1 Control Popup
- Domestic Pump 2 Control Popup
- Domestic Pump 3 Control Popup
- Fire Pump 1 Control Popup
- Fire Pump 2 Control Popup
- Fire Pump 3 Control Popup
- Station Monitoring
- Alarm Log
- Pump Alarm Setup
- Statistics

The HMI in SLWTF's SCADA system shall include the following displays:

- Sebago Heights Pump Station Overview

2. PUMP CONTROL PROGRAM “CP-01”

2.1 DESCRIPTION

Three Domestic water pumps (for normal residential flow) and three emergency fire pumps (for emergency firefighting efforts) convey finished water from a low-pressure zone to a high-pressure zone. Each of the water pumps is connected to its own variable frequency drive (VFD) which varies the speed and subsequent flow rate from the pump. Each pump can be controlled by an operator either locally from a Local Control Station (LCS) or remotely from the Operator Interface Terminal (OIT), both of which are located on the face of their respective control panel. Additionally the pumps can be controlled from the Human Machine Interface (HMI) at the Sebago Water Plant, which communicates with the booster station over the radio telemetry network.

2.2 FIELD I/O AND STATUS INDICATORS

Tag Name	Description	Range (Units)	OIT	HMI
WIB02PS_VFD662#0_YI	Sebago Heights PS Dom Pump # Run Status		X	X
WIB02PS_VFD663#0_YI	Sebago Heights PS Fire Pump # Run Status		X	X
WIB02PS_PMP662#0_HI1	Sebago Heights PS Dom Pump # LOR in Remote		X	X
WIB02PS_PMP662#0_HI2	Sebago Heights PS Dom Pump # LOR in Local		X	X
WIB02PS_PMP663#0_HI1	Sebago Heights PS Fire Pump # LOR in Remote		X	X
WIB02PS_PMP663#0_HI2	Sebago Heights PS Fire Pump # LOR in Local		X	X
WIB02PS_VFD662#0_YC1	Sebago Heights PS Dom Pump # Stop Command		X	X
WIB02PS_VFD662#0_YC	Sebago Heights PS Dom Pump # Start Command		X	X
WIB02PS_VFD663#0_YC1	Sebago Heights PS Fire Pump # Stop Command		X	X
WIB02PS_VFD663#0_YC	Sebago Heights PS Fire Pump # Start Command		X	X
WIB02PS_PMP662#0_SI	Sebago Heights PS Dom Pump # Speed Feedback		X	X
WIB02PS_PMP663#0_SI	Sebago Heights PS Fire Pump # Speed Feedback		X	X
WIB02PS_VFD662#0_YI3	Sebago Heights Dom Pump # Amps	? to ? Amps	X	X
WIB02PS_VFD663#0_YI3	Sebago Heights Fire Pump # Amps	? to ? Amps	X	X
WIB02PS_VFD662#0_YA3	Sebago Heights PS Dom Pump # VFD fault		X	X
WIB02PS_VFD663#0_YA3	Sebago Heights PS Fire Pump # VFD fault		X	X
WIB02PS_VFD662#0_YA	Sebago Heights PS Dom Pump # Manual Motor Protector Trip		X	X
WIB02PS_VFD663#0_YA	Sebago Heights PS Fire Pump # Manual Motor Protector Trip		X	X
WIB02PS_ALM66200_YA	Sebago Heights PS Dom Pump E-Stop		X	X

WIB02PS_ALM66300_YA	Sebago Heights PS Fire Pump E-Stop		X	X

2.3 CALCULATED VALUES, ALARMS AND SETPOINTS

Tag Name	Description	Range (Units)	Initial Value	OIT	HMI
WIB02PS_VFD662#0_YA2	Sebago Heights PS Dom Pump # Fail to Start			X	X
WIB02PS_VFD663#0_YA2	Sebago Heights PS Fire Pump # Fail to Start			X	X
WIB02PS_VFD662#0_YA2_KI	Sebago Heights PS Dom Pump # Fail to Start Delay Timer	0 to 60 seconds	15	X	
WIB02PS_VFD663#0_YA2_KI	Sebago Heights PS Fire Pump # Fail to Start Delay Timer	0 to 60 seconds	15	X	
WIB02PS_PMP662#0_YI3	Sebago Heights PS Dom Pump # in Auto			X	X
WIB02PS_PMP662#0_YI4	Sebago Heights PS Dom Pump # in Manual			X	X
WIB02PS_PMP663#0_YI3	Sebago Heights PS Fire Pump # in Auto			X	X
WIB02PS_PMP663#0_YI4	Sebago Heights PS Fire Pump # in Manual			X	X
WIB02PS_PMP662#0_YC1	Sebago Heights PS Dom Pump # Man Command			X	X
WIB02PS_PMP662#0_YC	Sebago Heights PS Dom Pump # Auto Command			X	X
WIB02PS_PMP663#0_YC1	Sebago Heights PS Fire Pump # Man Command			X	X
WIB02PS_PMP663#0_YC	Sebago Heights PS Fire Pump # Auto Command			X	X
WIB02PS_PMP662#0_YI1	Sebago Heights PS Dom Pump # in Lead			X	X
WIB02PS_PMP662#0_YI2	Sebago Heights PS Dom Pump # in Lag			X	X
WIB02PS_PMP662#0_YI5	Sebago Heights PS Dom Pump # in Standby			X	X
WIB02PS_PMP663#0_YI1	Sebago Heights PS Fire Pump # in Lead			X	X
WIB02PS_PMP663#0_YI2	Sebago Heights PS Fire Pump # in Lag			X	X
WIB02PS_PMP663#0_YI5	Sebago Heights PS Fire Pump # in Standby			X	X
WIB02PS_PMP662#0_KQI	Sebago Heights PS Dom Pump # Run time	0 to 100K hours		X	X
WIB02PS_PMP663#0_KQI	Sebago Heights PS Fire Pump # Run time	0 to 100K hours		X	X
WIB02PS_VFD66200_SC	Sebago Heights PS Dom Pump Hand Speed SP	0.0 to 100.0%	40	X	
WIB02PS_VFD66300_SC	Sebago Heights PS Fire Pump Hand Speed SP	0.0 to 100.0%	50	X	
WIB02PS_VFD66200_SC1	Sebago Heights PS Dom Pump Manual Speed SP	0.0 to 100.0%		X	
WIB02PS_VFD66300_SC1	Sebago Heights PS Fire Pump Manual Speed SP	0.0 to 100.0%		X	

WIB02PS_PMP66200_YC2_SP1	Sebago Heights PS Dom Lag Start Setpoint	0.0 to 100.0%	90	X	
WIB02PS_PMP66200_YC2_KI1	Sebago Heights PS Dom Lag Start Delay	0-60 seconds	0	X	
WIB02PS_PMP66200_YC2_SP2	Sebago Heights PS Dom Lag Stop Setpoint	0.0 to 100.0%	80	X	
WIB02PS_PMP66200_YC2_KI2	Sebago Heights PS Dom Lag Stop Delay	0-60 seconds	30	X	
WIB02PS_PMP66300_YC1_SP2	Sebago Heights PS Fire Lead Pump Stop Setpoint	0.0 to 100.0%	40	X	
WIB02PS_PMP66300_YC1_KI2	Sebago Heights PS Fire Lead Pump Stop Delay	0-60 seconds	30	X	
WIB02PS_PMP66300_YC2_SP1	Sebago Heights PS Fire Lag Start Setpoint	0.0 to 100.0%	75	X	
WIB02PS_PMP66300_YC2_KI1	Sebago Heights PS Fire Lag Start Delay	0-60 seconds	10	X	
WIB02PS_PMP66300_YC2_SP2	Sebago Heights PS Fire Lag Stop Setpoint	0.0 to 100.0%	65	X	
WIB02PS_PMP66300_YC2_KI2	Sebago Heights PS Fire Lag Stop Delay	0-60 seconds	20	X	
WIB02PS_VFD66200_YI6_SP	Sebago Heights PS Dom Sleep on Speed SP	0.0 to 100.0%	50	X	
WIB02PS_VFD66200_YI6_KI	Sebago Heights PS Dom Sleep on Delay	0 to 180 seconds	120	X	
WIB02PS_VFD66200_YI6_SP1	Sebago Heights PS Dom Sleep Mode Speed SP	0.0 to 100.0%	40	X	
WIB02PS_VFD66200_YC_KI	Sebago Heights PS Dom Pump Power Fail Start Delay	0-60 seconds	0	X	
WIB02PS_VFD66300_YC_KI	Sebago Heights PS Fire Pump Power Fail Start Delay	60-120 seconds	60	X	
WIB02PS_VFD662#0_YC_KI	Sebago Heights PS Dom Pump # Start Command Delay Timer	0-60 seconds	10	X	
WIB02PS_VFD663#0_YC_KI	Sebago Heights PS Fire Pump # Start Command Delay Timer	0-60 seconds	10	X	

2.4 EQUIPMENT OPERATION

Each pump will have a local control station (LCS) consisting of a pushbutton station with a RUN indicator light (green), a speed potentiometer, a speed percentage readout, and a LOCAL-OFF-REMOTE (LOR) selector switch. The control system shall provide the following control options:

1. LOCAL/OFF
2. REMOTE-MANUAL
3. REMOTE-AUTO

The run time for each pump (WIB02PS_PMP662#0_KQI and WIB02PS_PMP663#0_KQI) will be totalized based on the RUNNING status (WIB02PS_VFD662#0_YI and WIB02PS_VFD663#0_YI), regardless of the control mode. The run time will be displayed as ##,### hours at the OIT and HMI and will roll over to zero at 100,000 hours.

2.4.1 Local/Off

Using the LOCAL-OFF-REMOTE selector switch, the pump can be placed into either the LOCAL, OFF or REMOTE positions. In the OFF position, the pump will not operate. In the LOCAL position, the pump will run continuously, and the speed can be manually adjusted using the manual speed potentiometer. A minimum and maximum pump speed will be programmed into each VFD, which will limit the operable speed of the pump in both LOCAL and REMOTE modes

Use of LOCAL or OFF modes are intended for maintenance purposes, pump testing, or if the control system is not functioning. Programmed software interlocks are disabled when the LOCAL-OFF-REMOTE selector switch is in the LOCAL or OFF positions.

The LOCAL, OFF, and REMOTE control modes are displayed at the OIT/HMI to reflect the position of the switch.

2.4.2 Remote-Manual

With the LOCAL-OFF-REMOTE selector switch in REMOTE position, the operator can put the pump in MANUAL mode at the HMI/OIT. In MANUAL mode, the pump is operated using the START and the STOP pushbuttons on the HMI/OIT. The speed of the pump is manually adjusted using a manual speed setpoint (WIB02PS_VFD66200_SC1 and WIB02PS_VFD66300_SC1) from 0 to 100% (limited by the

VFD minimum and maximum speeds). In MANUIAL mode, the equipment will operate with programmed interlocks intact but without automated functionality.

The REMOTE and MANUAL control modes are displayed at the OIT/HMI.

2.4.3 Remote-Automatic

With the LOCAL-OFF-REMOTE selector switch in the REMOTE position, the operator can put the pump in AUTO mode at the HMI/OIT. In AUTO mode, the pump will be operated using the Flow Control Strategy (CS-01) or the Pressure Control Strategy (CS-02).

The REMOTE and AUTO control modes are displayed at the OIT/HMI

2.4.4 Hardwired Interlocks

An E-STOP (one at each pump control panel) will be hardwired interlocked to immediately remove power from the motors and shut down the pumps. The status of the E-STOP is monitored by the PLC. A Sebago Heights Domestic Pump E-STOP Alarm (WIB02PS_ALM66200_YA) or a Sebago Heights Fire Pump E-STOP Alarm (WIB02PS_ALM66300_YA) is activated when the respective E-STOP is pressed. The alarm is reset at the E-STOP and at the OIT/HMI.

Software interlocks are active in both Remote-Manual and Remote-Auto control modes. The interlocks are disabled when operating in Local mode at the local control station.

2.4.5 Alarms and Warnings

The alarms listed below are provided for each of the three Domestic pumps and each of the three Emergency Fire pumps.

Sebago Heights Dom Pump # VFD Fault Alarm

Alarm Tag: WIB02PS_VFD662#0_YA3
Alarm occurs when: The variable frequency drive (VFD) detects a fault of the motor or power source and activates the Sebago Heights Dom Pump # VFD Fault input contact.
Software interlock: shuts down the pump
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 5 seconds, non-adjustable
Enable/Disable: no
Reset Procedure: The alarm is reset on the front of the VFD enclosure *and* at the OIT or HMI.

Sebago Heights Fire Pump # VFD Fault Alarm

Alarm Tag: WIB02PS_VFD663#0_YA3
Alarm occurs when: The variable frequency drive (VFD) detects a fault of the motor or power source and activates the Sebago Heights Fire Pump # VFD Fault input contact.
Software interlock: shuts down the pump
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 5 seconds, non-adjustable
Enable/Disable: no
Reset Procedure: The alarm is reset on the front of the VFD enclosure *and* at the OIT or HMI.

Sebago Heights Dom Pump # Fail to Start Alarm:

Alarm Tag: WIB02PS_VFD662#0_YA2
Alarm occurs when: The Pump Status (WIB02PS_VFD662#0_YI) is STOPPED and the Pump # Start Command (WIB02PS_VFD662#0_YC) is attempting to START the pump for a delay time.
Software interlock: Shuts down the pump
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 0 to 60 seconds, adjustable (WIB02PS_VFD662#0_YA2_KI)
Enable/Disable: yes
Reset Procedure: The alarm is reset at the OIT or HMI.

Sebago Heights Fire Pump # Fail to Start Alarm:

Alarm Tag: WIB02PS_VFD663#0_YA2
Alarm occurs when: The Pump Status (WIB02PS_VFD663#0_YI) is STOPPED and the Pump # Start Command (WIB02PS_VFD663#0_YC) is attempting to START the pump for a delay time.
Software interlock: Shuts down the pump
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 0 to 60 seconds, adjustable (WIB02PS_VFD663#0_YA2_KI)
Enable/Disable: yes
Reset Procedure: The alarm is reset at the OIT or HMI.

Sebago Heights Dom Pump # Manual Motor Protector Trip

Alarm Tag: WIB02PS_VFD662#0_YA
Alarm occurs when: the Manual Motor Protector (MMP) detects a current over a preset limit and activates the Sebago Heights Dom Pump # Manual Motor Protector Trip input contact
Software interlock: Shuts down the pump
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 5 seconds, non-adjustable
Enable/Disable: no
Reset Procedure: The alarm is reset by manually resetting the MMP and resetting the alarm at the OIT or HMI.

Sebago Heights Fire Pump # Manual Motor Protector Trip

Alarm Tag: WIB02PS_VFD663#0_YA
Alarm occurs when: the Manual Motor Protector (MMP) detects a current over a preset limit and activates the Sebago Heights Fire Pump # Manual Motor Protector Trip input contact
Software interlock: Shuts down the pump
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 5 seconds, non-adjustable
Enable/Disable: no
Reset Procedure: The alarm is reset by manually resetting the MMP and resetting the alarm at the OIT or HMI.

Sebago Heights Dom Pump E-STOP Alarm

Alarm Tag: WIB02PS_ALM66200_YA
Alarm occurs when: the pump's local E-STOP has been pressed for a 5 second delay time.
Software interlock: Shuts down pump.
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 5 seconds, non-adjustable
Enable/Disable: no
Reset Procedure: The alarm is reset by resetting the E-STOP, clearing the fault at the VFD and resetting the alarm at the OIT or HMI.

Sebago Heights Fire Pump E-STOP Alarm

Alarm Tag: WIB02PS_ALM66300_YA
Alarm occurs when: the pump's local E-STOP has been pressed for a 5 second delay time.
Software interlock: Shuts down pump.
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 5 seconds, non-adjustable
Enable/Disable: no
Reset Procedure: The alarm is reset by resetting the E-STOP, clearing the fault at the VFD and resetting the alarm at the OIT or HMI.

2.4.6 Power Failure Recovery

The pumps will shut down on loss of utility power and automatically restart once the generator is running and the ATS has switched to the emergency power position. The Domestic pumps will have an adjustable start delay (WB02PS_VFD66200_YC_KI) settable by the operator from 0 to 60 seconds when starting under generator power, initially set for 0 seconds. The Emergency Fire Pumps will have an adjustable start delay (WIB02PS_VFD66300_YC_KI) settable by the operator from 60 to 120 seconds when starting under generator power, initially set for 60 seconds. The emergency fire pumps start delay is set longer than the domestic pump start delay to avoid the emergency fire pumps starting prematurely and over pressurizing the system. The domestic and fire pumps will restart on transfer from generator to utility power without delay.

2.4.7 Pump Sleep Mode

Sleep Mode, which only applies to the domestic pumps, will be activated when domestic pump speed drops below the operator defined Sleep On Speed Setpoint (WIB02PS_VFD66200_YI6_SP) for the operator adjustable Sleep On Delay (WIB02PS_VFD66200_YI6_KI). Initially, these setpoints shall be set to 50% speed or below for 120 seconds. When Sleep Mode is activated, the active pump will run continuously at an operator defined speed (Sleep Mode Speed Setpoint, WIB02PS_VFD66200_YI6_SP1). Sleep Mode will remain active until one of two conditions is met:

1. system pressure drops an operator adjustable value (Wake Pressure Drop Setpoint, WIB02PS_FIT66200_PI_SP1) below the Domestic System Pressure Setpoint (WIB02PS_PIT66200_PI_SP), at which point the pumps will return to PID control.
2. while pump speed runs at the Sleep Mode Speed Setpoint, system pressure rises above the operator defined Lead Pump Stop Pressure Setpoint (WIB02PS_PMP66200_YC1_SP2) for the operator defined Domestic Lead Pump Stop Delay (WIB02PS_PMP66200_YC1_KI2) and the Lead pump shuts off.

The purpose of sleep mode is to ensure system pressure has stabilized before allowing the pumps to shut down in attempts to avoid any potential water hammer that could arise from shutting pumps down prematurely.

3. FLOW MONITORING CONTROL PROGRAM “CP-02”

3.1 DESCRIPTION

The flow rate from the domestic pumps is measured by an electromagnetic flow meter located on the domestic discharge piping. The measured flow rate will be displayed at the OIT and HMI.

3.2 FIELD I/O AND STATUS INDICATORS

Tag Name	Description	Range	OIT	HMI
WIB02PS_FIT66200_FI	Sebago Heights Dom Pump Flow	0 to 200 GPM	X	X

3.3 CALCULATED VALUES

Tag Name	Description	Range	OIT	HMI
WIB02PS_FIT66200_FQI	Sebago Heights Gallons Pumped Today	0 to 100,000 Gal	X	X
WIB02PS_FIT66200_FQI1	Sebago Heights Gallons Pumped Yesterday	0 to 100,000 Gal	X	X
WIB02PS_FIT66200_FQI2	Sebago Heights Gallons Pumped 2 Days Ago	0 to 100,000 Gal	X	X
WIB02PS_FIT66200_FQI3	Sebago Heights Gallons Pumped 3 Days Ago	0 to 100,000 Gal	X	X
WIB02PS_FIT66200_FQI4	Sebago Heights Gallons Pumped 4 Days Ago	0 to 100,000 Gal	X	X
WIB02PS_FIT66200_FQI5	Sebago Heights Gallons Pumped 5 Days Ago	0 to 100,000 Gal	X	X
WIB02PS_FIT66200_FQI6	Sebago Heights Gallons Pumped 6 Days Ago	0 to 100,000 Gal	X	X
WIB02PS_FIT66200_FQI7	Sebago Heights Gallons Pumped 7 Days Ago	0 to 100,000 Gal	X	X
WIB02PS_FIT66200_FQI8	Sebago Heights Total K Gallon Pumped	0 to 100,000 KGal	X	X
WIB02PS_FIT66200_FI_MAX	Sebago Heights Dom Pump Discharge Pressure Max	0 to 200 psi	X	X
WIB02PS_FIT66200_FI_MIN	Sebago Heights Dom Pump Discharge Pressure Min	0 to 200 psi	X	X

3.4 EQUIPMENT OPERATION

3.4.1 Pump Flow Rate

The flow rate from the discharge of the domestic pumps (WIB02PS_FIT66200_FI) is measured by an electromagnetic flow meter. The flow rate is displayed at the OIT/HMI from 0 to 200 gallons per minute (GPM).

The minimum and maximum flow rates for the Domestic pumps (WIB02PS_FIT66200_FI_MAX and WIB02PS_FIT66200_FI_MIN) are calculated over a 3-minute cycle period and displayed at the OIT and HMI. The purpose is to capture sudden changes in flow that may not be captured by the SCADA system due to the 1 to 2-minute polling cycle of the radio telemetry system.

The pump flow rate along with the 3-minute minimum and maximum flow rates are historically trended in Pi.

3.4.2 Flow Totals and Trending

The flow will be totalized for today, yesterday, 2 days ago, 3 days ago, 4 days ago, 5 days ago, 6 days ago, and 7 days ago (WIB02PS_FIT66200_FQI, WIB02PS_FIT66200_FQI1, WIB02PS_FIT66200_FQI2, WIB02PS_FIT66200_FQI3, WIB02PS_FIT66200_FQI4, WIB02PS_FIT66200_FQI5, WIB02PS_FIT66200_FQI6, and WIB02PS_FIT66200_FQI7) in gallons (GAL) along with continuous totalizer (WIB02PS_FIT66200_FQI8) in thousands of gallons (KGAL) on the Statistics popup screen of the OIT and the Sebago Heights Pump Station Overview popup screen on the HMI.

4. PRESSURE MONITORING CONTROL PROGRAM “CP-03”

4.1 DESCRIPTION

Pressure is measured and transmitted to the telemetry panel at the Domestic Pump Suction Pipe, Emergency Fire Pump Suction Pipe, the Domestic Pump Discharge, and the Emergency Fire Pump Discharge. Redundant sensors are located at the Domestic Pump Discharge and the Emergency Fire Pump Discharge. The pressures will be displayed at the OIT and HMI and alarmed on low- and high-pressure points.

4.2 FIELD I/O AND STATUS INDICATORS

Tag Name	Description	Range	OIT	HMI
WIB02PS_PIT66211_PI	Sebago Heights Dom Pump Suction Pressure	0 to 200 psi	X	X
WIB02PS_PIT66212_PI	Sebago Heights Dom Pump Primary Discharge Pressure	0 to 200 psi	X	X
WIB02PS_PIT66213_PI	Sebago Heights Dom Pump Secondary Discharge Pressure	0 to 200 psi	X	X
WIB02PS_PIT66311_PI	Sebago Heights Fire Pump Suction Pressure	0 to 200 psi	X	X
WIB02PS_PIT66312_PI	Sebago Heights Fire Pump Primary Discharge Pressure	0 to 200 psi	X	X
WIB02PS_PIT66313_PI	Sebago Heights Fire Pump Secondary Discharge Pressure	0 to 200 psi	X	X
WIB02PS_PIT66211_YA	Sebago Heights PS Dom Suction Pressure Sens Fault		X	X
WIB02PS_PIT66212_YA	Sebago Heights PS Dom Discharge Pressure Sens Fault		X	X
WIB02PS_PIT66213_YA	Sebago Heights PS Dom Secondary Pressure Sensor Fault		X	X
WIB02PS_PIT66311_YA	Sebago Heights PS Fire Suction Pressure Sen Fault		X	X
WIB02PS_PIT66312_YA	Sebago Heights PS Fire Discharge Pressure Sen Fault		X	X
WIB02PS_PIT66313_YA	Sebago Heights PS Fire Secondary Pressure Sensor Fault		X	X

4.3 CALCULATED VALUES

Tag Name	Description	Range	Initial Value	OIT	HMI
WIB02PS_PIT66214_PI_ACTIVE	Sebago Heights PS Dom Pump Active Discharge Pressure			X	X
WIB02PS_PIT66314_PI_ACTIVE	Sebago Heights PS Fire Pump Active Discharge Pressure			X	X
WIB02PS_PIT66211_PI_MAX	Sebago Heights Dom Pump Suction Pressure Max	0 to 200 psi		X	X
WIB02PS_PIT66211_PI_MIN	Sebago Heights Dom Pump Suction Pressure Min	0 to 200 psi		X	X
WIB02PS_PIT66212_PI_MAX	Sebago Heights Dom Pump Discharge Pressure Max	0 to 200 psi		X	X
WIB02PS_PIT66212_PI_MIN	Sebago Heights Dom Pump Discharge Pressure Min	0 to 200 psi		X	X
WIB02PS_PIT66311_PI_MAX	Sebago Heights Fire Pump Suction Pressure Max	0 to 200 psi		X	X
WIB02PS_PIT66311_PI_MIN	Sebago Heights Fire Pump Suction Pressure Min	0 to 200 psi		X	X
WIB02PS_PIT66312_PI_MAX	Sebago Heights Fire Pump Discharge Pressure Max	0 to 200 psi		X	X
WIB02PS_PIT66312_PI_MIN	Sebago Heights Fire Pump Discharge Pressure Min	0 to 200 psi		X	X
WIB02PS_PIT66211_PAL	Sebago Heights Dom Suction Low Pressure Alarm			X	X
WIB02PS_PIT66211_PAL_SP1	Sebago Heights Dom Suction Low Pressure Alarm Setpoint	0 to 200 psi	20	X	
WIB02PS_PIT66211_PAL_SP2	Sebago Heights Dom Suction Low Pressure Alarm Delay	0 to 60 seconds	30	X	
WIB02PS_PIT66212_PAL	Sebago Heights Dom Discharge Low Pressure Alarm			X	X
WIB02PS_PIT66212_PAL_SP1	Sebago Heights Dom Discharge Low Pressure Alarm Setpoint	0 to 200 psi	40	X	
WIB02PS_PIT66212_PAL_KI	Sebago Heights Dom Discharge Low Pressure Alarm Delay	0 to 60 seconds	30	X	
WIB02PS_PIT66212_PAH	Sebago Heights Dom Discharge High Pressure Alarm			X	X
WIB02PS_PIT66212_PAH_SP1	Sebago Heights Dom Discharge High Pressure Alarm Setpoint	0 to 200 psi	150	X	
WIB02PS_PIT66212_PAH_KI	Sebago Heights Dom Discharge High Pressure Alarm Delay	0 to 60 seconds	2	X	
WIB02PS_PIT66311_PAL	Sebago Heights Fire Suction Low Pressure Alarm			X	X
WIB02PS_PIT66311_PAL_SP1	Sebago Heights Fire Suction Low Pressure Alarm Setpoint	0 to 200 psi	20	X	
WIB02PS_PIT66311_PAL_KI	Sebago Heights Fire Suction Low Pressure Alarm Delay	0 to 60 seconds	30	X	
WIB02PS_PIT66312_PAL	Sebago Heights Fire Discharge Low Pressure Alarm			X	X

WIB02PS_PIT66312_PAL_SP1	Sebago Heights Fire Discharge Low Pressure Alarm Setpoint	0 to 200 psi	40	X	
WIB02PS_PIT66312_PAL_KI	Sebago Heights Fire Discharge Low Pressure Alarm Delay	0 to 60 seconds	30	X	
WIB02PS_PIT66312_PAH	Sebago Heights Fire Discharge High Pressure Alarm			X	X
WIB02PS_PIT66312_PAH_SP1	Sebago Heights Fire Discharge High Pressure Alarm Setpoint	0 to 200 psi	150	X	
WIB02PS_PIT66312_PAH_KI	Sebago Heights Fire Discharge High Pressure Alarm Delay	0 to 60 seconds	10	X	
WIB02PS_PIT66200_YA	Sebago Heights PS Dom Discharge Pressure Sensors Disagreement Alarm			X	X
WIB02PS_PIT66200_YA_SP1	Sebago Heights PS Dom Discharge Pressure Sensors Disagreement Alarm Setpoint	0 to 200 psi	10	X	
WIB02PS_PIT66200_YA_KI	Sebago Heights PS Dom Discharge Pressure Sensors Disagreement Alarm Delay	0 to 60 seconds	30	X	
WIB02PS_PIT66300_YA	Sebago Heights PS Fire Discharge Pressure Sensors Disagreement Alarm			X	X
WIB02PS_PIT66300_YA_SP1	Sebago Heights PS Fire Discharge Pressure Sensors Disagreement Alarm Setpoint	0 to 200 psi	10	X	
WIB02PS_PIT66300_YA_KI	Sebago Heights PS Fire Discharge Pressure Sensors Disagreement Alarm Delay	0 to 60 seconds	30	X	

4.4 EQUIPMENT OPERATION

4.4.1 Suction Pressure

The pressure in the Domestic Pump Suction Piping (WIB02PS_PIT66211_PI) will be measured by a pressure indicating transducer. The pressure will be displayed at the OIT/HMI from 0 to 200 psi and historically trended in Pi.

The pressure in the Emergency Fire Pump Suction Piping (WIB02PS_PIT66311_PI) will be measured by a pressure indicating transducer. The pressure will be displayed at the OIT/HMI from 0 to 200 psi and historically trended in Pi.

The PLC will calculate the minimum and maximum suction pressure (WIB02PS_PIT66211_PI_MAX, WIB02PS_PIT66211_PI_MIN, WIB02PS_PIT66311_PI_MAX, and WIB02PS_PIT66311_PI_MIN) over a 3-minute cycle period and displays these pressures on the OIT/HMI. This will be used to capture instantaneous pressure transients in the distribution system.

4.4.2 Discharge Pressure

The pressure in the domestic pump primary discharge piping and will be measured by a primary pressure indicating sensor (WIB02PS_PIT66212_PI) and a secondary pressure indicating sensor (WIB02PS_PIT66213_PI) for redundancy. Upon receiving a Primary Discharge Pressure Sensor Fault, pressure reading shall be read from the Secondary Discharge Pressure Sensor and vice versa. The pressure will be displayed at the OIT/HMI from 0 to 200 psi and historically trended in Pi.

The pressure in the emergency fire pump primary discharge piping will be measured by a primary pressure indicating sensor (WIB02PS_PIT66212_PI) and a secondary pressure indicating sensor (WIB02PS_PIT66212_PI) for redundancy. The pressure will be displayed at the OIT/HMI from 0 to 200 psi and historically trended in Pi.

The PLC calculates the minimum and maximum discharge pressure (WIB02PS_PIT66212_PI_MAX, WIB02PS_PIT66212_PI_MIN, WIB02PS_PIT66312_PI_MAX, and WIB02PS_PIT66312_PI_MIN) over a 3-minute cycle period and displays these pressures on the OIT/HMI. This will be used to capture instantaneous pressure transients in the distribution system.

4.4.3 Alarms and Warnings

Sebago Heights Dom Suction Pressure Sensor Fault Alarm

Alarm Tag: WIB02PS_PIT66211_YA
Alarm occurs when: the signal from the pressure transducer is out of range or lost
Software interlock: none
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 10 seconds
Enable/Disable: yes
Reset Procedure: The alarm is reset at the local OIT.

Sebago Heights Dom Discharge Primary Pressure Sensor Fault Alarm

Alarm Tag: WIB02PS_PIT66212_YA
Alarm occurs when: the signal from the pressure transducer is out of range or lost
Software interlock: the alarm is latching and interlocked to transition pressure reading to the secondary discharge pressure sensor, unless the secondary pressure sensor is faulted as well, in which case it will shut down the pumps.

Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 10 seconds
Enable/Disable: yes
Reset Procedure: The alarm is reset at the local OIT.

Sebago Heights Dom Discharge Secondary Pressure Sensor Fault Alarm

Alarm Tag: WIB02PS_PIT66213_YA
Alarm occurs when: the signal from the pressure transducer is out of range or lost
Software interlock: the alarm is latching and interlocked to transition pressure reading to the primary discharge pressure sensor, unless the primary pressure sensor is faulted as well, in which case it will shut down the pumps.
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 10 seconds
Enable/Disable: yes
Reset Procedure: The alarm is reset at the local OIT.

Sebago Heights Fire Suction Pressure Sensor Fault Alarm

Alarm Tag: WIB02PS_PIT66311_YA
Alarm occurs when: the signal from the pressure transducer is out of range or lost
Software interlock: the alarm is latching, but will not shut down the pumps.
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 10 seconds
Enable/Disable: yes
Reset Procedure: The alarm is reset at the local OIT.

Sebago Heights Fire Discharge Pressure Sensor Fault Alarm

Alarm Tag: WIB02PS_PIT66312_YA
Alarm occurs when: the signal from the pressure transducer is out of range or lost
Software interlock: the alarm is latching and interlocked to transition pressure reading to the secondary discharge pressure sensor, unless the secondary pressure sensor is faulted as well, in which case no fire pump discharge pressure reading will be available. In this scenario, the domestic pump discharge pressure reading shall be used.
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 10 seconds
Enable/Disable: yes
Reset Procedure: The alarm is reset at the local OIT.

Sebago Heights Fire Discharge Secondary Pressure Sensor Fault Alarm

Alarm Tag: WIB02PS_PIT66313_YA
Alarm occurs when: the signal from the pressure transducer is out of range or lost

Software interlock: the alarm is latching and interlocked to transition pressure reading to the secondary discharge pressure sensor, unless the secondary pressure sensor is faulted as well, in which case no pressure reading will be available.
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 10 seconds
Enable/Disable: yes
Reset Procedure: The alarm is reset at the local OIT.

Sebago Heights Dom Low Suction Pressure Alarm

Alarm Tag: WIB02PS_PIT66211_PAL
Alarm occurs when: If the measured pressure in the domestic suction pipe drops below the Sebago Heights Domestic Low Suction Pressure Alarm Setpoint for the Sebago Heights Domestic Low Suction Pressure Alarm Delay
Software interlock: none
Alarm Priority: 3 (low)
Alarm Setpoint: 0 to 200 psi (WIB02PS_PIT66211_PAL_SP1)
Delay Time: 0 to 60 seconds, adjustable (WIB02PS_PIT66211_PAL_SP2)
Enable/Disable: yes
Reset Procedure: The alarm is reset at the OIT or HMI.

Sebago Heights Dom Low Discharge Pressure Alarm

Alarm Tag: WIB02PS_PIT66212_PAL
Alarm occurs when: If the measured pressure in the domestic discharge pipe drops below the Sebago Heights Domestic Low Discharge Pressure Alarm Setpoint for the Sebago Heights Domestic Low Discharge Pressure Alarm Delay
Software interlock: none
Alarm Priority: 3 (low)
Alarm Setpoint: 0 to 200 psi (WIB02PS_PIT66212_PAL_SP1)
Delay Time: 0 to 60 seconds, adjustable (WIB02PS_PIT66212_PAL_SP2)
Enable/Disable: yes
Reset Procedure: The alarm is reset at the OIT or HMI.

Sebago Heights Dom High Discharge Pressure Alarm

Alarm Tag: WIB02PS_PIT66212_PAH
Alarm occurs when: If the measured pressure in the domestic discharge pipe rises above the Sebago Heights Domestic High Discharge Pressure Alarm Setpoint for the Sebago Heights Domestic High Discharge Pressure Alarm Delay
Software interlock: none
Alarm Priority: 3 (low)
Alarm Setpoint: 0 to 200 psi (WIB02PS_PIT66212_PAH_SP1)
Delay Time: 0 to 60 seconds, adjustable (WIB02PS_PIT66212_PAH_SP2)
Enable/Disable: yes
Reset Procedure: The alarm is reset at the OIT or HMI.

Sebago Heights Fire Low Suction Pressure Alarm

Alarm Tag: WIB02PS_PIT66311_PAL
Alarm occurs when: If the measured pressure in the emergency fire suction pipe drops below the Sebago Heights Fire Low Suction Pressure Alarm Setpoint for the Sebago Heights Fire Low Suction Pressure Alarm Delay
Software interlock: none
Alarm Priority: 3 (low)
Alarm Setpoint: 0 to 200 psi (WIB02PS_PIT66211_PAL_SP1)
Delay Time: 0 to 60 seconds, adjustable (WIB02PS_PIT66211_PAL_SP2)
Enable/Disable: yes
Reset Procedure: The alarm is reset at the OIT or HMI.

Sebago Heights Fire Low Discharge Pressure Alarm

Alarm Tag: WIB02PS_PIT66312_PAL
Alarm occurs when: If the measured pressure in the fire discharge pipe drops below the Sebago Heights Fire Low Discharge Pressure Alarm Setpoint for the Sebago Heights Fire Low Discharge Pressure Alarm Delay
Software interlock: none
Alarm Priority: 3 (low)
Alarm Setpoint: 0 to 200 psi (WIB02PS_PIT66312_PAL_SP1)
Delay Time: 0 to 60 seconds, adjustable (WIB02PS_PIT66312_PAL_SP2)
Enable/Disable: yes
Reset Procedure: The alarm is reset at the OIT or HMI.

Sebago Heights Fire High Discharge Pressure Alarm

Alarm Tag: WIB02PS_PIT66312_PAH
Alarm occurs when: If the measured pressure in the domestic discharge pipe rises above the Sebago Heights Domestic High Discharge Pressure Alarm Setpoint for the Sebago Heights Domestic High Discharge Pressure Alarm Delay
Software interlock: none
Alarm Priority: 3 (low)
Alarm Setpoint: 0 to 200 psi (WIB02PS_PIT66312_PAH_SP1)
Delay Time: 0 to 60 seconds, adjustable (WIB02PS_PIT66312_PAH_SP2)
Enable/Disable: yes

Reset Procedure: The alarm is reset at the OIT or HMI.

5. FLOW CONTROL STRATEGY "CS-01"

5.1 DESCRIPTION

The domestic pump flowrate will be monitored and used to trigger emergency fire pump runs on high flow.

5.2 CALCULATED VALUES, ALARMS AND SETPOINTS

Tag Name	Description	Range (Units)	Initial Value	OIT	HMI
WIB02PS_FIT66300_FAH	Sebago Heights High Flow Alarm			X	X
WIB02PS_FIT66300_FAH_SP	Sebago Heights High Flow Alarm Setpoint	0-100 GPM	100	X	
WIB02PS_FIRE_MODE_ACTIVE	Sebago Heights Emergency Fire Mode Active			X	X
WIB02PS_FIRE_MODE_FLOW_SP	Sebago Heights Emergency Fire Mode Start Flow Setpoint	0-100 GPM	100	X	
WIB02PS_FIRE_MODE_FLOW_KI	Sebago Heights Emergency Fire Mode Start Flow Delay Timer	0-60 seconds	5	X	

5.3 SYSTEM OPERATION

When in REMOTE – AUTO, the Sebago Heights Booster Station operates in a NORMAL MODE, EMERGENCY FIRE MODE, and SLEEP MODE to maintain pressure in the distribution system.

5.3.1 Discharge Flow

During normal operation, or NORMAL MODE, the domestic pump flowmeter will monitor flowrate. If the domestic pump flowrate exceeds an operator defined setpoint (Emergency Fire Mode Start Flow Setpoint, WIB02PS_FIRE_MODE_FLOW_SP) for an operator defined amount of time (Emergency Fire Mode Start Flow Delay Timer, WIB02PS_FIRE_MODE_FLOW_KI), EMERGENCY FIRE MODE will be activated. See "PRESSURE CONTROL STRATEGY CS-02" for more information on NORMAL MODE and EMERGENCY FIRE MODE.

:

5.3.2 Alarms and Warnings

Sebago Heights High Flow Alarm

Alarm Tag: WIB02PS_FIT66300_FAH
Alarm occurs when: the domestic pump discharge flowrate exceeds the Sebago Heights High Flow Alarm Set Point for a hardcoded 5 seconds
Software interlock: none
Alarm Priority: 4 (informational)
Alarm Setpoint: 0-100 GPM
Delay Time: 5 seconds
Enable/Disable: no
Reset Procedure: The alarm is reset at the OIT and HMI.

6. PRESSURE CONTROL STRATEGY “CS-02”

6.1 DESCRIPTION

The domestic and emergency fire pumps will operate in tandem to maintain pressure as measured by the Domestic Pump Discharge Pressure Transducers and the Emergency Fire Pump Discharge Pressure Transducers.

6.2 CALCULATED VALUES, ALARMS AND SETPOINTS

Tag Name	Description	Range (Units)	Initial Value	OIT	HMI
WIB02PS_PIT66200_PI_SP	Sebago Heights PS Dom Pressure Setpoint	0 to 200 psi	92	X	X
WIB02PS_PIT66300_PI_SP	Sebago Heights PS Fire Pressure Setpoint	0 to 200 psi	104	X	X
WIB02PS_PIT66200_PI_SP1	Sebago Heights PS Dom Wake Press Drop Setpoint	0 to 200 psi	5	X	
WIB02PS_VFD66200_YC1_SP1	Sebago Heights PS Dom Lead Pump Start Setpoint	0 to 200 psi	82	X	
WIB02PS_PMP66200_YC1_SP2	Sebago Heights PS Dom Lead Pump Stop Setpoint	0 to 200 psi	98	X	
WIB02PS_VFD66300_YC1_SP1	Sebago Heights PS Fire Lead Pump Start Setpoint	0 to 200 psi	50	X	
WIB02PS_VFD66300_YC1_KI1	Sebago Heights PS Fire Lead Pump Start Delay	0 to 60 seconds	20	X	
WIB02PS_FIRE_MODE_ACTIVE	Sebago Heights PS Emergency Fire Mode Active			X	X

6.3 SYSTEM OPERATION

When in REMOTE – AUTO, the Sebago Heights Booster Station operates in a NORMAL MODE, EMERGENCY FIRE MODE, and SLEEP MODE to maintain pressure in the distribution system.

6.3.1 Normal Mode

During normal operation, or NORMAL MODE, the Domestic Pumps will run near-continuously in a variable speed, Lead / Lag / Standby formation to maintain a constant, operator defined system pressure

(Normal Mode System Pressure Setpoint). This Lead / Lag / Standby formation will alternate daily at midnight to spread pump use between the 3 domestic pumps. The domestic pumps will automatically stop when pressure is at or above the Domestic Pump Stop Setpoint (WIB02PS_PMP66200_YC1_SP2) for a hard-coded time delay of 10 seconds. The domestic pumps will automatically re-start if the measured pressure is at or below the Domestic Pump Start Setpoint (WIB02PS_PMP66200_YC1_SP1) for a hard-coded time delay of 10 seconds. The Emergency Fire Pumps will stay in Standby during NORMAL MODE.

6.3.2 Emergency Fire Mode

If Domestic Pump Flowrate exceeds the Emergency Fire Mode Start Flow Setpoint (WIB02PS_FIRE_MODE_FLOW_SP) for the Emergency Fire Mode Start Flow Delay Timer (WIB02PS_FIRE_MODE_FLOW_KI) (see Flow Control Strategy CS-01 for more details) OR system pressure as measured at the Domestic Pump Discharge Piping (WIB02PS_PIT66214_PI_ACTIVE) falls below the Fire Lead Pump Start Setpoint (WIB02PS_VFD66300_YC1_SP1) for the Fire Lead Pump Start Delay (WIB02PS_VFD66300_YC1_KI1), EMERGENCY FIRE MODE will be activated. During EMERGENCY FIRE MODE:

- The Emergency Fire Pumps will be enabled and act in a variable speed, Lead / Lag / Standby formation to maintain a constant operator defined system pressure (Emergency Fire Pump Pressure Setpoint, WIB02PS_PIT66300_PI_SP). The Emergency Fire Pump Pressure Setpoint shall be set higher than the Domestic Pump Pressure Setpoint.
- Once the system pressure exceeds the Domestic Lead Pump Stop Setpoint (WIB02PS_PMP66200_YC1_SP2) for a hardcoded time delay of 10 seconds, the domestic pumps will shut off as system pressure requirements are being met by the Emergency Fire Pumps.

Once Emergency Fire Pump Speed (WIB02PS_PMP663#0_SI), as read from the VFD, falls below the Fire Lead Pump Stop Setpoint (WIB02PS_PMP66300_YC1_SP2) for the Fire Lead Pump Stop Delay (WIB02PS_PMP66300_YC1_KI2), NORMAL MODE will be activated and the Emergency Fire pumps will return to Standby mode.

6.3.3 PID Control

While in the REMOTE – AUTO mode, the PLC will utilize a PID function to modulate pump speed to maintain the active pressure setpoint.

6.3.4 Alarms and Warnings

Sebago Heights PS Emergency Fire Pumps Active

Alarm Tag: WIB02PS_FIRE_MODE_ACTIVE
Alarm occurs when: any of the three emergency fire pumps run status turns to “RUNNING”.
Software interlock: none
Alarm Priority: 4 (informational)
Alarm Setpoint: none
Delay Time: none
Enable/Disable: yes
Reset Procedure: The alarm is reset at the OIT or HMI.

7. STATION MONITORING CONTROL STRATEGY “CS-03”

7.1 DESCRIPTION

This narrative describes the monitoring and control of the pump stations subsystems including:

- Building Temperature
- Intrusion Monitoring
- Power Monitoring
- Generator and Automatic Transfer Switch (ATS)
- Cyber Key Access
- Communications

7.2 FIELD I/O AND STATUS INDICATORS

Tag Name	Description	Range (Units)	OIT	HMI
WIB02PS_TIT66100_TI	Sebago Heights PS Building Temperature	x to x °F	X	X
WIB02SD_RTU01000_YQI	Sebago Heights PS Telemetry Polling	0 to 100%	X	X
WIB02PR_ATS73200_ZI1	Sebago Heights PS ATS Normal		X	X
WIB02PR_MOT73100_YI	Sebago Heights PS Generator Running		X	X
WIB02PR_JAX73600_YA2	Sebago Heights PS UPS Failure Alarm		X	X
WIB02SD_SCD01100_YA	Sebago Heights PS Telemetry Panel Fail Alarm		X	X
WIB02PR_JAX73600_YI	Sebago Heights PS Utility Power Status		X	X
WIB02PS_SCD66200_YA	Sebago Heights PS Dom VFD Panel Fail Alarm		X	X
WIB02PS_SCD66300_YA	Sebago Heights PS Fire VFD Panel Fail Alarm		X	X
WIB02PR_JAX73600_YA	Sebago Heights PS Phase Fail Alarm		X	X
WIB02PR_ATS73200_ZI2	Sebago Heights PS ATS Emergency Power		X	X
WIB02PR_MOT73100_YA1	Sebago Heights PS Generator Fault Alarm		X	X
WIB02PR_MOT73100_YA2	Sebago Heights PS Generator Low Battery Alarm		X	X
WIB02PR_MOT73100_YA3	Sebago Heights PS Generator Low Fuel Alarm		X	X
WIB02SE_SEC77000_YA	Sebago Heights PS Building Intrusion		X	X
WIB02FI_FPE78100_YA	Sebago Heights PS Fire Alarm		X	X
WIB02SE_SEC77100_YA	Sebago Heights PS Telemetry Panel Intrusion		X	X
WIB02SE_SEC77200_YA	Sebago Heights PS Dom Panel Intrusion		X	X
WIB02SE_SEC77300_YA	Sebago Heights PS Fire Panel Intrusion		X	X

7.3 CALCULATED VALUES

Tag Name	Description	Range	OIT	HMI
WIB02PS_TIT66100_YA	Sebago Heights PS Building Low Temp		X	X
WIB02PS_TIT66100_YA_SP	Sebago Heights PS Building Low Temp Setpoint	x to x °F	X	
WIB02PR_PMP73100_EI	Sebago Heights PS Fire/Dom Power Consumption		X	X
WIB02SD_RAD01200_YA	Sebago Heights PS Telemetry Fail		X	X

7.4 EQUIPMENT OPERATION

7.4.1 Building Temperature

The ambient temperature in the building will be measured by a temperature sensor and displayed at the OIT and HMI in deg F.

7.4.2 Intrusion Monitoring

The Sebago Heights Building will be monitored for intrusion by triggering a prompt on the OIT once the entrance door is opened. If the prompt is not acknowledged in 120 seconds, a Sebago Heights Building Intrusion Alarm will be triggered.

7.4.3 Power Monitoring

The status of the power at the station is displayed at the OIT and the HMI for the following conditions:

- (WIB02SD_SCD01100_YA) Telemetry Power monitors the 120VAC control power feed available at the Telemetry Panel.
- (WIB02PR_JAX73600_YA1) Utility Power status monitors the status of the 480VAC power feed to the station.
- (WIB02PR_JAX73600_YA) Phase Fail monitors the phases of the utility power to the station

- (WIB02PR_JAX73600_YA2) UPS Status monitors power from the ups to the Telemetry Panel.

7.4.4 Generator and ATS Monitoring

The run status of the generator and the position of the Automatic Transfer Switch (ATS) is displayed on the OIT and HMI.

7.4.5 Cyber Key Access Control

A PWD “Cyber Key” socket is located on the front of the Telemetry Panel will allow the operator to access additional monitoring and control functions within the local Operator Interface Terminal. This generally includes access to pump control functions, process parameters and alarm setpoints.

7.4.6 Communications

The Sebago Heights radio telemetry system sends data to the Sebago Lake Water Treatment Facility through the radio located in the Telemetry Panel and the antenna located outside the building.

7.4.7 Alarms and Warnings

Sebago Heights Generator Fault Alarm

Alarm Tag: WIB02PR_MOT73100_YA1
Alarm occurs when: If the generator control panel activated a general alarm, then the PLC will display a SEBAGO HEIGHTS GENERATOR FAULT ALARM. The specific alarm condition can be viewed from the generator control panel.
Software interlock: none
Alarm Priority: 3 (low)
Alarm Setpoint: none
Delay Time: none
Enable/Disable: yes
Reset Procedure: The alarm is reset at the generator control panel and at the OIT or HMI.

Sebago Heights Generator Low Battery Alarm

Alarm Tag: WIB02PR_MOT73100_YA2
Alarm occurs when: If the generator control panel activated a low battery alarm, then the PLC will display a SEBAGO HEIGHTS GENERATOR LOW BATTERY ALARM.
Software interlock: none
Alarm Priority: 3 (low)

Alarm Setpoint: none
Delay Time: none
Enable/Disable: yes
Reset Procedure: The alarm is reset at the generator control panel and at the OIT or HMI.

Sebago Heights High Generator Low Fuel Alarm

Alarm Tag: WIB02PR_MOT73100_YA3
Alarm occurs when: If the generator control panel activated a low fuel alarm, then the PLC will display a SEBAGO HEIGHTS GENERATOR LOW BATTERY ALARM.
Software interlock: none
Alarm Priority: 3 (low)
Alarm Setpoint: none
Delay Time: none
Enable/Disable: yes
Reset Procedure: The alarm is reset at the generator control panel and at the OIT or HMI.

Sebago Heights Telemetry Panel Power Fail Alarm

Alarm Tag: WIB02SD_SCD01100_YA
Alarm occurs when: If the power fail relay opens due to loss of power to the Telemetry Panel after a 120 second delay, then the PLC will display a SEBAGO HEIGHTS TELEMETRY PANEL POWER FAIL.
Software interlock: none
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 120 seconds, fixed
Enable/Disable: no
Reset Procedure: The alarm is reset at the OIT or HMI.

Sebago Heights Telemetry Panel UPS Alarm

Alarm Tag: WIB02PR_JAX73600_YA2
Alarm occurs when: the UPS detects an internal fault and after a 15 second fixed delay, then the PLC will display a SEBAGO HEIGHTS TELEMETRY PANEL UPS FAIL. This will result in the automatic transfer relay switching the telemetry panel to line power, giving the PWD time to respond to the alarm.
Software interlock: none
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 15
Enable/Disable: no
Reset Procedure: The alarm is reset at the OIT or HMI

Sebago Heights Fire Alarm

Alarm Tag: WIB02FI_FPE78100_YA
Alarm occurs when: the facility's fire panel detects an alarm from the fire detectors, then the PLC will display a SEBAGO HEIGHTS FIRE ALARM.
Software interlock: none
Alarm Priority: 1 (critical)
Alarm Setpoint: none

Delay Time: 15 seconds, fixed
Enable/Disable: no
Reset Procedure: The alarm is reset at the fire alarm panel inside the station and at the HMI or OIT.

Sebago Heights ATS on Emergency Power

Alarm Tag: WIB02PR_ATS73200_ZI2
Alarm occurs when: the ATS senses a loss of utility feed power.
Software interlock: none
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: none
Enable/Disable: no
Reset Procedure: The alarm is reset at the OIT or HMI.

Sebago Heights Building Low Temperature Alarm

Alarm Tag: WIB02PS_TIT66100_YA
Alarm occurs when: If the measured temperature in the pump room drops below the Sebago Heights Pump Room Low Temperature Alarm Setpoint (GOB02_HV_TIT72030_TAL_SP) for an adjustable delay time of 0 to 120 seconds (GOB02_HV_TIT720230_TAL_TMR), then the PLC will display a SEBAGO HEIGHTS ELECTRICAL ROOM LOW TEMPERATURE ALARM.
Software interlock: none
Alarm Priority: 2 (high)
Alarm Setpoint: 0 to 150 deg F
Delay Time: 0 to 120 seconds, adjustable (default = 60 seconds)
Enable/Disable: yes
Reset Procedure: The alarm is reset at the OIT or HMI.

Sebago Heights Telemetry Failure

Alarm Tag: WIB02SD_RAD01200_YA
Alarm occurs when: (all of the message blocks go into error for 30 minutes) the station has lost communication with the master telemetry system. A value from the free running clock in the master RTU will be written to a RTU register in the Local PLC. The Local PLC will activate a "Telemetry Fail Alarm" at the OIT if the register does not change after a 15-minute fixed time delay period
Software interlock: none
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 15 minutes, fixed
Enable/Disable: yes
Reset Procedure: The alarm is reset at the OIT or HMI (once communication is re-established).

Sebago Heights Phase Fail Alarm

Alarm Tag: WIB02PR_JAX73600_YA
Alarm occurs when: the phase fail relay senses a loss of power on one or more phases of the utility supply
Software interlock: none
Alarm Priority: 2 (high)

Alarm Setpoint: none
Delay Time: none
Enable/Disable: yes
Reset Procedure: The alarm is reset at the OIT or HMI.

Sebago Heights Domestic Pump VFD Panel Power Fail

Alarm Tag: WIB02PS_SCD66200_YA
Alarm occurs when: the power fail relay opens due to loss of power to the Domestic Pump VFD Panel after a 120 second delay, then the PLC will display a SEBAGO HEIGHTS DOM PUMP VFD PANEL POWER FAIL.
Software interlock: none
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 120 seconds
Enable/Disable: yes
Reset Procedure: The alarm is reset at the OIT or HMI.

Sebago Heights Fire Pump VFD Panel Power Fail

Alarm Tag: WIB02PS_SCD66300_YA
Alarm occurs when: the power fail relay opens due to loss of power to the Fire Pump VFD Panel after a 120 second delay, then the PLC will display a SEBAGO HEIGHTS FIRE PUMP VFD PANEL POWER FAIL.
Software interlock: none
Alarm Priority: 2 (high)
Alarm Setpoint: none
Delay Time: 120 seconds
Enable/Disable: yes
Reset Procedure: The alarm is reset at the OIT or HMI.

Sebago Heights Building Intrusion Alarm

Alarm Tag: WIB02SE_SEC77000_YA
Alarm occurs when: the building door has been opened and the security prompt has not been confirmed for a delay time of 120 seconds
Software interlock: none
Alarm Priority: 4 (informational)
Alarm Setpoint: none
Delay Time: 120 seconds
Enable/Disable: yes
Reset Procedure: The alarm is reset at the OIT or HMI.

SCADA System Standards Manual

Portland Water District

September 1, 2021 – Rev. 6.0

Portland Water District

FROM SEBAGO LAKE TO CASCO BAY

MASTER INDEX

Revision

MASTER INDEX

MASTER INDEX

MASTER INDEX

MASTER INDEX

Revision

TABLE OF CONTENTS

1. SCADA SYSTEM STANDARDS OVERVIEW

1.1. INTRODUCTION

This document, the SCADA System Standards, is a record of the Portland Water District (PWD) design standards for SCADA control systems and is adopted for all of PWD’s water and wastewater treatment plants and remote facilities.

SCADA systems are installed in PWD facilities to support the operator's ability to control the process by presenting information that is complete and accurate. Data and functionality provided by the SCADA system shall be standardized between processes and systems as much possible to present a consistent and uniform presentation of the system facility operations.

1.1.1. Purpose

The purpose of this document is to provide SCADA System Standards for all PWD designers, consultants and contractors to ensure uniformity and consistency of automation control projects in Portland Water District facilities.

This approach, when used by consultants and PWD staff, will unify and standardize the control system equipment and design in contract specifications and serve as the guide for future upgrades.

For any standard to be successful, it must be constantly and consistently applied to all projects that deal either directly or indirectly with process control (i.e. the SCADA System). The SCADA System Standards is not just a list of equipment standards but an entire approach for designing, specifying, implementing, and testing. The SCADA System Standards define installation and equipment standards such as wiring methods, interface connections, operator interfaces, and other technical information. The SCADA System Standards provide a source of technical information to promote the use of standard project methodologies, instruments, equipment, and control philosophies within PWD. The SCADA System Standards furnish acceptable design practices and design standards that are in accordance with applicable codes. However, all users are expected to exercise good judgment and independent thought when applying the standards.

1.1.2. New or Upgraded Facilities

When new automation is incorporated into PWD's facilities, or existing automation is upgraded, the work shall be designed in accordance with the design standards set out in this document. This is to ensure that work done is consistent with overall goals of PWD.

1.1.3. Existing Facilities

Existing facilities will not be upgraded merely to comply with these SCADA System Standards. Where appropriate, these standards provide a policy and methods by which existing facilities should be migrated towards these Standards.

1.1.4. Dissemination

For the SCADA System Standards to be useful they must be properly distributed to project participants. Since the SCADA System Standards cover technical as well as contractual standards the dissemination of the information must be controlled carefully.

Section 1.2, Document Organization, explains how the SCADA System Standards are structured.

Section 1.3, Revisions and Updating, explains the revision process and the documentation standards to be used when further developing the SCADA System Standards.

Section 1.4 provides a Glossary and Definition of terms found in this document or normally found within the industry and pertaining to SCADA control systems.

1.2. DOCUMENT ORGANIZATION

1.2.1. Document Structure

The SCADA System Standards are divided into six parts for quick access to information and for ease of maintenance. Each part has its own numbering sequence and is divided into sections as necessary. The Index, List of Figures, and List of Tables (where applicable) precedes each part of the Standards. Appendices follow at the end of the document.

The six sections are defined as follows:

Part 1 – SCADA System Standards Overview
Part 2 – General SCADA System Standards
Part 3 – Electrical Design Standards
Part 4 – Control System Hardware Design Standards (i.e. PCs & PLCs networks, etc.)
Part 5 – Control System Software Programming Standards
Part 6 – Appendices

1.2.2. General SCADA System Standards

Part 2 of the SCADA System Standards consists of general sections used to support the standards in Parts 3 – 5. These standards apply to all sections and are intended to provide background information and document deliverable formats.

Topics covered include:

a) Basic Design Requirements
b) SCADA System Philosophy and Concepts
c) Naming Standards
d) Documentation Standards
e) Drawing Standards
f) Quality Assurance
g) Testing Standards

h) Supplies and Spare Parts
i) Warranty
j) Training Standards.

1.2.3. Electrical Design Standards

Part 3 of the SCADA System Standards consists of standards that are used to describe the design and component makeup of a control system.

Topics covered include:

a) Basic Design Requirements
b) Wiring and Cable Standards
c) Grounding Standards
d) Equipment Panel Design Standards
e) Electrical Device Standards.

1.2.4. SCADA System Hardware Design Standards

Part 4 of the SCADA System Standards consists of the hardware components required for process measurement and monitoring, data transmittal, processing, and local display.

Topics covered include:

a) System Architecture
b) Network Design Standards
c) Programmable Logic Controllers
d) PanelView Displays
e) Control Device I/O Interfaces
f) Instrumentation.

1.2.5. SCADA System Software Programming Standards

Part 5 of the SCADA System Standards consists of the software components required for system development, PLC and HMI/OIT programming.

Topics covered include:

a) General SCADA Software Development Standards
b) User Interface Development Standards
c) PLC Programming Standards.

1.2.6. Appendices

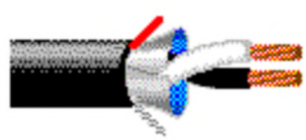
Part 6 of the SCADA System Standards contains numerous appendices containing specific details on several topics.

Topics covered include:

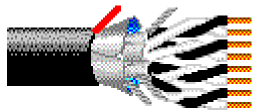
a) Control Narrative Standards
b) Naming Convention Standards

c) Documentation Standards
d) Standard Components
e) FAT/SAT Documents
f) PLC Code Standards
g) HMI/OIT Display Standards

1.3. GLOSSARY AND DEFINITIONS

Term	Definition
AESS	Application Engineering Service Supplier
Administrative Network	A network or PCs and servers that is not part of the SCADA System. This network is where all of the PWD staff's desktop PCs reside, and it is connected to the SCADA Network through the firewall.
API Node	A PC application that is usually running on a View node. This application is the interface between the PI node and the SCADA node. This resides on a View node on a redundant SCADA node system because the View node always knows which SCADA node is active.
ATR	Automatic Transfer Relay. This is a relay that will provide a power bypass function to a UPS unit. The relay will switch a SCADA panel between UPS and building/utility power in the event of a UPS failure. See Section 3.1.3 for more details.
Backbone	The primary communications path on a LAN and on which segments or network devices attach. A backbone is typically fiber optic and can support bandwidth capacities higher than the devices can communicate. A typical example of a network with a ring topology backbone is the segments that create the ring itself.
Cable	An individual signal wire consisting of two or three conductors, and possibly a  shield.
Control Circuit	Any circuit operating at 120 volts AC whose principal purpose is the conveyance of information, and not the conveyance of energy, for the operation of an electrically powered device.
Control Loop	A combination of one, or more, interconnected instruments arranged to measure or control a process variable, or both. (*Source ISA Standards and Practices for Instrumentation*)
Control Room	An environmentally controlled room intended for housing digital control equipment, computers, large control panels, etc., and generally intended to be regularly occupied by operators.
Data Sheets	Data sheets as used in this specification shall comply with the requirements of ISA TR20.01.00

Term	Definition
Electrical Isolation	Pertaining to an electrical node having no direct current path to another electrical node. As used in this million bits per second specification, electrical isolation refers to a device with electrical inputs and/or outputs which are galvanically or optically isolated from ground, the device case, the process fluid, and any separate power supply terminals, but such inputs and/or outputs are capable of being externally grounded without affecting the characteristics of the device or providing a path for circulation of ground currents.
Ethernet	Common name for a type of shared-media, packet switching, contention-oriented LAN. Ethernet uses the CSMA/CD media access method, and can operate over several different media. The original standard specified a transmission rate of 10 million bits per second.
Fail	Hardwired shut down mode or virtual condition that prevents the equipment from operating in a normal state.
Fast Ethernet	Common name for the LAN specified by IEEE 802.3 and CCITT 8802.3. A base band, local area network that operates at 100 million bits per second and can be extended up to 1.5 kilometers of cable. It uses a carrier sense multiple access/collision detection protocol.
Firewall	A network router that is a protective link between the SCADA Network and the Administrative network.
Four-Wire Transmitter	A transmitter which derives its operating power supply separate from the signal transmission circuit and therefore requires separate power supply connections. As used in this specification, four-wire transmitter refers to a transmitter that provides a 4 to 20 milliampere current regulation of signal with a maximum external circuit resistance of 600 ohms separate from an external 120-volt alternating current power source. Referred to as a self-powered transmitter.
Global OIT	Global Operator Interface Terminal. The graphical interface between the user and the SCADA system. This OIT will reside on the PLC network and it will not be specifically assigned to a single PLC.
HMI	Human Machine Interface. The graphical interface in the main control room between the user and the SCADA system. Normally used by an Operator to monitor and control the process.
LAN	Local Area Network. A system of physical cables and associated procedures to allow the exchange of information between two or more personal computers, host computing system and computer terminals. The most common LANs are Ethernet (IEEE 802.3 and CCITT 8802.3).
LOCAL	Local-Off-Remote Switch is set in the LOCAL position and commands to the field device are initiated through the local hardwired buttons. Commands from the PLC are disabled.
Local Control Panel (or LCP)	An electrical enclosure that could contain: PLC, Local OIT, Global OIT, or any other SCADA related equipment. These enclosures should not be located in any electrically hazard rated area.
Local Panel	An electrical enclosure that has push button and status lights that can be used by an operator to control and monitor a sub process of a treatment plant or pump station. Usually these panels are used for hazardous areas where an OIT cannot be used. All devices and equipment in a local panel have to be intrinsically safe or the panel itself must be explosion proof.

Term	Definition
Local OIT	Local Operator Interface Terminal. The graphical interface at a PLC control panel between the user and the SCADA system. This will be a direct short range serial communication link between the PLC and the OIT. The local OIT will be independent of the PLC network for control functions. The Local OIT will be connected to the PLC Ethernet for facilitating remote programming when installed in the treatment plant.
L-O-R	A Local-Off-Remote switch, located at the associated field device, a local panel, or the MCC.
Multi-conductor Cable Assembly	An assembly composed of more than one cable. It typically has 12 or more cables. Each cable will consist of two or three conductors and are individually shielded. The main assembly will have a rip cord. 
Multimode Fiber	Glass fibers, with a common diameter in the 50-to-100 micron range for the light carry component (the most common size used by PWD is 62.5 microns). Multimode fiber provides high bandwidth at high speeds over medium distances. Light waves are dispersed into numerous paths or modes through the cable's core typically 850 or 1300nm. Typical multimode fiber core diameters are 50, 62.5, and 100 micrometers. However, in long cable runs (greater than 3000 feet [914.4 m), multiple paths of light can cause signal distortion at the receiving end, resulting in an unclear and incomplete data transmission.
OFF	Local-Off-Remote Switch is set in the OFF position and commands to the field device from the local hardwired controls or buttons are disabled. Commands from the PLC are disabled.
Operator	The person responsible for running the process operations. Typically interacts with the process through use of an HMI or OIT.
Panel	An instrument support system that may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems. Unless otherwise specified or clearly indicated by the context, the term "panel" in these SCADA System Standards shall be interpreted as a general term that includes flat panels, enclosures, cabinets and consoles.
PI Node	A server class PC that collects data from the SCADA Nodes through the API node. This data is available for PWD staff for other applications and troubleshooting. The primary uses of this data are trending and reports.
PLC	Programmable Logic Controller
PLC Network	A Ethernet network of PLCs. PWD prefers to use a star configuration, but the SLWTF PLC Network is a star/ring hybrid because of the legacy fiber installation.
PLC Panel	Generic name of a panel that contains a PLC and the necessary support devices for operation of the PLC.
Power Circuit	Any circuit operating at 120 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.

Term	Definition
Ready	Ready is defined as all hardwired conditions, including power, satisfied to permit remote control of the equipment.
Real Time	Pertaining to a system or mode of operations in which computation is performed during the actual time that an external process occurs, in order that the computation results can be used to control, monitor, or respond in a timely manner to the external process.
REMOTE	Local-Off-Remote Switch is set in the REMOTE position and commands to the field device are initiated through the PLC. Commands from the PLC may be initiated by operator command or a control strategy.
SCADA PC Network	An Ethernet network of PCs and/or servers that connect the SCADA nodes, View nodes, PI node, and other SCADA System PC’s together. This will be a Fast Ethernet configuration that will consist of auto speed selection elements.
SCADA Node	A PC or a server class PC that scans and collects data from the PLCs. This can be a single or a redundant configuration. If it is a single configuration, the SCADA Node will be a development node has the capability of configuring the SCADA System. If it is a redundant configuration, the SCADA node could either be a development node or a runtime node. The latter has all of the runtime functionality, but none of the programming functionality.
SCADA System	Supervisory Control and Data Acquisition. The top-end control system for remote monitored sites comprised of hosts, multiple workstations, peripherals, front-end processors, and is the user interface for monitoring and control, trending, report generation, and other functions commonly provided in a human-machine interface for SCADA
Signal Circuit	Any circuit operating at less than 120 volts AC or DC.
TCP/IP	Transaction Control Protocol/Internet Protocol A communication protocol that allows multi vendor systems to participate on a network.
Two-Wire Transmitter	A transmitter that derives its operating power supply from the signal transmission circuit and therefore requires no separate power supply connections. As used in this specification, two-wire transmitter refers to a transmitter that provides a 4 to 20 milliamp current regulation of signal in a series circuit with an external 24-volt direct current driving potential and a maximum external circuit resistance of 600 ohms. Referred to as a loop-powered transmitter.
UPS	Uninterruptible Power Supply.
View Node	A PC that has the HMI capability, but works through the SCADA Nodes. The View cannot communicate directly with the PLCs.
WAN	Wide Area Network. The radio and leased-line networks that support communications to the remote sites to include the East End WWTF, Sebago Lake WTP, and Douglass Street Administration Building.

Revision Memo

Rev. 0	May 7, 2004	Draft Version for comments
Rev. 1	June 18, 2004	Final Version for comments
Rev. 2	July 30, 2004	Final Project Version
Rev. 3	April 14, 2006	First PWD Version
Rev. 4	February 27, 2009	Numerous Minor Revisions
Rev. 4.1	August 1, 2012	Minor Definition Changes
Rev. 5.0	September 20, 2016	Two New Definitions Added: AESS & ATR
Rev. 6.0	September 1, 2021	Removed formatting descriptions and simplified

TABLE OF CONTENTS

LIST OF FIGURES

2. GENERAL SCADA SYSTEM STANDARDS

2.1. BASIC DESIGN REQUIREMENTS

The SCADA system must support the Operator's ability to control the process by presenting information to him or her that is complete and accurate. Initial considerations in designing the SCADA system are: to understand the process, to analyze possible disturbances or variations imposed on the process system, and to define the strategies or goals for reliably controlling the process.

All SCADA systems rely on instrumentation and sensors to provide monitoring and control capabilities. Therefore, it is imperative that these devices be given careful consideration as an essential part of any SCADA system. In addition, standardization of hardware, software, and functionality allows PWD the ability to benefit from cost effective, uniform, and consistent SCADA Systems.

All of the elements discussed here in Section 2 are discussed in much greater detail in other sections of this document. The purpose of this section is to provide an overview of the requirements for the SCADA System.

Functions provided by the SCADA System are used in sites throughout PWD and they shall be standardized where ever possible. The following functions should be available in every SCADA System at a PWD facility:

2.1.1. Process Monitoring

All equipment involved with a process or in support of a process should be instrumented as necessary to provide, but not be limited to: flows, levels, speeds, pressures, temperatures, positions, and equipment status.

2.1.2. Equipment Fault Monitoring

Any time the field equipment fails to respond to commands, or changes of status without an Operator or a strategy intervention, the SCADA system shall generate an alarm.

2.1.3. Process Controls

The SCADA System has four of levels of control:

- Local Control
- Local OIT
- Global OIT
- HMI

Each level has a defined functionality that is detailed in the following sections.

2.1.3.1. Local Control

All equipment shall be provided with the means to operate the equipment locally in LOCAL mode. Such control may be at the device itself or at the associated MCC or local panel. Local control shall be fully independent of PLC control, and it is activated by placing the Local-Off-Remote (LOR) switch in the LOCAL position. Indication of the position of all LOR switches shall be provided on the HMI and OITs. Local control shall override PLC/SCADA control and operate if the PLC/SCADA control system fails. It should be noted that the LOCAL position disables any interlocks programmed in the PLC or backup control system, and only interlocks that are “hardwired” to the starter circuit will still be applied.

2.1.3.2. Local OIT

The Operator should have control of only the elements controlled by the PLC contained within the control panel that the Local OIT is mounted on. This OIT is directly connected to the serial port of the local PLC. The Local OIT shall be independent of the PLC Network. In a treatment plant environment, or other similar sites where multiple PLCs are located, the OIT is connected to the PLC Ethernet for remote programming purposes only. Exceptions to this standard will be approved on a case by case basis.

2.1.3.3. Global OIT

The Operator has control over whatever was designed into the Global OIT. The Global OIT can have access to any PLC that is communicating on the PLC Network. That means that the Global OIT is dependent on the health of the PLC Network. If the PLC Network fails, the Global OIT fails.

Global OITs are usually required by the SCADA System for special functions, or equipment locations, which cannot be performed by an HMI or a Local OIT. The reasons for requiring a Global OIT may vary, but they could include: an “OIT to PLC” distance that exceeds the maximum serial link cable length specification.

2.1.3.4. HMI (Human Machine Interface)

The Operator should have control of all major equipment and setpoints from the HMI. The Operator must be able to respond to process changes or alarms by operating valves, turning on pumps and motors, and changing the setpoints on control loops. Control should be executed primarily through the HMI in the control room, or an HMI in a remote site. As a backup, control through a Local OIT is available.

Global, and some Local, OITs are positioned to facilitate some operational procedures that can not be performed from the control room. An example of this would be a bulk storage tank filling operation that would require an operator present at a site outside of the control room.

2.1.4. Process Variable Monitoring (HMI and PI Trending)

Variables such as flow, level, temperature, speed, and measurements from analytical instruments shall be able to be trended historically. An Operator should have the ability to call up real-time or historical trends that display interdependencies between process variables.
In some cases trending is done redundantly on both the iFIX SCADA Nodes (via the HTR application) and the PI Node. The redundancy maximizes the reliability of the trending operation, plus it gives multiple points of access to the data. The iFIX HTR historical data can only be accessed through an HMI, or SCADA PC (either a SCADA Node or an iClient View Node). The

PI historical database can be access from both the SCADA PC Network, and the PWD Administrative Network (the SCADA System Architecture will be discussed in Section 4).

2.1.5. Constraint or Interlocks

The SCADA system should provide an Operator with reasons why the command issued failed. Equipment interlocks that inhibit the commanded action need to be included in as-built record documentation.

2.1.6. Instrumentation Faults

The SCADA system should have the ability to identify and react to malfunctioning instrumentation. Input signals that are abnormal or out of range should be alarmed. In addition, the SCADA system must be capable of modifying or inhibiting control that uses signals identified as abnormal or out of range.

2.1.7. Settings

An authorized Operator should be able to change settings through a HMI or OIT. This function must be protected via the security levels discussed in a later section of this document and it may be made available only from selected workstations or OITs.

2.1.8. Report Generation

The primary SCADA based report generating software is through the Hach WIMS (Water Information Management Solution).

2.2. SCADA SYSTEM PHILOSOPHY AND CONCEPTS

This section defines the general control and monitoring philosophy for PWD facilities. SCADA Systems are used within PWD facilities to provide real-time monitoring and control of the process operations, and to provide Operators a meaningful interface to process operations.

2.2.1. Facilities Control System Philosophy

PWD facilities shall be automated to the greatest extent possible, relieving Operators of time consuming and repetitive operations, allowing them to focus on other activities. To achieve these objectives, the SCADA system shall be designed such that:

- The process shall be instrumented to that extent required to allow automated, unmanned operation.
- Process operations shall be automated, and controlled by process control strategies executed in the PLCs.
- A level of redundancy is provided, when possible, that a failure of any PLC, or PLC I/O Card, will not affect more than one process area, thus allowing for a partial operation of the facility.

- In the event of PLC failure, all equipment can be operated locally by the use of manual switches (LORs).
- Most PLCs shall be provided with a local operator interface terminal (Local OIT) using a touch screen interface, rather than hardwired pushbuttons, so that each process area can be controlled from the local control panel and the PLC (See Section 1.4, Glossary for details). A Global OIT is dependent on the health of the PLC network, and it cannot be used as a substitute for a Local OIT. The Local OIT will be connected directly to the PLC via. a redundant ethernet cable, making it independent of the PLC Ethernet network.
- In the event of Ethernet network failure, all equipment can be operated by the use of the Local OIT located on the PLC control panels.
- The PLC shall be powered from a UPS that is capable of providing power to the PLC and the loop powered instruments. Transmitter powered instruments, or instruments not powered from the PLC panel shall be powered by its own UPS if it is deemed critical to the process by PWD. The amount of running time provided by the UPS is specified in Section 3.1.3, bullet item #3.
- Provide the management tools, or data, for all chemical usage. This would include, but are not limited to, the following elements: index counter (a continuous running total value that is reset at a prescribed large value, i.e. 1,000,000), daily totals, yesterday's total, current day running total, dosage rate, re-order prompt, current inventory, and amount of free storage space.
- Provide the management tools for all major equipment. This would include, but not limited to, runtime clocks that are reset at a prescribed large value, i.e. 1,000,000.
- Provide a real time clock and date synchronization of all SCADA PCs, Servers and PLCs (see the details in Section 5).

2.2.2. Remote Site Control System Philosophy

- Remote sites shall be instrumented to that extent required to allow automated, unmanned operation.
- Primary control shall be by PLC.
- For wastewater pump stations, a backup control system shall be provided that will assume control of the process following PLC failure.
- Remote sites should be capable of being monitored from a central control facility.
- Some remote sites will also be capable of being controlled from a central control facility. This would include large wastewater pump stations, water pump stations, and some wastewater treatment facilities.
- PLCs shall be powered from a UPS that is capable of providing power to the PLC and the loop powered instruments. Transmitter powered instruments, or instruments not powered from the PLC panel shall be powered by its own UPS if it is deemed critical to the process by PWD. The amount of running time provided by the UPS is specified in Section 3.1.3. Each UPS will be provided an ATR, Automatic Transfer Relay, that will maintain the panel power in the event of a UPS failure (Section 3.1.3).
- In the event of PLC failure, all equipment can be operated by the use of manual switches (LOR).
- Provide the management tools, or data, for all chemical usage. This would include, but are not limited to, the following elements: index counter, daily totals (for yesterday), current day running total, dosage rate, re-order prompt, current inventory, and amount of free storage space.
- Provide the management tools for all major equipment. This would include, but not limited to, runtime clocks that are reset at a prescribed large value, i.e. 1,000,000.

2.2.3. Control Modes

When process equipment is provided with local and automatic control capability, coordination between local control and control provided through PLCs is extremely important. Control Modes are coordinated through the use of LOCAL-OFF-REMOTE (LOR) switches. Different terminology and nameplate engravings are in use as PWD facilities for these switches, such as HAND-OFF-AUTO. It is a requirement of this Standard that as equipment is replaced or upgraded, nameplate engravings be changed to match the terminology defined by this Section.

The following control modes are defined for use in PWD facilities:

- LOCAL: Changes to process equipment are initiated from the LOR switch. A pump or motor in the LOCAL position shall startup if all of the hardwired interlocks are satisfied. A valve in the LOCAL position may be opened and closed through the use of local OPEN and CLOSE buttons or a switch. In some instances, putting the LOR switch into the LOCAL position will immediately open the valve without further action on the operator’s part.

- OFF: All commands to the device are disabled. A pump in the OFF position will be stopped. Moving the LOR switch in this position does not meet the requirements of the Lockout/Tagout safety policy.

- REMOTE: Changes to process equipment are initiated from the PLC, or backup control system The REMOTE control mode has two states, which may be changed from the HMI or OIT.
  - REMOTE-MANUAL: Changes to process equipment are initiated by an Operator. This may be from the OIT or the HMI in the control room.
  - REMOTE-AUTO: Changes to process equipment are initiated by a control strategy resident within the PLC logic.

When in REMOTE mode, switching from MANUAL to AUTO is performed using a dedicated faceplate (or popup) graphic on an HMI or OIT. Switching from REMOTE-MANUAL to REMOTE-AUTO changes the current condition of the equipment (e.g. RUNNING or OPEN) to that required by the control strategy. Switching from REMOTE-AUTO to REMOTE-MANUAL does not change the current condition.

EMERGENCY STOP buttons and important safety interlocks shall be operable independent of the position of any other switches or control modes.

2.2.4. Process Monitoring

All process parameters such as flows, pressures, levels, etc., are to be displayed as required on the HMI and the OIT. The status of major process equipment shall also be indicated required on the HMI and the OIT.

All process and equipment faults and abnormal situations shall be indicated and alarmed at the OITs and on the HMI workstations. All alarms are generated within the PLCs and transmitted to the HMI.

Interfaces (i.e. PLCs, SCADA Nodes, PI Nodes, OITs, PLC I/O Cards, etc.) must provide not only process information but also status information. For example, if a PLC to PLC link fails, the failure must be indicated, annunciated, or alarmed to operator.

Most pumps, valves, gates, process equipment (i.e. blowers, mixers, etc.), and power systems shall have signals to the SCADA system which define the equipment’s state of readiness, operation and control mode. PWD reserves the right to exempt some equipment from this requirement. Typical items exempted include: hand operated valves, sump pumps, room lighting systems, etc.

The following items are general guidelines for the selection of points that will be monitored by the SCADA System. The following list of items is not intended to be complete, and all inclusive.

a) Analog values for all major process variables, such as flow, level, and pressure

b) The status and health of all major process equipment (including support equipment, i.e. motors, VFD’s, etc.) such as pumps, blowers, compressors, etc.

c) The status of all process variables or equipment monitored or controlled by a PLC.

d) The status of all LOR switch “Local” and “Remote” positions.

e) Limit switches on all computer controlled multi-state valves (i.e. open and closed).

f) Limit switches on all valves and gates used for flow routing, sluice gates and other critical equipment.

g) Motor speed and motor amps for all variable speed devices that are to be monitored or controlled by the SCADA system.

h) All safety indicators (e.g., chlorine leak, fire detection, gas detection, security, etc.).

i) Valves used strictly for maintenance such as isolation valves on pump suction and discharge will generally not be monitored.

2.2.5. Alarm Monitoring Guidelines

Alarms are referred as “Operator Annunciation”, and the details are thoroughly described in Section 5.2.5. The following general guidelines apply:

a) “Alarm” is the industry’s accept term that covers all types of operator annunciations. PWD has adopted the use of the term “Operator Annunciation” for this function. They are broken up into two major types: Alarms and Warnings. A complete table of all the accepted variations of these annunciations is given in Table 5.2.5-1. The operations staff is responsible for making the final determination of the annunciation type assigned to specific process events. The intent of the following descriptions is to give a general interpretation of these major annunciation types:

   a. **Alarms** are defined as critical annunciations (priority 1, 2 and 3) that require an operator to perform an action. An action could take the form of a variety of things such as: high-high alarm setpoints, low-low alarm setpoints, turning off a pump, shutting down a process, taking manual control of an automated process, notifying a maintenance person, resetting a breaker, evacuating the building, etc. Alarms require, at minimum, a reset action. The reset could be a software button on an HMI display or a hardwired button on a control panel. Only after the reset is performed can the alarm be cleared when the alarm condition is resolved. Alarms will be audibly annunciated using the control room, or building page, alarm horn.
   b. **Warnings** are defined as non-critical annunciations (priority 4) that do not require an operator to perform an action. Some typical warnings include: high analog point setpoints, low analog point setpoints, low RTU polling, lag pump started, etc. Warnings will not generate an audible annunciation (a.k.a. alarm horn), and they will automatically reset themselves when the warning condition has cleared.

b) The PLCs will generate annunciation signals for all process equipment, process values, equipment status changes, extreme signal levels (value out of range), excessive rates of change, controlled device failure to respond, and system diagnostic signals. The PLCs will generate all analog point limit value alarms and warnings. PLCs will manage the resetting of annunciation signals.

c) All annunciation conditions shall be reported to the Local OIT, all HMIs, and, if appropriate, a Global OIT for Operator acknowledgement and response as determined by the annunciation priority.

d) Annunciation management at the Local and Global OITs will be different than at the HMIs. An unacknowledged annunciation within a PLC will be indicated at the Local OIT, and any appropriate Global OITs. The unacknowledged annunciation will display on the OIT video screen (both on the process display and the alarm summary display), and an alarm light will be turned on. The operator can acknowledge this annunciation via the OIT, and the light will be turned off. Also if the unacknowledged annunciation is cleared before it is acknowledged, the light will be turned off. Also if the annunciation is acknowledged by the HMI, the light will be turned off.

e) Each annunciation will be assigned a priority (iFIX configuration setting for alarm blocks) reflecting its severity and importance. Figure 2.2.5-1 shows a table in the upper right quadrant that illustrates the iFIX priority levels. Refer to Section 5.2.5 for more details. Below is a translation table of terms between iFIX priority and the SCADA Standard levels:
   a. Priority 1 (critical alarms).
   b. Priority 2 (high priority alarms).
   c. Priority 3 (low priority alarms).
   d. Priority 4 (information warnings).

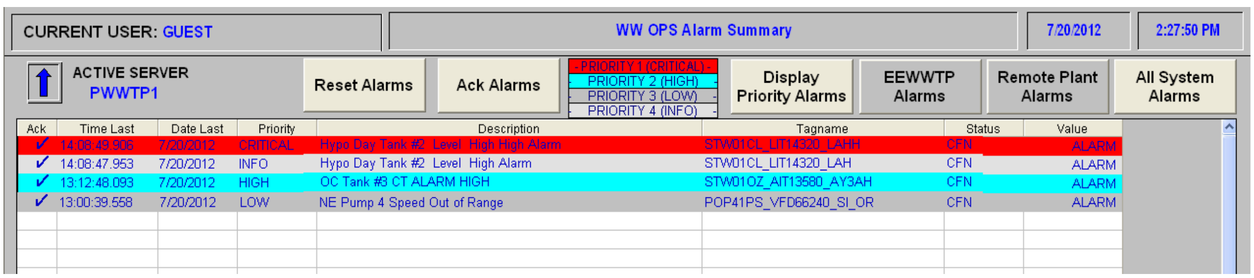


Figure 2.2.5-1 Screen Capture of the Alarm Summary Display

f) The Alarm Summary Display will have the following columns:
   a. Ack.
   b. Time Last.
   c. Date Last.
   d. Priority.
   e. Description.
   f. Tagname.
   g. Status.
   h. Value.

2.2.6. Process Control Narrative

2.2.6.1 General

Process Control narratives shall be used to describe how each process is to be controlled. These narratives are important for PLC programming, HMI and OIT development, and plant operation. These narratives should be organized and divided based on a logical assessment of the process being controlled. Each process narrative identifies all associated equipment within the control scheme for each individual process element, or subdivision.

The Process Control Narrative describes how the SCADA system interfaces with the process. It gives details on the process indicators that need to be monitored to ensure that the process is operating correctly. This includes complete listings of all device names, I/O points, control loops, tag names, control modes.

The Process Control Narrative shall follow the format described as follows:

2.2.6.2 Narrative Structure

The narrative structure described below is PWD's preferred method. Other methods are acceptable based on PWD's approval. The information contained within the narrative is the same regardless of the structure or format of the narratives. Examples of PWD's preferred narrative structure can be found in Section 6.1, along with additional details. The following section outlines the basic structure to be followed and described in the following paragraphs:

GENERAL INFORMATION (For all elements within a project)

- Overview
- Details.

CONTROL NARRATIVE SECTIONS (Repeated for each Control Strategy or Control Program)

- Title
- 1 Description
  - 1.1 Process and Instrument Drawings

- 2 Equipment Operation
  - 2.1 Local/Off
  - 2.2 Remote-Manual
  - 2.3 Remote-Automatic

- 3 Power Failure Recovery

- 4 Alarms and Interlocks

a) General Information

The following describes the information to be included in the applicable sections.

- Overview – A description of the goals of the project, or proposed process control changes, and how it fits into the overall SCADA system. Shall include interfaces to other process control programs, or narratives, that are affected by this project. It shall reference drawings, or auxiliary information required to interact with the control narrative.
- Details – This is a list of all the control programs and control strategies that are described in Control Narrative Sections. A mockup of the subprocess overview HMI/OIT display is presented if it is appropriate to the project. The Details section shall also include, but not limited to, the following list of additional item:
    1. HMI/OIT display titles (popups and overviews)
    2. Description of PLC Hardware Changes (if needed)
    3. Description of Test Requirements (i.e. FAT, SAT, SAD, etc.)
    4. Description of the Project Execution Requirements and Constraints

b) Control Narrative Sections

The following describes the information to be included in the applicable sections.

- Title – Name for the Control Program or Control Strategy (Control Programs are prepared for individual pieces of equipment and Control Strategies are prepared for groups of equipment).

- 1 Description – A brief description of the goals of the control strategy or program.

    - 1.1 Process and Instrumentation Drawings – A listing of all related P&IDs, Loopsheets (if available) and other associated drawings.

    - 1.2 Field I/O and Status Indicators – A table of all of the hardwired I/O and logic points. This table will have the tagname and the description of the point. Subsections within the table can be used to group table rows for clarity purposes.
    - 1.3 Calculated Values - A table listing the values calculated (runtime, number of starts, totalizers, etc.) within the PLC's. This table will use the same column structure as section 1.2 above.

- 2 Equipment Operation – Describes how the process is to be controlled within the required three modes of control: Local/Off, Remote-Manual and Remote-Automatic (see Section 2.2.3 for details).

    - Includes step-by-step descriptions to how they function in all control modes. **This is the most important section because it gives the purpose for the control strategy.** This section shall have at minimum, but not limited to, the following subsection:
        - 2.1 Local/Off
        - 2.2 Remote-Manual
        - 2.3 Remote-Automatic
    - Description of any hardwired interlocks that may alter equipment operation and all control modes associated with the device.
    - Description of all programmed interlocks and setpoints that are required to drive the process.

- o Alarms and Warnings – Provides specific details for all points that have alarming parameters. Alarm and warning priority level, display requirements, and messaging content are to be included.
- o Signal Conditioning – If any signal conditioning is required, it will be included under this section.
- o Calculated Values – If any processing of any SCADA value is needed. This could include: totalizers, dosage rates, level change/flow estimations, etc.
- o Includes descriptions of all field selector switches, including all I/O that is part of the process.

- 3 Power Failure Recovery - A description of all of the fail-safe provisions of the equipment related to the control program or strategy. If a power failure occurs (either through a utility failure or through an accidental panel shutdown), what is the safest state to leave the equipment to prevent a safe hazard or to prevent damage to equipment.

- 4 Alarms and Interlocks
  - o 4.1 Interlocks
    - Provide a listing of equipment interrelationships. For example a valve is required to be open before a pump is started
  - o 4.2 Alarms
    - Provide specific details for all points that have alarming parameters that are not following the standards described in Section 6.6.5. For these nonstandard alarms and warnings provide: priority level, display requirements, and alarm text.
    - Listing of all discrete annunciation conditions and their priority settings (see Section 2.2.5). For analog related annunciations, all limits will be given for high-high, high, low, and low-low limits.

2.3. NAMING STANDARDS

Each piece of equipment (or asset) in PWD facilities requires a unique identification asset name. These asset names will be permanently attached to the associated equipment and used to develop tagnames for all SCADA related documentation including process flow diagrams, P&IDs, interconnect drawings, PLC code symbols, O&M manuals, loopsheet drawings and PI and iFIX system databases. The format of the tagnames must be carefully followed by all projects dealing with SCADA systems or related instrumentation.

<u>The contractor and PWD will work together at the onset of a project to establish the needed tagnames for a given project.</u> Once these tagnames are developed, sub-element names within the PLC and HMI programming can be developed by the designer alone by using the following standard.

Failing to follow the tagnaming standards may lead to database configuration problems which will make interfacing, documenting, and troubleshooting SCADA systems, operational data, and report generation extremely difficult.

2.3.1. Tagnaming Standard

A tagname is a combination of alphanumeric characters. The instrument naming is a combination of asset naming identification and process loop numbering schemes. Refer to Section 6.2.1 for the details. PWD reserves the right to review and request a modification of any tagnames assigned by the contractor.

2.3.2. Loop Assignment Procedure

There is not an exact recipe for assigning loop numbers. A good understanding of the process and a good set of P&IDs are critical to correct assignment of loop numbers.

First, each asset must have a unique name. Asset naming consists of two main components: the prefix and the suffix. The prefix consists of a location code and a process code and these elements are discussed in Section 6.2.1. The suffix consists of two components: the three (3) letter PWD asset type and a five (5) digit loop number (see Section 6.2.1 for PWD asset type designations). Based on this format, different types of assets will share similar loop numbers if they are related to the same control loop or process group.

The procedure is found in Section 6.2.1 deals with the typical loop numbering process that has been followed for naming loops. In cases where deviation from the typical numbering procedure is required, good engineering judgment is needed to number the loops.

PWD should have an opportunity to review loop and tagname creation prior to the code being developed.
.

2.4. DOCUMENTATION STANDARDS

This section defines the general content and format for the documentation that is a requirement for all SCADA system projects. Refer to Section 6.3 for some specific examples of the following documentation components.

The Portland Water District is the sole owner of any document produced as a result of a contract with an outside organization, and it reserves all rights to these documents.

SCADA system documentation should include the following major parts (PWD reserves the right to exclude any of the following elements from a specific project based on the needs of that project):

- Functional Design Documentation
- Detail Design Documentation
- Operations and Maintenance (O&M) Manuals
- System Engineer’s Manuals
- Site Configuration Inventory
- Record Documentation.

2.4.1. Functional Design Documentation

Functional Design Documentation shall include the following:

a) Product Information for O&M Manual

Product information shall include, but not be limited to: vendor PDF manuals, catalog cuts, data sheets, performance surveys, test reports, equipment lists, material list, diagrams, pictures, and descriptive material. The product information shall cover all items including mechanical devices, mounting components, wiring, terminal strips, connectors, accessories, and spare parts. The submittal information shall show the standard and optional product features, as well as all performance data and specifications.

b) Panel Fabrication and Layout Drawings

Panel fabrication drawings are scaled drawings that shall show the physical dimensions, materials, and construction of panels, cabinets, terminal boards, or other electrical or mechanical equipment enclosures. These drawings show the physical arrangement and mounting of all components in or on a panel, terminal board, cabinet, or enclosure. These drawings show the physical dimensions, and the space and mounting requirements of mechanical, electrical, control and instrumentation devices or pieces of equipment. Other information provided may include ventilation requirements, locations of connections, weight, and paint color, material and dry film thickness.

As a minimum, panel fabrication and layout drawings shall include a bill of materials: front, back, and section views; the locations of all components to be mounted in or on the panel, cabinet, console, enclosure or assembly; drawing scale; nameplate engraving schedule; and structural materials and supports. All drawings shall be scaled. Overall dimensions and minimum clearances shall be shown. Sufficient detail shall be included to demonstrate material choices, outward appearance, and construction methods.

2.4.2. Detail Design Documentation

Detail Design Documentation shall include the following:

a) Panel Wiring Drawings

Panel wiring drawings (or schematics) shall show all connections internal to each panel, and specifically power wiring connections, wiring not shown on Instrument Loopsheets, network connections, and connections to the PanelView OIT. There shall also be a Bill of Materials (BOM) for the panel that provides, but is not limited to: Manufacturer, Model Number, Serial Number (as built information), Sizing Specification, Description, etc.

b) Instrument Loopsheet Drawings

Instrument loopsheet drawings shall be provided for each loop, and shall conform to ISA S5.4. Each loopsheet shall be documented such that there is one loop per sheet with each connection point shown. Loopsheet drawing (or diagrams) shall be provided with all optional information as outlined in ISA S5.4. An example of the required format is presented in Section 6.3.1. Additional details are provided in Section 2.5.5.

c) Network Drawings

Network Drawing (or Diagrams) shall show all interconnections between SCADA components (i.e. PLCs, SCADA PCs, HMIs, OITs, etc.). All Ethernet and serial connections shall be shown along with all network switches. Other required elements that shall be shown on the diagrams include, but are not limited to, the following:

1. Network Name
2. Description
3. Asset Name
4. IP Address

All major facilities at PWD have existing Network Drawingss. Any modifications to these sites shall require revisions to the diagrams. An example of a Network D can be found in Section 6.3.5.

d) Equipment Lists (or Bill of Materials)

The Equipment Lists shall provide, but are not limited to:

1. Serial Number
2. Service Tag Number (for PCs)
3. Express Service Code Number (for PCs)
4. Part Number
5. Description
6. Quantity
7. Manufacturer
8. Purchase Price
9. Supplier
10. Warranty Time
11. Wiring Schedules (if needed)
12. Cable Schedules (if needed)
13. Conduit Schedules(if needed)
14. Instrument Indexes (if needed)

The Equipment List shall be provided in an **Excel spreadsheet format**. The list shall be supplied to PWD in an “as-built” revision.

e) Software

The software documentation shall provide a comprehensive description of all software necessary for the operation and maintenance of all components of the SCADA system. It shall include a description of any engineered or custom software required to meet the specifications.

Documentation shall be furnished for the PLC programming software, PanelView programming software, and any PLC loadable modules or other custom software. This document shall include, as a minimum, but not limited to:

- A list, with descriptions, of any PLC loadable modules used for configuration.

- A list, with descriptions, of any other custom software used.
- Cut sheets or product data sheets for the non-standard software required for meeting the specifications.
- PLC Ladder rung comments and cross-references
- PLC Tagname Assignments
- For the PLC, provide both electronic (both PLC loadable files and PDF formatted report files) and printed copies
- I/O Spreadsheet, see Section 6.3.3 for the details.
- For the PanelView, provide both electronic (both PanelView loadable files and PDF formatted screen capture files) and color printed screen captures copies.
- For the iFIX HMI, provide both the electronic files (i.e. Database Builder CSV files of the new database points, loadable PIC files for the HMI displays and PDF formatted screen capture files of the new HMI displays) and color printed screen captures of the new HMI displays.
- Provide a 'Memory Map' showing the addressing for each signal from the remote PLC to the MTU (where applicable). An example is shown in Section 6.3.5.

  Note: PWD can provide examples for many of these documents from recent projects upon request from the integrator.

2.4.3. Operations and Maintenance (O&M) Manuals

For any piece of equipment that is not listed as a standard component is section 4, the O&M Manual Documentation typically includes the following:

a) Instruction Manual

The instruction manual shall be illustrated in detail to the component level, including assemblies, subassemblies, and components. It shall contain a detailed analysis of each major component so that maintenance personnel can effectively service, inspect, maintain, adjust, troubleshoot, and repair the equipment.

Each manual shall include a Table of Contents, arranged in systematic order, and shall be divided into the following sections:

- Introduction: The purpose of the manual, special tools and equipment, and safety precautions.

- General Information and Specifications: A general description of the equipment item, and specifications of its major components.

- Listings: Supplier's name, address, web site information, and telephone number. Each product shall include name, address, web site information, and telephone number of subcontractor, or installer, recommended maintenance contractor, and local source for replacement parts.

- Theory of Operation: A description of how the control program, or control strategy, operates the process equipment. This section shall be written so that an equipment operator can understand how the automatic control operates and how an operator can interface with the automatic control. This shall include, but not limited to:

    a) Equipment interlocks, alarms, and controls details. This is in addition to the comments described in the PLC code.
    b) Details describing and illustrating all HMI/OIT display elements. This would include, but not limited to: setting entries, control points and monitoring points. This is especially critical for any special, or non-standard, control strategy.

- Software: Listing and explanatory text for any software or firmware. This includes loadable modules used in the PLC at each site.

- Operation Procedures: The locations and functional descriptions of all controller indicators, or displays installed at each site.

2.4.4. System Engineer's Manuals

For any piece of equipment, software, or system that is **not listed as a standard component** is section 4, the System Engineer's Manuals typically includes the following:

a) System Software Engineer's

The Software Engineer's Guide shall be a user's manual for the PLC and OIT software programs. It shall include the step-by-step procedures required to obtain communications between the programming computers, PLCs, and OITs used in the project. It shall include a list of all cables and other hardware required for the programming of the PLCs and OITs.

2.4.5. Configuration Inventory Documentation (or Bill of Materials)

Configuration Inventory Documentation typically refers to an inventory list for all contract equipment, software, for all contract documentation, spare parts, and test equipment for the SCADA system. Hardware identification of each unique module by serial number and each software unique module shall be included on the list. The inventory list shall include, but not be limited to, the following information:

- Manufacturer's name, part number, and serial number
- Quantity of units supplied with the deliverable System/subsystem

- Software Licenses
- Software modules supplied
- System documentation supplied
- Site, cabinet, rack number or slot, and cables.

2.4.6. Record Documentation

Record Documentation refers to final as-built documentation following final acceptance and prior to project closeout. This documentation is divided into two parts: Text and Drawings.

Three (3) hardcopies and one (1) electronic copy on CDs of all Record Documentation shall be delivered and approved by PWD prior to project close-out, final payment, and release of retainage (if applicable). All electronic documents of manufacturers' equipment shall be provided in Adobe PDF or Microsoft Word, with drawings in AutoCAD. **All electronic documents of Contractor's documents shall be provided in Microsoft Word, with drawings in AutoCAD**.

2.4.6.1 Text Record Documentation

Prior to project closeout, the Contractor shall provide all "as-built" documentation. In addition to the electronic PDF and WORD formatted versions, the documentation shall be bound in 3-ring binder(s) and shall be clearly labeled and include the project name, project number, and date submitted. Each section shall be identified by color-coded tabs with a corresponding index to allow for quick access.

The sections shall be divided and include the following information:

1. Index with reference to color-coded sections
2. Contractor and manufacturer's contact names, addresses, phone #s, and website addresses
3. Network System Diagram and installation details including cable labeling
4. Equipment Matrix to include list of make and models, and serial numbers
5. Project specific configuration and programming instructions
6. Project specific troubleshooting and support guidelines
7. Diagnostic Tool User Guides and Instruction Manuals
8. Device Manufacturer's Manuals, cut-sheets, and installation guidelines
9. Product Warranties

* All extraneous information including advertising and marketing information not specific to the products shall be removed from manufacturer documentation.

2.4.6.2 Drawing Record Documentation

The drawings that need to be revised to reflect any changes related to the equipment installation, usually described as "As-Built", shall include, but are not limited to:

- Loopsheets
- Panel Wiring Diagrams
- I/O Spreadsheet

- PLC Interconnect Drawings

2.5. DRAWING STANDARDS

This section defines the general content and format for the drawings that are a requirement for all SCADA system projects. All of the SCADA System related drawings (i.e. P&IDs, Loopsheets, Network Drawings, etc.) shall be drawn to an 11”x17” drawing size. PWD will provide templates for all of the necessary drawings.

2.5.1. Drawing Preparation

All new drawings shall be prepared utilizing AutoCAD the latest version supported by PWD.

Prior to issue of the final drawings, letters or numbers (e.g., Revision A, Revision B, etc.) shall identify revisions. Revision of drawings shall be indicated as follows:

a) Change revision letters in the title block; and
b) Enter the new revision letter and specify revisions in the revision column.

Symbols used in documents and drawings shall conform to the list of standard symbols as specified below:

- PWD P&ID Standard Symbols, available upon request.
- Institute of Electrical and Electronics Engineers,
- National Electrical Manufacturers Association,
- ISA-S5.1 Instrumentation Symbols and Identifications, as defined in PWD’s Standard Symbols drawing
- ISA-S5.3 Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems,
- ISA-S5.5 Graphic Symbols for Process Displays,
- ISA-S5.4 Instrument Loop Diagrams.

Each drawing shall use symbols from only one standard reference source. The contractor shall follow the PWD Standard Symbols drawing and submit all non-standard symbols for approval.

The Contractor shall submit three (3) hard copies of all final drawings and one electronic copy on USB flash drive. **All files on the drive shall be submitted both in native file format (i.e. dwg) and in pdf format.**

Lettering shall be minimum .125-inch height. All lettering shall be Helvetica regular 12 point for general notes and dimensions, 18 points for subtitles and 24 point for general titles and Helvetica slant 12 point shall be used for all general revisions and as-builts.

Drawings shall be 11 x 17 inches unless explicitly directed by PWD.

Each drawing shall indicate the following information in the title block:

a) Drawing number, date, title, and revision number;
b) Contractor's name; and

c) Subcontractor/Manufacturer name (if applicable).

Drawings must be arranged to be easily readable. Drawings must not be crowded or cluttered. Notes shall be located as far toward the right-hand border of the drawing as possible. Circuitry shall be presented on the drawing with a minimum of crossed or offset lines. Electrical connection drawings for panels shall be drawn to reflect the actual physical wiring of the panels.

The contractor must be required by the contract drawings to use the following line work when preparing drawings:

a) Minimum 0.01 inch for the use of Dim Lines, Leader Lines, and background
b) Minimum 0.03 inch for the use in the primary object of the drawing
c) Maximum 0.07 inches for the use of diagrammatic drafting and reinforcing.

2.5.2. Piping and Instrumentation Diagram (P&ID) Drawings

Piping and Instrumentation Diagrams (P&ID's) convey process, instrument and control equipment information. Understanding these diagrams allows individuals to understand the means of measurement and control of the process within a given treatment process. P&IDs are accurate representations of the physical process or system and shall show equipment in the proper functional relation. Refer to Section 6.3.2 for a typical example of PWD's standard P&ID format.

2.5.2.1 Purpose and Scope

A set of P&ID's for a process or sub-process shall include all aspects of the process or sub-process. All major piping, equipment, valves, instrumentation and controls related to that process must be included.

PWD P&ID's shall show the following:

- Current project additions, deletions, and modifications
- All automated and non-automated systems
- All instruments and equipment providing inputs to the PLC
- All instruments and equipment receiving outputs from the PLC
- All hardwired interlocks (symbol only)
- Instrument naming with asset name derivation information included
- Implied instrument symbols shall be used in conjunction with a "Typical Detail" legend drawing that shows the relationship between the implied symbols and the shown symbol.

2.5.3. Loopsheet Drawings

Loopsheet Drawings shall depict the wiring layout from a field device to the final SCADA System termination point. The final termination point is commonly an I/O channel to a PLC, but it could also be a hardwired device within a control panel. Refer to Section 6.3.1 for an example of a loopsheet drawing the meets PWD's standards. All loopsheets shall contain at least, but not limited to, the following elements:

- All wire colors and labels.
- All panel labels
- All related electrical and electronic devices (i.e all elements with the same 4 digit designation for the loop number: **<u>XXXX</u>**Y. If an item does not meet this criteria, it will need to be put on its own loopsheet drawing with other items with the same loop number). This includes, but limited to: power supplies, signal converters, push buttons, selector switches, relays, etc.
- All terminal blocks (both panel terminal blocks and device terminals) and the terminal block connection point labels.
- Loopsheets shall be draw to present the clearest depiction of the wiring between the field and the final terminal points. Every effort shall be made to avoid confusing or conflicting information on the drawings.
- Refer to Section 6.2.8 for the loopsheet file naming convention.

2.5.4. PLC Interconnect Drawings

Interconnect drawings shall depict the layout of the PLC I/O cards. There shall be one interconnect drawing for each slot in the PLC rack. Spare or unoccupied slots will have a drawing created. Refer to Section 6.3.6 for an example of an interconnect drawing that meets PWD's standards. All interconnect drawings shall contain, but are not limited to, the following elements:

- A physical depiction of the PLC I/O card
- Terminal and wire labels
- Technical information of the I/O cards (i.e. part number, slot and rack numbers, etc.)
- Identify all field devices (i.e. manufacturer, model number, terminal points on device, process function, SCADA tagname, etc.). The only exception to this would be for simple push buttons and selector switches.
- Identify the boundary between the PLC panel devices from the field (or external to the PLC panel) devices. This is depicted via a dashed line (see example in Section 6.3.5)
- Show all non-PLC power sources. This will provide information of a specific point as "loop powered" vs. "transmitter powered".

2.6. QUALITY ASSURANCE

2.6.1. Quality Assurance and Control

SCADA system providers shall maintain quality control over suppliers, manufacturers, products, equipment, software, services, site conditions, and workmanship, to produce Work of specified quality. The SCADA system provider shall maintain adequate records to provide evidence of quality and accountability. These records shall include results of inspections, tests, certification of processes and personnel, discrepant material (including records of disposition) and other quality requirements defined in the project requirements. These records shall be maintained and made available to PWD at all times during the performance of the project and for the retention period as specified in the project. Inspection and testing records shall, as a minimum, indicate the nature of the observations, the number of observations made, and the number and types of deficiencies found. Records for monitoring work performance, inspection, and testing shall indicate the acceptability of work or products and the action taken to correct deficiencies. The records shall be retrievable and traceable from a component failure to demonstrate its original acceptance by test, inspection, and the criteria used.

The most significant part of the SCADA Quality Assurance and Quality Control (QAQC) component revolves around software development (i.e. PLC code, HMI database, Graphic displays, etc.). Figure 2.6.1-1 shows an activity flow chart (or Standard Operating Procedure, SOP) for making changes to the SCADA System:

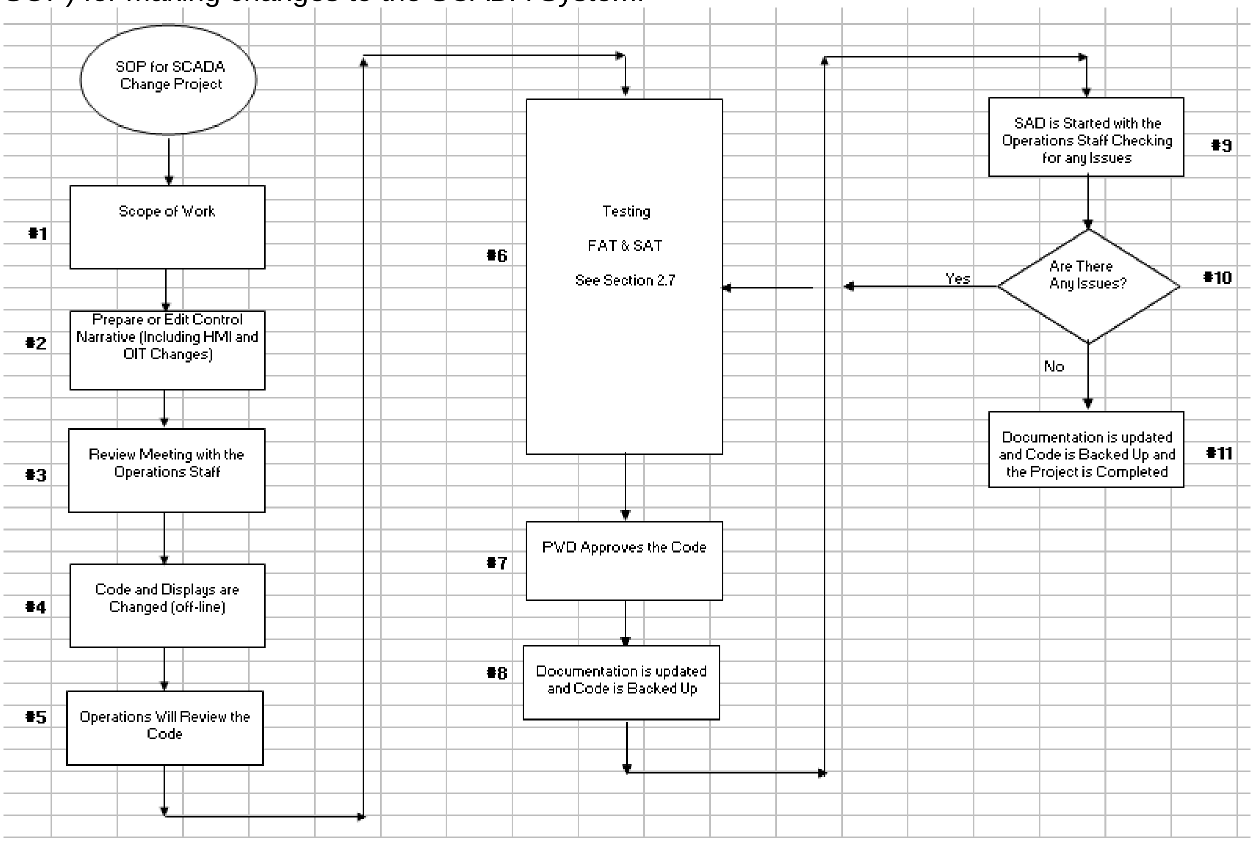


Figure 2.6.1-1 SCADA Change Activity Chart

This SOP is designed to be performed by all programmers (internal and external to PWD). All changes, large and small, will be held to this process. It is critical to follow this SOP because it reduces rework and creates a clear goal that the PWD Operations Staff (the customer) and the programmer can see through a written document that is measureable. Too often the programmer and the customer have a different goal that is only recognized after many man-hours are spent.

Step #1 is where a “Scope of Work” (SOW) document is written by the operations staff, usually with help by AMAP. If the SCADA change is part of a contract, then the contract specification will become the SOW. The SOW defines in clear English what the goal is for the SCADA change. It needs to be as long as necessary to fully describe the goal. This could be just a couple of paragraphs or a multipage document. Usually the P&ID will be edited to show a new asset. The important point is defining the end goal.

Step #2 is where the Control Narrative (CN) is developed (using either the PWD preferred format found in Section 6, or an approved alternate format) or edited. This is where new tagnames are developed using the P&IDs. The goals in the SOW are formatted for PLC code development. HMI/OIT displays are mocked up and edited using screen captures of the existing displays which are inserted in the CN. This is where any asset information is generated and entered into Hansen (PWD's Asset Management System).

Step #3 is the critical review of the CN by the programmer and the customer. This is a critical cross check to see if these two parties are in sync with the original goals before any programming is done. This step is like a conceptual design for a capital project where changes at this stage are easily made. Again, the amount of effort needed for the review will depend on the size of the change. One of the major reviews done here is of the HMI/OIT display mock ups. The mock ups help the customer visualize the final product and this step significantly reduces rework and improves the product quality.

Step #4 is where the programmer does his/her work.

Step #5 provides another review by the customer of the preliminary PLC code and it acts as a QAQC step.

Steps #6 is the Testing step. There can be a combination of a Factory Acceptance Test (FAT) and a Site Acceptance Test (SAT) or just a SAT. The FAT and SAT are described in Section 2.7.

Step #7 where the code is approved by the customer based on a successful test.

Step #8 is where the documentation is updated and the code is backed up. Details of the asset information (serial numbers, model number, etc.) are entered into Hansen for new assets.

Step #9 is the Site Availability Demonstration (SAD, see Section 2.7 for details) period is started. The Operations Staff fully exercises the changes with the process equipment and records any observations about the performance. Minor items are just recorded without any programming corrections, where major items are reprogrammed immediately. At the end of the SAD (usually two weeks long) the records are given to the programmer for reprogramming, taking the SOP back to Step #6.

Step #11 is reached if there are no issues The SOP is completed with a final revision of the documentation and a final back up of the code.

2.6.1.1 QC Program

The SCADA system provider shall establish and maintain written procedures defining a Quality Control (QC) Program. The procedures shall include, but not be limited to, functional testing, discrepancy control, measuring and test equipment calibration/certification, drawing control, quality assurance records, shipping inspection, software design, installation techniques, installation inspection, and other quality provisions to meet the requirements of the Contract. The procedures shall be made available to the PWD upon request.

The Quality Control Program shall provide for adequate inspection instructions for handling, storing, preserving, packaging, marking, and shipping to protect the quality of products and to prevent damage, loss, deterioration, degradation, or substitution thereof. The Quality Control Program shall require and monitor the use of procedures to prevent handling damage to products.

Handling procedures shall include the use of special crates, boxes, containers, transportation vehicles, and facilities for material handling. Means shall be provided for protection against deterioration or damage to products in storage. Periodic inspection for the prevention and correction of such deterioration or damage shall be provided.

2.6.1.2 Product and Support Services

The SCADA system provider shall ensure that calibration services from equipment vendors or others utilize an effective time or usage-cycled calibration/certification program. SCADA system supplier shall ensure validity of measurements and tests through the use of suitable inspection, measuring, and test equipment of the range and type necessary to determine conformance of items with the Specification requirements. Measuring devices shall be verified or calibrated against certified standards that have a known traceable relationship to the National Institute for Testing and Standards (NIST). Furthermore, every device so verified or calibrated shall bear an indication attesting to the current status and showing the date (or other basis) on which inspection or recalibration is next required. Devices suspected of being out of calibration before the stated recalibration date shall be promptly recalibrated.

The SCADA system provider shall be responsible for ensuring that all supplies and engineering services procured conform to the project requirements. PWD has the right to inspect and reject at the source or project site, any supplies furnished or services rendered under the project requirements.

The SCADA system provider shall inspect and physically or functionally acceptance-test all equipment and software delivered under the Contract. Inspection shall occur at appropriate points in the manufacturing sequence to ensure quality consideration for compliance with drawings, test specifications, process specifications, and quality standards. Testing shall provide a measure of the overall quality of the completed product and shall be performed so that the testing simulates, to a sufficient degree, end product use and function. When modifications, repairs, or replacements are required, there shall be re-inspection or retest of characteristics affected. Inspection and testing shall provide for reporting to PWD any unusual difficulties, deficiencies, or questionable condition.

2.7. TESTING

Testing requirements shall be part of every project that is planning on making changes to the SCADA System. The testing requirements shall require that the contractor, or PWD employee, who is designated as the “Application Engineering Service Supplier” (or AESS) throughout this Section 2.7, shall demonstrate that the system was fully tested after installation, and that it is a fully functioning system before the final payment is released or project closure is made. The testing requirements shall require a comprehensive and progressive series of AESS conducted tests, AESS certifications, and PWD conducted demonstrations.

The basic testing requirements (or procedure) shall require the AESS to provide tests for all equipment and software. If equipment or software does not have specific tests defined in the contract, or SOW, then the AESS shall be required to develop testing procedures. All software and all equipment including mechanical, instrumentation, electrical, and all other equipment related to the SCADA system shall be tested both individually and together as a system.

The testing procedure will depend on any combination of the following: the contract specifications, SOW or operation constraints. The AESS shall propose a testing procedure with the proper amount of FAT, SAT and SAD needed to test the changes to the SCADA System. PWD will then review and approve the proposed testing procedure.

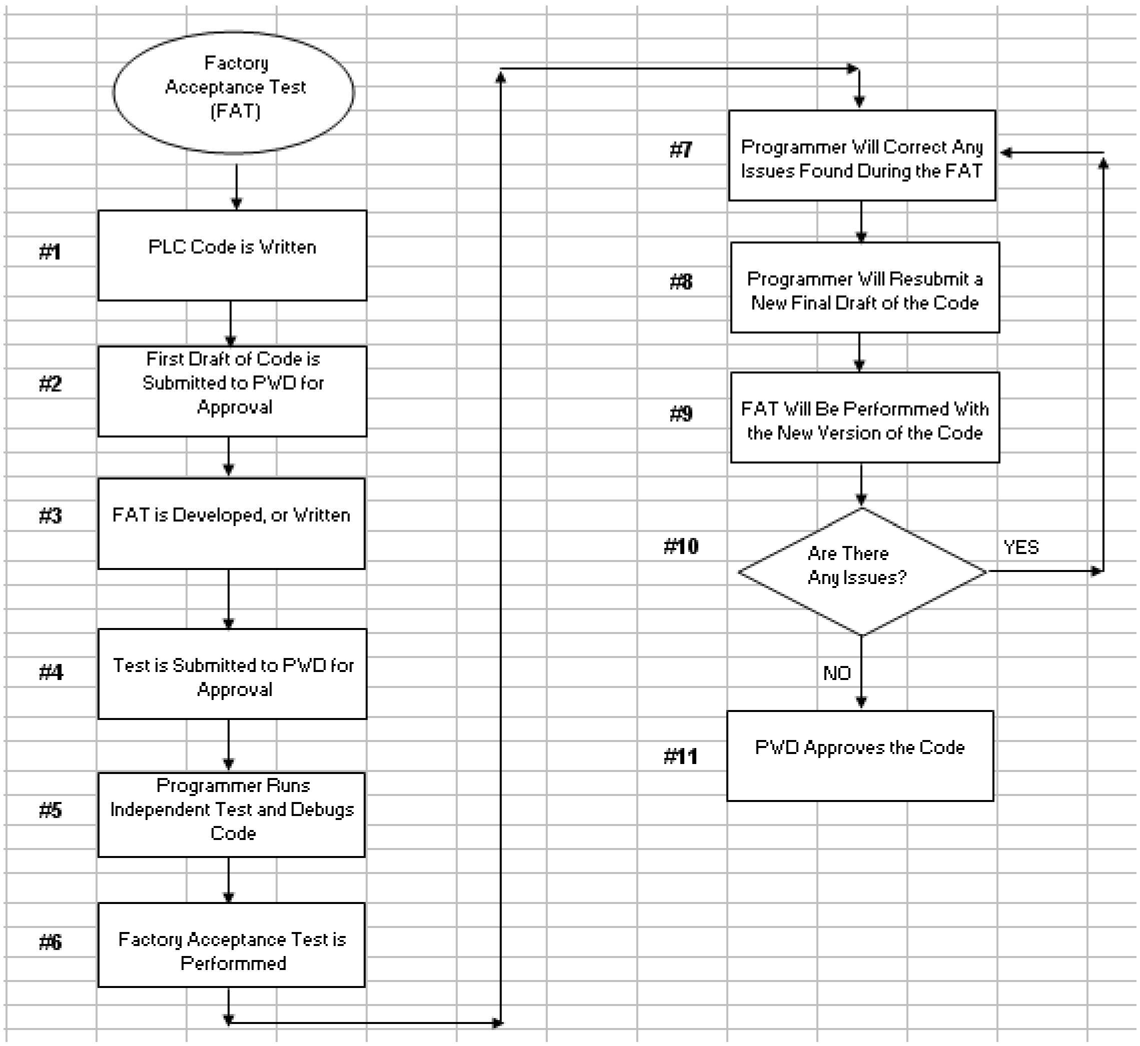


Figure 2.7.1-1 – Factory Acceptance Test Activity Chart

2.7.1. Factory Acceptance Testing (FAT)

The requirements of this section shall be applied to all major SCADA system projects. If the amount of equipment and software to be provided under a particular project does not appear to warrant such a Factory Test, these requirements may be waived at the discretion of the PWD Project Manager.

A Factory Acceptance Test and verification for all deliverable equipment, software, and associated documentation shall be performed prior to subsystem or major components shipment. The equipment factory tests shall be performed to verify that the equipment is manufactured and assembled correctly, is operating as designed, and is in compliance with the contractual requirements for the deliverables. The functional factory tests shall be performed to verify that the software and hardware will meet the functional and performance requirements of this document.

Figure 2.7.1-1 shows a typical flow chart of the activities involved with performing an FAT. Below is a description of some of the key components arranged by steps from the flow chart:

> Step #1 – The PLC code is written following the Scope of Work (SOW) document or the Project Specification document. The control narratives shall be a component of both the SOW and the Project Specifications. The programmer will write the code using all of the elements found within them.
>
> Step #2 – The first draft of the PLC code is presented to PWD for review. This shall be done in a manner agreed upon by PWD (i.e. a PDF document of the PLC code prepared by the programmer for PWD to examine, a presentation of the code by the programmer to PWD staff members, etc.). PWD will make comments and the programmer will respond to the comments.
>
> Step #3 – The FAT Test Criteria Document is written by the AESS and it is submitted to PWD for approval in step #4 (see Section 6.4 for an example). The AESS is required to submit the FAT Test Criteria Document 10 days prior to performing the Pre-FAT step for PWD approval.
>
> Step #5 – This is referred to as the “Pre-FAT”. In this step the AESS performs the FAT test without the owner present (see Sections 2.7.1.1-5 below for details). This gives the programmer a chance to debug the software and make modifications before the actual FAT.
>
> Step #6 – The FAT is performed. PWD will arrive at the “factory” site to witness the system perform the FAT elements. PWD does reserve the right to witness all or part of the test elements. The AESS will perform all of the tasks requested by PWD and PWD will take notes on the outcome of each test element performed. PWD reserves the right to decide the severity of the issues found during the FAT. If more than 3 severe issues are found during the FAT, PWD will suspend further testing and request that the programmer repeats the Pre-FAT in its entirety. A FAT checklist will be used to inspect the SCADA Panels (see Section 6.4 for an example) and verify that key SCADA Standard requirements are met.
>
> Steps #7 through #10 – These steps are necessary if significant issues, or problems, are found during the FAT. These steps could lead to performing all or part of the FAT again once the SSS has fixed any issues. PWD reserves the right to decided how to proceed with the FAT at this point. This decision could lead to a brief interruption of the testing or a complete suspension of the FAT.
>
> Step #11 – Bliss! The FAT is complete because the SOW or contract specifications have been met. We are good to go and the equipment can be shipped to the job site.

Only the final form of the deliverable equipment, software and associated documentation shall be accepted at the FAT unless PWD has agreed to waive this requirement. If no waiver is granted and the final form of the deliverable equipment, software and associated documentation are not available, then the FAT cannot proceed.

2.7.1.1 FAT System Configuration and Serialization Verification

Prior to beginning the Factory Acceptance Testing, the elements shall be subjected to system deliverable configuration and serialization verification. A copy of the Configuration Inventory Documentation for each site shall be annotated to reflect this verification and shall be included with the Factory Acceptance Test Report. No equipment replacement or substitutions shall be permitted without PWD’s approval.

2.7.1.2 FAT Equipment Test and Verification

Hardware Tests

The Factory Acceptance Test for the equipment (hardware) shall include individual end-item verification and integrated testing of all components. These tests shall include visual inspection verification and running the hardware diagnostic programs, plus all special diagnostic programs used by the SCADA system supplier to demonstrate that the hardware integration task has been completed.

Inspections

The following inspection checks shall be performed on all deliverable hardware items, as a minimum:

a) I/O Subsystem physical layout
b) Power supply mounting
c) Power cable routing
d) Data cable routing
e) Wiring runs properly installed
f) Fans and blowers are unobstructed
g) Power supply and power conditioning equipment correctly installed
h) Wire numbering and color coding
i) Device labeling
j) Enclosure integrity
k) Paint work.

2.7.1.3 FAT I/O Point Checkout

The SCADA system supplier shall perform a complete, end-to-end checkout for every I/O point from the field wiring terminal strip to a SCADA workstation and the local PanelView. The I/O Point Checkout shall be witnessed by PWD or PWD’s Representative and shall be conducted on PLCs on a site-by-site basis. The SCADA system supplier shall test every input and output point including spares for proper operation. Test signals shall be injected to verify the operation of each Analog Input (AI) and Discrete Input (DI). Each Analog Output (AO) and Discrete Output (DO) shall be also tested for proper operation.

The SCADA system supplier shall develop a complete I/O Point Checkout Test Procedure. The test procedure shall identify the method to be used by the SCADA system supplier for injecting test signals for each input point type and the method to be used for verifying the appropriate output signals for each output point type. The SCADA system supplier shall program the PLCs and demonstrate that signals are alarmed when reporting under 4 mA and over 20 mA and do not report negative or out of range values.

The SCADA system supplier shall develop a point checkout form for each I/O point. The point checkout form shall include the point ID, description, all checks performed for the point, date and time of the check, and a signoff block for the SCADA system supplier's representative, PWD representative, and the PWD staff representative. For each item checked, the form shall include both the expected value/result and the actual value/result witnessed.

The following items shall be checked for each I/O point:

a) For each analog input point, the following values shall be checked:
- Value at -1% of full scale (ramped in both directions)
- Value at 0% of full scale (ramped in both directions)
- Value at 25% of full scale (ramped in both directions)
- Value at 50% of full scale (ramped in both directions)
- Value at 75% of full scale (ramped in both directions)
- Value at 100% of full scale (ramped in both directions)
- Value at 101% of full scale (ramped in both directions)
- HiHi Alarm Limit (if entered in database)
- High Alarm Limit
- Low Alarm Limit
- LoLo Alarm Limit (if entered in database)
- Alarm Deadband.

b) For each analog output point, the following values shall be checked:
- Milliamp reading at 0% of full scale (ramped in both directions)
- Milliamp reading at 25% of full scale (ramped in both directions)
- Milliamp reading at 50% of full scale (ramped in both directions)
- Milliamp reading at 75% of full scale (ramped in both directions)
- Milliamp reading at 100% of full scale (ramped in both directions).

c) For each discrete input point, the following items shall be checked:
- For status points, proper indication
- For alarm points, proper alarm notification.

d) For each discrete output point, the following items shall be checked:
- Proper operation
- Actuation time-out alarm (if value is entered in database).

The completed I/O Checkout forms for all points shall be included as part of the I/O Checkout Test Report to be prepared and submitted at the conclusion of all I/O checkout activities.

2.7.1.4 FAT System Configuration

The SCADA system supplier shall stage in its facilities PLCs, control panels, PanelViews, controllers, signal simulators, etc. for an integrated Factory Acceptance Test.

2.7.1.5 FAT System Functional Test

The system functional test shall exercise every specified system function and shall include, but not be limited to, the following:

a) Rigorous exercising of all devices both individually and collectively
b) Verification of proper scanning and data acquisition of all status and data points
c) Verification of all Control Strategies and Control Programs to ensure that they result in the correct sequence of operation for each site
d) Demonstration of all required device control functions
e) Demonstration of analog input, pulse input, and analog output accuracy
f) Testing the user interface functions for all PLCs that have local operator interfaces, HMI Displays and Radio Telemetry.
g) Create and process device failure conditions
h) Demonstration of all functions and components
i) Demonstration of recovery from power loss
j) Demonstration of UPS and battery backup functionality.

Software Tests

The FAT shall demonstrate compliance to each explicitly stated requirement in the specification. The SCADA system supplier shall provide a FAT Test Criteria Document that lists each specification paragraph that imposes a uniquely identifiable technical requirement (refer to Section 6.4 for an example). The SCADA system supplier shall add to fields for the FAT test result “check off” space, date and tester initials. These fields will be filled out during the FAT once the software has demonstrated compliance with the requirement.

72-Hour Continuous Test

After the successful completion of the functional testing specified above, a 72-hour continuous run of each PLC provided shall be performed. The test shall be passed if no function is lost, no hardware or software failure occurs, and no module automatic failover occurs. Hardware failure is defined for this test as the loss of a major piece of hardware, such as a PLC processor, I/O board, power supply, UPS, other panel equipment, or improper operation by the controller.

During this test, the PLC shall be exercised (with simulated inputs, events, and conditions) in a manner that approximates an operational environment. At least 24 hours of unstructured testing shall be included in which PWD or PWD’s representatives shall be allowed to operate the equipment without the SCADA system supplier's supervision. PWD personnel will exercise the PLCs by randomly selecting functions to perform from the FAT Test Criteria Document. The PLC shall perform as specified.

No programming changes will be allowed during this test. Any software and/or hardware correction made to the PLC shall result in the mandatory rerun of the entire 72-hour test for that PLC. Any changes to the PLC shall be demonstrated to PWD or PWD’s representative.

PWD will issue an acceptance document officially ending the FAT.

2.7.2. Site Acceptance Testing (SAT)

A Site Acceptance Test of the functions, software, and performance shall be conducted individually at each site (or plant process) after all elements have been installed and the I/O Point Checkout has been completed at each site.

All software, programs, displays and databases will be delivered to PWD prior to the SAT for cyber security reasons. The inbound files for the SAT shall be handled via the following procedure:

1. As desired, request files from the PWD project lead. Specify whether the file request is for offline editing or for review only. The project lead will maintain a log of file requests.

2. If offline edits were made to any files, prior to commencing on-site work email the files to the PWD project lead. The files will be scanned for viruses and uploaded to the associated SCADA PC network. For work at remote sites, the files will be scanned for viruses and saved on the District's server for backup purposes.

3. Direct connection with a laptop, thumb drive, or other device is not permitted at the facilities where SCADA PC networks are available (SLWTF, EEWWTF, WGWRWWTF). Instead, utilize the PWD programming nodes and establish a VNC connection.

4. The PWD project lead will provide you with a list of IP addresses and passwords to establish the VNC connection, access iFIX, and for controller access at remote sites as needed.

5. Prior to commencing site work, create a copy of any impacted files and store them in the working folder on the SCADA PC network or save them on your laptop if working at a remote site. Include ****** in the filename.

6. Upon completion of site work at the end of EACH DAY, save a copy of impacted files you worked on and store them in the working folder on the SCADA PC network or save them to your laptop. Include **** in the filename.

7. When working at remote sites, email the PWD project lead a copy of the impacted files at the end of each work day.

8. When working on a SCADA PC network over multiple days, ****overwrite**** the file at the end of each day. At the start of the SAD period the PWD project lead will copy the "before and after" files to the District's server for backup storage.

The system Site Acceptance Tests shall be performed to verify complete operation of the system, requiring a repeat of much of the factory acceptance tests but with the equipment installed at the permanent sites, and shall include additional tests required to verify field-installed equipment which was not available at the factory. PWD reserves the right to decide run all, part, or none of the FAT Test Criteria for the SAT.

The SCADA system supplier shall:

a) Verify the facility installation. **This will include, but not limited to, the removal of pull box covers to verify the proper installation of instrument wiring between the**

field device and the PLC panel. Also a check of the field wiring labels will be performed.

b) Demonstrate each functional requirement identified by the specification. This demonstration shall repeat the tests used during FAT, but using real rather than simulated conditions.

c) Demonstrate all equipment control functions, including the operation of automatic control strategies. Actuation of field devices shall be closely coordinated with PWD's staff.

d) Verify system performance parameters and system responses under field operational conditions.

e) Verify accuracy of documentation, especially operator's manuals, software documentation, and site operating instructions.

As each Site Acceptance Test is completed, the SCADA system supplier shall repeat steps a-e for the next site until all sites have been successfully transferred and tested. During this test phase, the SCADA system supplier shall provide technical representatives for the execution of the Site Acceptance Tests.

The SCADA system supplier's test support personnel shall be qualified to resolve and correct problems encountered with the system during the tests. In addition to test support personnel, the SCADA system supplier shall provide all test instruments and equipment necessary to troubleshoot any of the PLC problems encountered.

PWD reserves the right to increase the requirements for test support personnel if support by the SCADA system supplier is inadequate. PWD may request the SCADA system supplier perform other work not specified in these specifications but necessary to accomplish the site testing under the provision of this section.

At the completion of the SAT, the project files will be either returned to, or posted in, the PWD Asset Center server. The Asset Center server runs Rockwell Automation's ASSET CENTRE software and it is used to manage all of PWD's SCADA software assets.

2.7.3. System Availability Demonstration (SAD)

At the completion of Site Acceptance Tests, PWD will conduct a System Availability Demonstration (SAD) test utilizing all equipment, software, and services provided under the project in the normal day-to-day operation of the system. During the test, the system shall meet the availability criteria as defined below. SCADA system supplier personnel may participate in any and all parts of this demonstration as observers at the discretion of PWD.

The System Availability Demonstration shall be performed under field operating conditions. All functional and performance requirements specified in this document shall be met during the SAD.

The system shall be subjected to an SAD evaluation for a period specified by PWD. If at the end of this period, the system availability is determined to be less than that required, the SAD shall be continue on a day-by-day basis. This sliding window concept shall continue until the system passes the evaluation or until 45 days have passed, at which time PWD shall have the right to pursue other alternatives as specified under the project contract.

2.8. SUPPLIES AND SPARE PARTS

For any piece of equipment that is not listed as a standard component is Section 6.4 (Appendix D), the SCADA system supplier (the contractor) shall furnish all spare parts (listed below):

1. All nonstandard maintenance items or tools that are required to support nonstandard instrumentation related components.
2. All nonstandard programming software. Provide at least one licensed copy of software that shall be owned by PWD.
3. All special test equipment needed to maintain any of the nonstandard elements within the system.

Quantities of spare parts shall be determined as follows:

1. One (1) of each nonstandard PLC component (i.e. CPU Cards, Racks, Adapters, etc.)
2. One (1) each type of nonstandard PLC I/O cards
3. One (1) each of each nonstandard instrument or instrumentation equipment
4. 25% spare I/O capacity in each PLC configuration (unless waived by PWD)
5. Minimum of one (1) or 10% of nonstandard network components such as routers, switches, hubs, splice kits and FX connectors

The requirements of this section shall be applied to all SCADA system related projects. If the amount of equipment and software to be provided under a particular project does not appear to warrant such a spare parts list, **these requirements may be waived at the discretion of PWD**.

Spare parts shall be identical to the installed components. Any modifications required of the installed components shall be provided on the spare parts at no extra cost. The spare parts must be related to the sections of the O&M manual, inventoried, and jointly signed for at the location of the PWD's choice.

Spare parts shall be in their original factory sealed packages (with no signs of physical damage) to prevent accidental damage or degradation during storage and the package shall be clearly marked as to model, type, part number, etc.

2.9. WARRANTY

The warranty of the SCADA System is bound by the requirements of the Contract.

In general terms, typically the warranty period for the SCADA system shall commence at the time of Final Acceptance of the complete system. The warranty should not commence after satisfactory installation, or after successful completion of the System Acceptance Test (SAT) described above. Only Final Acceptance as defined in the contract documents shall be used as the milestone that verifies completion of the project and allows the warranty period to commence.

Final Acceptance shall be specifically defined in the project contract documents, and shall include, as a minimum, the following technical requirements:

1. Satisfactory completion of the Site Acceptance Test
2. Satisfactory completion of the Site Availability Demonstration
3. Submittal and approval of Record Documentation

4. Delivery and acceptance of all supplies and spare parts
5. Completion of all training obligations.

The SCADA system supplier shall ensure that all guarantees or warranties, issued by manufacturers of machinery, equipment and all other materials supplied by SCADA system supplier or by SCADA system supplier’s subcontractors, or by SCADA system supplier’s Vendors, covering the performance of the material and equipment supplied by them, be issued in the joint name of the SCADA system supplier and PWD such that PWD enjoys the same benefits and protection provided by any such guarantees or warranties as the SCADA system supplier. The issuance or existence of any such guarantees or warranties shall however in no way relieve the SCADA system supplier of his obligations under the project contract.

2.10. TRAINING STANDARDS

Training for applicable engineering, operations and maintenance personnel should be included for all SCADA project phases including design, implementation, start-up and operation. Management, Engineering, Operations and Maintenance staff involvement is critical to the final success and acceptance of a SCADA system project.

It is important that PWD personnel be adequately trained in the installation, operation, maintenance, and expansion procedures and techniques of any system purchased. Therefore, the system provider should be required to provide training for PWD personnel either at the system provider’s or PWD facilities as appropriate.

2.10.1. General Requirements

Experienced personnel should conduct training and the contractor should provide all necessary training material. Each trainee should receive individual copies of the technical manuals and pertinent documents. All courses should include approximately 50% lecture and 50% hands-on training with the system (This requirement maybe waived by PWD based on the subject of the course and logistics concerns). All training courses (or key portions of multiple-day sessions) should be videotaped and copies shall be provided to PWD for review and reference.

The following subjects should be covered in the training:

1. PLC code walk through with the Instrumentation Staff
2. Functional description review
3. Control narrative review
4. Nonstandard instrumentation O&M review
5. HMI display review (and database)

2.10.2. Provided Materials

Comprehensive training manuals shall be provided for all training courses. The manuals shall be professionally written to present the course material in a format that is easy to comprehend. The manuals shall serve as teaching aids during presentation of the training classes and shall additionally serve as reference material after the training has been completed. It shall not be acceptable for the Contractor to use system technical documentation solely as the training manuals since system documentation is generally not written in an instructional format. Portions of system documentation may be incorporated into training manuals provided that the overall manual achieves an instructional format.

2.10.3. Types of Courses

The PWD personnel training requirements will depend upon the nature of the SCADA system change or SCADA related project. The duration of each training course should depend upon the complexity of the scope of work. The type of training needed for a project is at the discretion of the PWD Project Manager. In general the following types of training should be available to PWD personnel as required:

1. Management/Supervisor Training - It is paramount that management and supervisors have a general understanding of the system. Therefore, the contractor should provide a course of an appropriate duration to include an overview of system operation.

2. Instrument Software Training - The contractor should provide sufficient training to enable the creation, modification, integration, testing and documentation of any software utilized by the system.

3. Instrument Hardware Training - The contractor should provide sufficient training to enable the addition, deletion, modification, integration, testing and documentation of any hardware utilized by the system.

4. System Operator Training - Operations personnel should be provided with training to enable and encourage effective and straightforward operation of the PWD facilities. The training duration will vary according to the system, but it shall accommodate multiple shifts for each facility.

5. Electrical/Mechanical Training (if applicable to the SCADA Related Components) - The contractor should provide sufficient training to enable the efficient preventive and corrective maintenance required to keep the entire system in proper operating condition.

2.10.4. Training Plan

The Contractor shall be required to submit a Training Plan not less than 60 days prior to the scheduled start of training. The Training Plan should address:

- Syllabus for all classes
- Instructor names and qualifications
- Schedule of classes
- Pre-requisites for classes, if any
- Sample training materials.

Revision Memo

Rev. 0	May 7, 2004	Draft Version for comments
Rev. 1	June 18, 2004	Final Version for comments
Rev. 2	July 30, 2004	Final Version
Rev. 3	April 14, 2006	PWD's First Version
Rev. 4	February 27, 2009	Major revisions to sections 3, 4, 5, & 7 Minor revisions throughout
Rev. 4.1	August 1, 2012	Minor revisions throughout Major changes to sections 2, 6 & 7
Rev. 5.0	September 20, 2016	Revisions throughout, some related to the Change to CompactLogix
Rev. 6.0	September 1, 2021	Minor Changes Throughout Section

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

3. ELECTRICAL DESIGN STANDARDS (FOR SCADA RELATED SYSTEMS)

3.1. BASIC DESIGN REQUIREMENTS

3.1.1. Introduction

The electric power serving a control computer system must be "clean," stable, and reliable. This means the electrical distribution system must be protected against power outages, voltage fluctuations, distortions, transients, surges, and spikes.

In addition, all electrically powered equipment, from computers to instrumentation, must be properly grounded to reduce noise and interference, protect personnel and equipment, and provide a "quiet" environment for electronic instrumentation.

This section of the SCADA System Standards describes what is required to provide a proper power source and system ground to minimize electrical problems.

3.1.2. Power Requirements

Provide electrical power to SCADA system cabinets and equipment from an uninterruptible power supply (UPS). See Section 3.1.3 below for more details.

Providing clean power for the SCADA system is critical. Voltage fluctuations and outages can cause output errors, loss of data, equipment damage, and other problems. High-speed transients can damage memory devices, power supplies, and semiconductor components. Transients can cause data errors in instrumentation, communication, and computing devices.

Problems can occur in a process plant regardless of whether power is supplied by the utility or by an on-site generator. Typical utility problems include load switching, load shedding, accidents, and brownouts. Normal power net switching by a local utility can cause several hundred outages per year, each lasting one second or more. The inability of utilities to meet power demands in peak periods forces them to schedule "brownouts" (i.e., a planned 3, 5, or 8% voltage reduction at the generating point). Such a major reduction could take the computer's voltage below its lower operating limit. On-site power generation has many of the above problems, plus capacity limitations and frequency stability difficulties.

3.1.3. Uninterruptible Power Supply

Uninterruptible power supplies shall be provided to support the SCADA system for the following equipment:

- All SCADA system equipment in the control room
- All SCADA related elements components within the PLC panels (i.e. PLC, both Local and global OITs, instrument power supplies, etc.)
- All SCADA network components (i.e. switches, radios, etc.)

Refer to Section 6.4.3 (Standard Instruments and Components table) for standard models of UPSs used by PWD. The following are general UPS sizing and feature guidelines (These guidelines are subject to change based on the application and PWD reserves the right to approve any deviation from them):

1. Check with PWD project lead for current standard UPS unit. Specify standard PWD equipment unless there is a specific need for deviation. All deviation from PWD standard UPS units shall require approval of PWD project lead.
2. System Continuous Rating: Minimum output voltage of 120 VAC, 60 Hz over entire battery voltage range at specified power factor. Maintain output voltage within specified limits at any load from full load to no-load.
3. Size system with 50% KVA capacity over and above the total connected load capacity.
4. Battery Capacity: Capable of operating at full rated load for four hours.
5. System shall have front panel with a Multi-function LCD status and control console, Alarm when on battery, distinctive low battery alarm, and configurable alarm delay timer.
6. Provide an Automatic Transfer Relay (ATR). This is a relay installed in the panel that will switch the UPS powered circuit between the UPS output power and utility power when the UPS fails. The ATR is a three pole double throw (3PDT) relay that is rated to handle the power load of the UPS circuit (the minimum rating shall be 15 AMPS). An example of an ATR schematic is given in Figure 3.1.3-1 below. The ATR will provide an alarm to PLC when the UPS has failed.

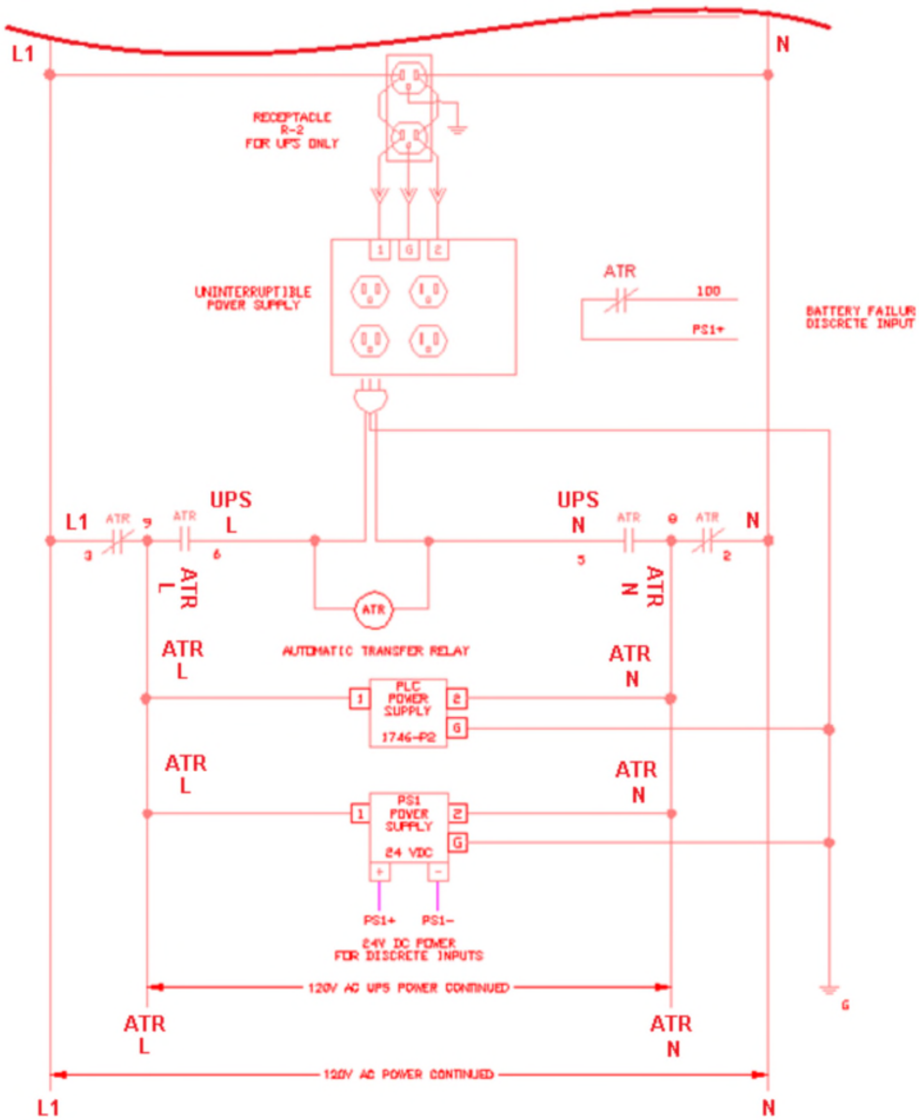


Figure 3.1.3-1 Automatic Transfer Relay (ATR) Schematic Example

3.1.4. Codes and Standards

The contract documents should require that all work by the contractor conform to the applicable requirements of the current National Electrical Code and the local Electrical Code, together with the code and regulations of public utilities and all others having jurisdiction.

The contract documents should require that all equipment be designed, constructed, installed and tested and is in conformity with all requirements, and as a minimum the following applicable standards:

a) Institute of Electrical and Electronics Engineers (IEEE)

b) Underwriters Laboratories, Inc. (UL)

c) National Electrical Manufacturers Association (NEMA)

d) National Electrical Code (NEC)

e) American Society for Testing and Materials (ASTM)

f) American National Standards Institute (ANSI)

g) National Board of Fire Underwriters (NBFU)

h) National Fire Protection Association (NFPA)

i) National Electrical Contractor's Association "Standard of Installation" (NECA)

j) Joint Industrial Council (JIC)

k) Insulated Cable Engineers Association (ICEA)

l) International Society of Automation (formally the Instrument Society of America) (ISA)

m) Occupational Safety and Health Administration (OSHA).

In addition, all materials and equipment shall be listed by Underwriters' Laboratories, Inc., except for classes of materials and equipment not available with such listing.

3.1.5. Shop Drawings Requirements

The shop drawings provide the PWD Engineer a way to monitor the contractor’s compliance with the contract requirements. This section covers what should be included in an electrical submittal in order to maintain project control. Quantities of drawings and submittal requirements are defined in Section 2.5.

The following sections describe the minimal requirements for a typical project. Of course there is no such thing as a typical project, so the needs and requirements for drawings will have to be tailored for each project. **Electrical shop drawings should be provided and defined in the contract documents.** The typical expectation by PWD for the minimal submittal of electrical shop drawings is listed below:

a) **Overall site plans**. Show exterior conduits (or wireway) and wiring to radio antennas, termination (or junction) boxes, pull boxes, PLC panels, major equipment, significant buildings, and all other related components.

b) **Interior power plans**. Show interior conduits (or wireway), wiring, lighting panels, breaker boxes, junction boxes, all control system equipment, control panels, instruments, and all other related components.

c) **Interior and exterior wall elevations**. Show mounting of PLCs, disconnect switches, power distribution panels, conduit connections to existing power distribution panels, light switches, emergency pull switches in control centers, antenna feed line routing, and locations of all other electrical devices and conduit systems.

d) **Back Panel Details**. Drawings for backup panel, interposing relay panel, relay control cabinet, PLC assembly and installation. Include conduit entry, exterior panel elevations, interior panel elevations, device and nameplate schedules, wire way and terminal block placement, electronic module and power supply placement, fans, heaters, thermostats, filters, and all other devices.

e) **Elementary control and wiring diagrams -** for all control panels, PLC control panels, remote I/O panels (if required) switch.

f) **Elementary control diagrams for all switchgear**, motor starters, and process equipment control circuits having interfaces with the SCADA related project. Elementary control diagrams shall use the ladder diagram format incorporating line number, operation function statement, contact location line number with an underline for a normally closed contact and a description of operation of each device. Label each contact with its tagname and description, e.g.: "POS01DC_FIT15100, Discharge Flow ". Format and symbols should be subject to approval by PWD. Show terminals for field wiring. Show field wiring as dashed lines.

g) **Loopsheet Drawings** shall depict the wiring layout from a field device to the final SCADA System termination point (refer to ISA Standards 5.4). The final termination point is commonly an I/O channel to a PLC, but it could also be a hardwired device within a control panel. Refer to Section 6.3.1 for an example of a loopsheet drawing the meets PWD's standards. All loopsheets shall contain at least, but not limited to, the following elements:

- All wire colors and labels.
- All panel labels
- All related electrical and electronic devices. This includes, but limited to: power supplies, signal converters, push buttons, selector switches, relays, etc.
- All terminal blocks (both panel terminal blocks and device terminals) and the terminal block connection point labels.
- Loopsheets shall be draw to present the clearest depiction of the wiring between the field and the final terminal points. Every effort shall be made to avoid confusing or conflicting information on the drawings.

h) Instruction booklets, operating manuals and parts list with all necessary information required for the installation and maintenance of the equipment and for ordering replacement parts.

i) Manufacturer's recommended list of spare parts.

j) Detailed drawings, descriptive data and other data sheets showing design information that verifies that the equipment meets the technical requirements of the Specifications.

k) **Instrumentation cable schedule** detailing each cable routing shall be developed using the latest version of Microsoft Excel or Microsoft Access supported by PWD. The schedule shall include, as a minimum, the following data for each cable:

1. Cable number

2. Cable type and conductor size

3. Conductor insulation color each cable conductor

4. Instrument loop number served by each conductor group

5. Terminating instrument numbers (source and destination)

6. Conductor numbers

7. Conduit number through which cable is routed.

l) **Point-to-point conduit, wire, and cable lists** for all conduit, wiring and cabling from field devices to and from I/O cabinet shall be developed using the latest version of Microsoft Excel or Microsoft Access supported by PWD. Include conduit, wiring, and cabling for all intermediate conduit runs to junction boxes, manholes, pull boxes, termination cabinets, interposing relay panels, backup panels, and all other points of access or termination for wiring and cabling.

Include as a minimum, the following database fields for each run of conduit/raceway:

1. Conduit tag number
2. Conduit/raceway source
3. Conduit/raceway destination
4. Conduit/raceway length
5. Conduit/raceway intersections
6. Conduit/raceway size
7. Wire sizes and types for all wires
8. Cable type and conductor sizes for all wires
9. Wire tag numbers for all wires
10. Cable tag number for all cables
11. Instrument loop numbers for all wires and cables.

k) **Catalog cuts** (sometimes referred to as "**Cut Sheets**") from manufacturers' data sheets for conduit, wire, cable, enclosures, disconnect switches, circuit breakers, lighting equipment, indicator lights, pushbuttons, selector switches, relays, sockets, terminal blocks, fuse blocks, wireways, control panels, termination cabinets, pull boxes, power line conditioners, UPS systems, heat tracing systems, and all other electrical equipment described in the contract documents.

Where catalog cuts describe more than one model or option, circle the item that applies, or stamp the item with a bold arrow pointing to it. Draw a bold line through all text and pictorial information that does not apply to the item.

Information on catalog cuts submitted for approval shall be according to the requirements of the submittal section of the contract specification and shall include:

1. Specification section and paragraph number.
2. Manufacturer's name and product designation or catalog number.
3. Electrical ratings.
4. Standards or specifications of ANSI, ASTM, ICEA, IEEE, ISA, NEMA, NFPA, OSHA, UL, or other organizations, including the type, size, or other designation.
5. Assembly drawings in sufficient detail to identify every part of the specified equipment.
6. Dimensioned plan, sections, and elevations showing means for mounting, conduit connections, and grounding, and showing layout of components.
7. Materials and finish specifications, including paints.
8. List of components including manufacturers' names and catalog numbers.
9. Wiring diagrams including single-line, elementary connection and interconnection diagrams.

3.1.6. Cable Way and Conduit Requirements

The building may require extensive internal cabling initially and should be provided with features that permit easy modification and addition of cable and conduit in future years. Cable troughs should be sized to accommodate cables anticipated for each area and for future expansion.

Vertical cable shafts are recommended for routing cables and conduits between floors of any two-story sections of a building. Conduits and cables should be arranged to avoid immediately adjacent routing of heavy current carrying circuits and low-level data circuits. Steel conduit should always be used to minimize inductive coupling between parallel wiring.

Instrumentation related conduits shall be segregated three ways: Instrumentation Power Wires, Analog Signal Wires and Discrete Signal Wires. This requires three separate conduits, or cable tray runs (see Section 3.2 for more details). This is done to prevent high voltage (110 VAC) from mixing with low voltage (24 VDC) service wires. Also it is done to prevent discrete signal wiring from causing noise disturbances in the analog signal wires. Exceptions to this standard must be approved by the Engineer.

3.1.7. Conduit and Wireway Fill Requirements

The National Electrical Code (NEC) prescribes fill factors, or the maximum percentage of the internal cross-sectional area of conduit and tubing that it is permissible to fill with electrical conductors. The NEC also calls attention to the fact that the length of a conduit run, number of bends, and other factors might result in less fill than the maximum. Tables in the NEC indicate the maximum number of conductors of a given size and type that are permitted to occupy a given trade size of conduit.

3.1.8. Conduit and Wireway Clearances

Maintain clearances from electrical panels and other electrical installations as required by the NEC. Maintain working clearances around electrical equipment required for proper maintenance, operation and accessibility.

3.2. WIRING AND CABLE STANDARDS

This section defines general guidelines for wiring and cable for monitoring and control signal wiring between field-mounted transmitters, control devices, local panels, device panels, and PLC control panels. This standard is also applicable to power wiring between the power distribution panel, motor control center, and field mounted transmitter.

In addition to requirements set forth elsewhere in these standards, the following requirements apply:

1. There are three distinct conduit, or wireway, services for PLC Control Panels that are not to be mixed within one conduit. <u>**They are always segregated into separate conduits, or wireways, unless specifically approved by the Engineer**</u>:
    a. Analog Signals (4-20 mA, 24 VDC)
    b. Discrete Signals (24 VDC)
    c. Power (110 VAC)
2. Separate signal wiring from control power wiring (refer to section 3.2.4.2), group functionally, and arrange neatly to facilitate tracing circuits.
3. <u>**Do not install DC and AC signal wires within the same bundle or conduit.**</u>
4. If possible, organize I/O points in racks so that I/O from two or more pieces of equipment, with the same process function, is divided among at least two groups of I/O cards in a rack. This way if an I/O card fails, the redundant process signal will be secure.
5. If possible, organize the I/O points so that if one I/O card fails, at least one piece of equipment from the group that has the same process function will remain fully operational.
6. **Without exception, all multi-stranded wire ends (both in the field and inside the panels) shall be fitted with the appropriate ferrules (see Section 3.4.3).**
7. **All analog Signals (both input and output to the PLC) shall provide a disconnect on all conductors in the PLC Panel using a WAGO part number 280-874 (see Section 6.4.1).**

3.2.1. Wiring and Cable Guidelines

All wiring and cable shall be installed in conduit, or segregated wireway, as described in Section 3.2.4 and Section 3.1.6. The type of conduit used shall be suitable for the purpose intended.

Each wire and cable shall use an identification or label (as described in section 3.2.3) to facilitate wiring and troubleshooting. <u>**Wire and corresponding terminals, on each end, shall be labelled.**</u>

<u>Wiring shall be continuous and without splices</u>. The contract documents should state the Engineer **<u>must approve any exceptions</u>**. If wires cannot be continuous, all terminations shall occur at a junction, pull box, or termination cabinet using terminal blocks (see Section 3.4.3).

3.2.1.1 Power Wiring and Cable Types

All power wire insulation shall be rated 600 volt THHN, or MTW. Conductors shall be tinned copper. No wire smaller than number 14 AWG shall be used for power wiring. Typically, THHN is run through conduits while MTW is better for within panels.

3.2.1.2 Discrete Control Wiring

Discrete control wiring shall be installed such that signals conform to the following conventions:

1. Circuit powered from field device power unless field device powered through panel.
2. Concept is that field devices should never be powered by more than one source.
3. **Discrete signals shall be brought into the PLC Control Panel as segregated pairs of wires. Daisy chaining of common leads in the field is not allowed unless approved by the Engineer.**
4. DI status from “On/Off” selector – Energized = Device On
5. DI status from “Local/Remote” selector – Energized = Remote
6. DI status from Breaker – Energized = Breaker Closed
7. DI status from Device – Energized = Running
8. DI status from Security Devices – Energized = Normal
9. DI status from Safety Interlock Devices – Energized = Normal (permissive active)
10. DI status from Non-life Threatening Interlock Devices – Energized = Alarm (permissive inactive)

The following requirements apply for discrete control wiring (Reference Table 3.2.2-1 for further details):

1. DC digital signals are 24 VDC and less than 24 mA, and received from auxiliary contact outputs used for controlling devices such as motor starters, push-buttons, pilot lights, and the like, or the use of an interposing relay maybe necessary if an auxiliary contact is not available.
2. Insulation shall have a minimum dielectric strength of 600 volts.
3. Insulation temperature range shall extend to at least 80 degrees C and the insulation shall be suitable for wet or dry locations.
4. Multi conductor cable overall jacket material shall be moisture resistant, abrasion resistant, flame retardant and compatible with the environment in which it is installed.
5. Single or multi Conductor: For single circuits use single conductor #16 AWG, 19x27 stranded copper conductor.
6. Unless specifically shown otherwise, all digital alarm contacts are “normally closed”, “open to trip” to facilitate fault detection (described in the previous paragraph on DI conventions).
7. Segregate digital signal wires away from AC power wires by using a separate conduit.

3.2.1.3 Analog Control Wiring

The following requirements apply for Analog control wiring (Reference Table 3.2.2-1 for further details):

1. Control signals shall be 4 to 20 mA, linear, isolated, and capable of driving a maximum load of 750 ohms. Existing equipment not conforming to this requirement shall be modified or replaced.
2. Single Pair: For individual instrument circuits use single pair, two inch lay, double - shielded twisted, foil-shielded cables with drain wire, #18 AWG, 300 volt, 19x29 stranded copper conductors (Belden 8760 or equal).
3. Multi Pair : For multiple instrument circuits use multi-pair double shielded cables made up of individual single pair, two inch lay, twisted, each pair individually foil shielded cables with drain wire, #18 AWG, 300 volt, 7x26 stranded copper conductors.
4. Shields: Signal shields shall have one ground point located at the PLC panel unless otherwise recommended by the instrument/equipment manufacturer. Shields shall be continuous through cabinets, panels and junction boxes.
5. Separate analog signal wiring at least six inches from power wiring.
6. Install optical signal isolators (aka signal conditioners) **only** on control loops with signal cabling running outside buildings, speed control signals into variable frequency drives, any other situation where potential EMF problems could develop and on all other high risk control wiring (high risk is defined as all I/O potentially exposed to surges, transients, capacitive ground effects, or ground potentials).
7. **Segregate analog signal wires away from digital signal wires and from any power wires by using a separate conduit or wireway.**

3.2.2. Color Coding

All single conductor wiring must be color-coded including wires in pull boxes or junction boxes, even if not terminated in the boxes. All single conductor wires shall be color-coded as defined in this standard. Wire and cable shall be identified using the following schedule:

DESCRIPTION AND/OR FUNCTION	VOLTAGE	Charge	COLORS	Panel (Internal) Wire Gauge and Insulation Type	Field (External) Wire Gauge and Insulation Type
AC Control	120	Ground	Green with yellow stripe	(See Note Below for Gauge) MTW	(See Note Below for Gauge) THHN
AC Control	120	Line Power	Black	(See Note Below for Gauge) MTW	(See Note Below for Gauge) THHN
AC Control	120	Signal to/from PLC	Red	(See Note Below for Gauge) MTW	(See Note Below for Gauge) THHN
DC Control	24 VDC	Positive	Purple	16 AWG MTW	14 AWG THHN
DC Control	24 VDC	Signal Input to PLC	White w/ Blue Trace	16 AWG MTW	14 AWG THHN
DC Control	24 VDC	Common	Dark Blue	16 AWG MTW	14 AWG THHN
4-20 mA (Field Source Power)	24 VDC	Positive	Black	Belden 8760 (or Equal)	Belden 8760 (or Equal)
4-20 mA (Field Source Power)	24 VDC	Negative	Clear	Belden 8760 (or Equal)	Belden 8760 (or Equal)
4-20 mA (Loop Source Power) within panel only	24 VDC	Positive (from PS+)	Purple	16 AWG MTW	N/A
4-20 mA (Loop Source Power) within panel only	24 VDC	Signal Input to PLC	Orange	16 AWG MTW	N/A
Motor Control or Relay Circuits	120	N/A	Red	(See Note Below for Gauge) MTW	(See Note Below for Gauge) THHN
Automatic Control or Foreign Power (in SCADA Panel Only)	120	--	Yellow	(See Note Below for Gauge) MTW	(See Note Below for Gauge) THHN

Note: Wire size is dependent on the breaker size per NEC Code requirements.

Table 3.2.2-1 Wire Selection Chart

3.2.3. Wire and Multi-Conductor Cable Assembly Identification and Labeling

This section defines the cable identification and labeling requirements. A block of numbers to be used for control cable identification will be assigned for each new project or contract. A wire label shall be applied to both ends of every wire, cable or multi-conductor assembly. The contractor is responsible for providing their own label maker. **Only** Brady BMP 41 Shrink-wrap labeler, using the **Bold 13 point** font on the printer, will be acceptable wire labels. Any exceptions to this must be pre-approved by the District.

Labeler	Brady BMP 41
Labels	MC-125-342 (.24”) MC-187-342 (.34”) MC-250-342 (.44”)

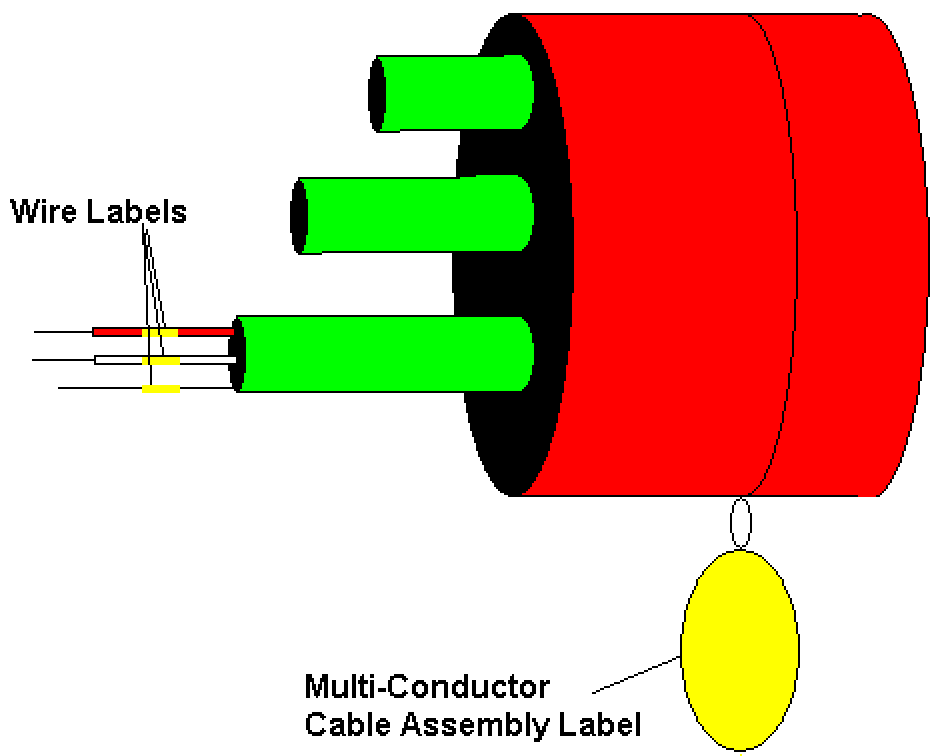


Figure 3.2.3-1 Wire and Multi-Conductor Cable Assembly Labels

Individual wires shall be labeled near the terminal (on either end) with an abbreviated form of the terminal number to which it is connected along with the signal type. The wires shall be identified near the connecting terminal one inch back from the wire end. Wire label naming shall use the scheme illustrated below in Figure 3.2.3-2:

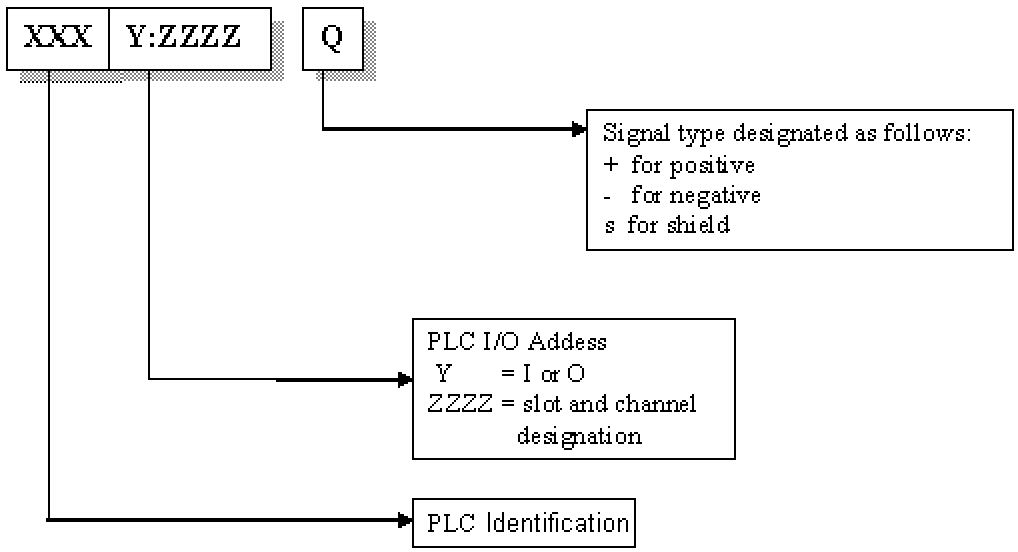


Figure 3.2.3-2 Wire Label Scheme

Wire label numbering shall use an alphanumeric numbering scheme composed that identifies the PLC (see Section 6.2.2) and the I/O hardware channel or terminal point, and they should follow the scheme illustrated in Figure 3.2.3-2.

Examples of wire labels:

1) A positive analog input signal assigned to a card in slot 7, and channel 1, on the EEWWTP Hypo PLC would have a label of:

DS1 I:7.1 +

2) A negative discrete output signal assigned to a card in slot 13 (second rack), and channel 10, on the EEWWTP Bisulfite System PLC would have a label of:

DS2 O:13/10 -

The same wire identification would be applied to all conductor lengths (or segments) from the field device to the PLC Panel and within the PLC Panel to the PLC I/O terminal. Refer to the Allen Bradley User Manuals for the details of the hardware slot number schemes for single and multiple rack configurations. Also not that the hardware I/O address maybe referred differently in the PLC Code.

Multiple conductor (shielded and unshielded) cable assemblies shall all be marked with its designated cable number where it enters the panel. The identification number tag shall be round plastic with the identification number engraved on the plastic tag. Groups of wires shall be separated and marked with #19 insulated twisted wire of the same color as group tracer. Individual cables shall be tagged as described above.

3.2.4. Signal Wiring and Grounding

Modern control systems use low voltage or current signals for the information transfer between the field-mounted equipment and the process control computer. These signals can get "lost" in unwanted background signals, commonly called noise, if proper design and installation techniques are not applied.

The accuracy of the SCADA system is dependent on the signals being clear of noise. A high signal-to-noise ratio is necessary to ensure the SCADA system is not compromised in terms of accuracy and sensitivity by high noise levels.

Proper I/O wiring and grounding will ensure a high signal-to-noise ratio and a working control system.

3.2.4.1 Noise Definitions

Measurements of the noise in the wiring arriving at either the computer or the field control device through the wiring are measured two different ways:

a) Normal Mode Noise
b) Common Mode Noise.

Many different types of problems may have created the noise but these are the two ways which the noise is defined and measured.

Normal mode noise is measured as the differential voltage between two signal wires. Normal mode noise is commonly the result of RFI (radio frequency interference) or EMI (electromagnetic interference). RFI is created by radio frequency energy coupled into signal wires. EMI is created by either high currents running in conductors or by large motors. A magnetic field is produced by these sources, which radiates through air. If signal wires are in the proximity of the magnetic field, voltage is generated in the signal wire by transformer coupling.

Common mode noise is measured between each signal wire and ground. Common mode noise is the result of an electrostatic field rather than an electromagnetic field. This field is capacitively coupled into the signal wire. Different ground potentials in a plant are the most common source. If there are two grounds used in a system the potential between the grounds will cause current to flow through the signal wire and create noise.

3.2.4.2 Noise Reduction Practices

Only shielded twisted pair wire shall be used for all 4-20 mA instrumentation wiring. Refer to Section 3.2.1.3. The mechanical strength of the cable must meet the pulling requirements for installation in conduit.

Separation of wires that contain different levels of voltage will also reduce noise problems. Signal levels can be divided into three categories:

a) High level signals, 50 volts and above
b) Medium level signals, 1 to 24 volts
c) Low level signals, millivolt range.

High voltage signals, 480 volts and above, shall be separated from signal wiring by a minimum distance of 12 inches and be run in different metallic conduit. In addition, the signal wires should be in metallic conduit and not in a cable tray anytime the path must parallel high voltage. Runs that cross should be at a ninety degree angle to reduce the EMI from the magnetic field generated by the high voltage cables.

Select a route for the signal wires which is free from noise sources. Large motors or SCR drives are a major source of noise.

Intermittent noise sources should also be identified and taken into account in the design. Welding equipment used for maintenance and radio transmitters which produce RFI can cause noise problems which are intermittent in nature and very difficult to track down. Survey the location where cabinets or boxes are going to be installed for RFI sources, both in the facility and outside of the facility (radio or TV transmitter nearby). Cabinets designed to eliminate RFI interference can be obtained for areas with high RFI interference.

All cables shall be installed in a wireway or a conduit. Conduit is the preferred. Conduit and wireway provide physical protection for signal cables. Metallic conduit provides the best protection from physical damage and noise.

The shielding on a twisted pair cable must be connected to ground at **one end, at the PLC panel**. The shield at the ungrounded end of the cable must be bent back, away from the conductors, and covered with insulating tape or shrink wrap. Installation requirements must call for installing an insulated sleeve over each of the drain wires and removing the shield material back to the point where the cable assembly is split to allow the individual conductors to be separated from the cable. The cable assembly shall be taped at the point where it is split to assure that the loose pieces of shield material do not contact the enclosure that the cable assembly enters.

The shield wires shall be connected to a dedicated instrument ground. This type of connection requires special attention to the shield in relationship to other conductors. Neither the shield drain wire nor the aluminized Mylar or braided copper shield material may touch anything connected to another grounding system.

The drain wire shall terminate on a terminal block that is then terminated on an insulated copper ground bus contained within the enclosure. At intermediate connection points such as field junction boxes the shield wires shall be connected to terminal blocks to maintain continuity of the shield across the entire signal path. No splicing of shields is allowed at any location.

Where there is a possibility of lightning striking the I/O wiring, surge arrestors shall be provided for the individual I/O points.

3.3. GROUNDING STANDARDS

3.3.1. Shielding

Article 250 of the NEC covers the general requirements for grounding and bonding of electrical installations. The NEC emphasizes safety as related to power circuits. Additionally, the problems of crosstalk and injection of unwanted signals into low-level data circuits and equipment must be considered.

In order to minimize interference between various equipment groups, the single point ground concept is recommended. The following definitions apply with the single point ground concept.

Earth Ground - A high quality earth ground of as low an impedance as practical.

Site Reference Ground - A central ground tie point which serves as a single reference ground point for all parts of the system and the building.

Grounding Circuits - With the single point ground concept, several independent insulated ground circuits are established by functional usage and all are terminated at the Site Reference Ground point. Except for structure ground, the individual ground circuits must be insulated from each other except at the Site Reference termination point. Computer cabinet and signal grounds must never share electric power ground circuits. Typically ground system circuits are established for:

a) Electric AC neutrals
b) Electrical equipment cabinet/conduit grounds
c) Computer/peripheral cabinet grounds
d) Signal ground
e) Facility/structure ground.

Site specific ground circuits can be established in different parts of the building. For example, all computer equipment type cabinets in a computer room may be connected by insulated cable to an insulated ground bar. This bar, in turn, is then terminated to the Site Reference Ground. Similar arrangements can be made in other areas.

3.3.2. Guidelines

In most cases, an isolated single point ground (SPG) system shall be used with electronic instrumentation and process control computers. This means that the system's ground connects to earth at only one point. This point may be a facility ground or a dedicated ground rod. If the process control system uses fiber optics as a data highway a single point ground does not have to be distributed to each distributed PLC. The fiber optic cable eliminates facility ground loops and isolation problems related to using copper conductors. With fiber optics each PLC will require a SPG local to only the equipment mounted in the PLC panel or located nearby.

A SPG system has grounding branches that serve various parts of the computer and instrumentation system. Major branches connect to the system ground, while minor branches connect to analog, digital, or rack ground buses. Each ground branch must be connected at one end only; the far ends of each ground branch must be disconnected from ground.

Do not allow the design or the contractor to use conduit, cable raceways, or building steel to distribute the SPG from point to point. Distribution should be through a well-insulated, dedicated wire of appropriate size.

The earth ground for a SPG system should conform to the National Electrical Code, Section 250-50 through 250-70. The buried ground should:

a) Be made of good electrical conductors;
b) Withstand mechanical abrasion;
c) Provide sufficient contact area with the soil to minimize grounding resistance.

Ground resistance to earth is measured using methods outlined in Standard Handbooks for Electrical Engineers, or by following procedures recommended by vendors of ground-measuring equipment. Although the NEC requires that ground resistance not exceed 25 ohms, electronic control systems ground should be as low as practicable, but not more than 5 ohms.

The conductor connecting the earth ground to the system ground should be insulated and stranded copper wire, #2/0 AWG. This conductor should follow the most direct path between the ground points. Sharp turns decrease the conductor’s ability to carry high currents, such as those encountered when lightning strikes nearby, and should be avoided.

3.3.3. I/O Racks

Guidelines for designing grounds for I/O racks containing analog and digital signals are:

a) For metallic enclosures: Each I/O rack shall have an isolated signal ground bus system. This system is made up of commoning earth ground terminal blocks (see Section 6.4 for specific details), DIN carrier rails, and grounding wire between the DIN rail and the enclosure. The grounding wire shall be connected to the enclosure back panel at only one point, via a stranded, insulated copper wire of #8 AWG or larger. If the rack contains analog and digital signals, a separate bus shall be provided for each signal type.

b) For non-metallic enclosures: Each I/O rack shall have an isolated signal ground bus system. This system is made up of commoning earth ground terminal blocks (see Section 6.4 for specific details), and DIN carrier rails. The DIN rail shall be connected via a grounding strap to a 1-inch wide by 1/4-inch thick, running from top to bottom in the enclosure. The bus shall have tapped holes to accommodate ground connections from various devices in the enclosure. The signal ground bus shall be connected to the system ground plate at only one point, via a stranded, insulated copper wire of #8 AWG or larger. If the rack contains analog and digital signals, a separate bus shall be provided for each signal type.

c) The I/O rack frame shall be connected to the system ground, via a connection that is kept isolated from the signal ground bus

d) Each chassis or panel in an enclosure shall have internal grounding lines that connect to the signal ground bus.

e) Connections shall be via ring tongue connectors that bolt to the bus.

f) If the enclosure has several types of signals that need to be grounded, such as low level sensor signals, high-level output modules, or noisy switching circuits, each shall have a separate line to the signal ground bus. Only circuits of the same voltage level shall share the same ground return line.

3.3.4. PLCs

Grounding requirements for the PLCs containing analog and digital signals are similar to those for the I/O racks:

a) Each PLC shall have a stranded, insulated, copper wire # 8 AWG or larger connecting the PLC ground terminal to a ground lug attached to the interior of the PLC cabinet.

3.3.5. Computer Components

Grounding requirements for the computer equipment and peripheral devices are similar to those for the I/O racks:

a) The cabinets of all computer equipment shall be connected to the system ground via a separate conductor.

b) Rack frames for all computer peripherals shall be connected to the system ground via a separate conductor.

c) The computer ground bus (supplied by the vendor, and usually located in the CPU cabinet) shall be connected to the system ground plate using an insulated #2/0 AWG (or larger) wire. The ground conductor shall run in conduit, using the shortest possible path to the ground plate. This line shall be separate from the cabinet frame ground. Follow the guidelines for the I/O signal bus ground.

d) In all cases the computer ground bus shall connect to the building ground. Electrical codes and safety require all grounds be bonded together. The computer ground shall be connected to the building ground at only one place. The location of the connection should be as close to the computer system ground rod as possible

3.3.6. Radio Antennas and Antenna Surge Arrestors

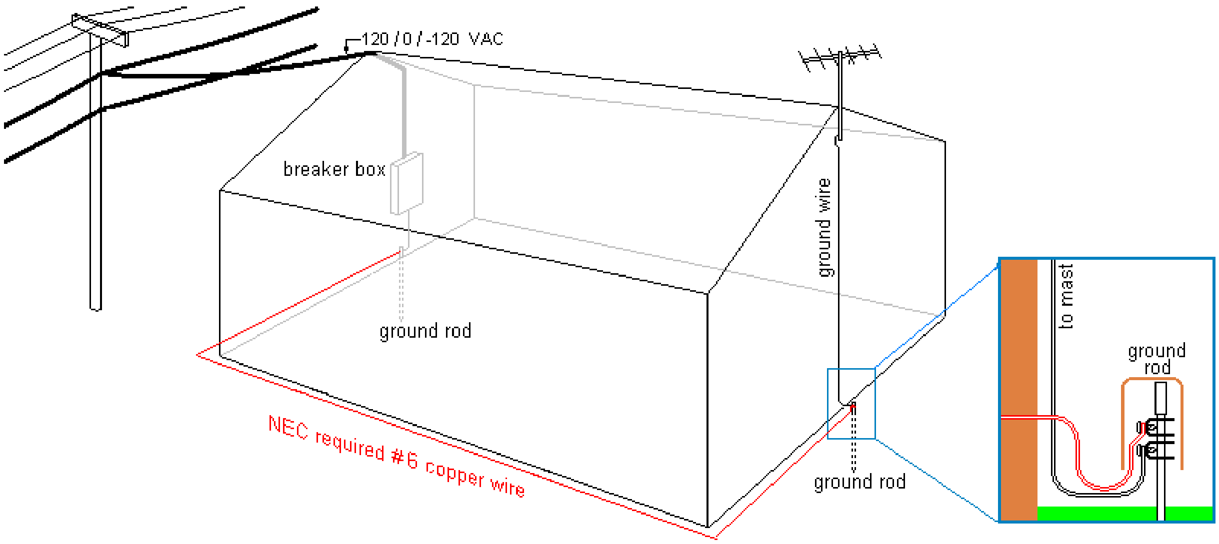


Figure 3.3.6-1 Radio Antenna Ground Example: Building (Also see Figure 3.3.6-3)

Figure 3.3.6-1 illustrates a typical antenna grounding system for a building. All of the elements required by NEC 810.15 regarding the installation of the antenna grounding system shall be followed. In summary, the grounding system (according to NEC) shall be made up of:

- A ground wire that runs from the antenna mast to the base of the building following the shortest practical path.
- Then at the base of the building there needs to be a grounding rod that is driven at least 3 feet into the ground.
- Then that grounding rod is electrically connected to the building service ground via an underground grounding wire (red line in the figure above) that runs 3 or 4 inches below grade. The length of this wire is not important, but the turns should be of a large radius. 6-gauge (#6 copper) wire shall be used for this ground connection.
- The surge arrestor for the coax antenna cable is located either outside the building (See Figures 3.3.6-3) or outside the telemetry panel when there is no building. The surge arrestor is grounded to the antenna ground. Refer to Section 6 for PWD's preference of surge arrestor.

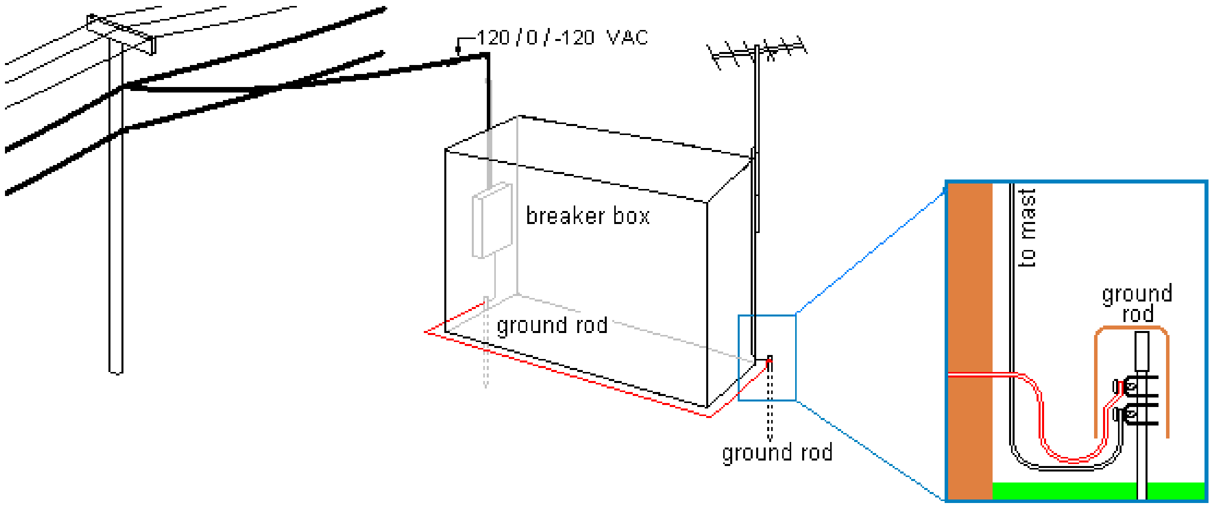


Figure 3.3.6-2 Radio Antenna Ground Example: Outside Panel

Figure 3.3.6-2 illustrates the grounding system for an outside panel (common for small pump stations). All of the elements described for the building example above apply to this example.

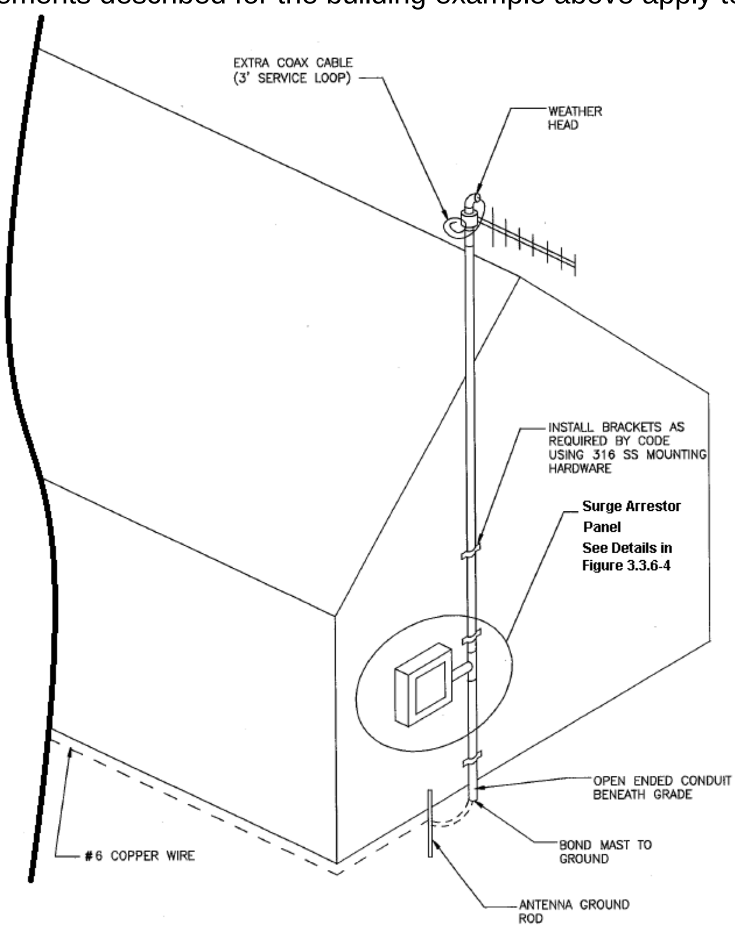


Figure 3.3.6-3 Surge Arrestor Panel Location

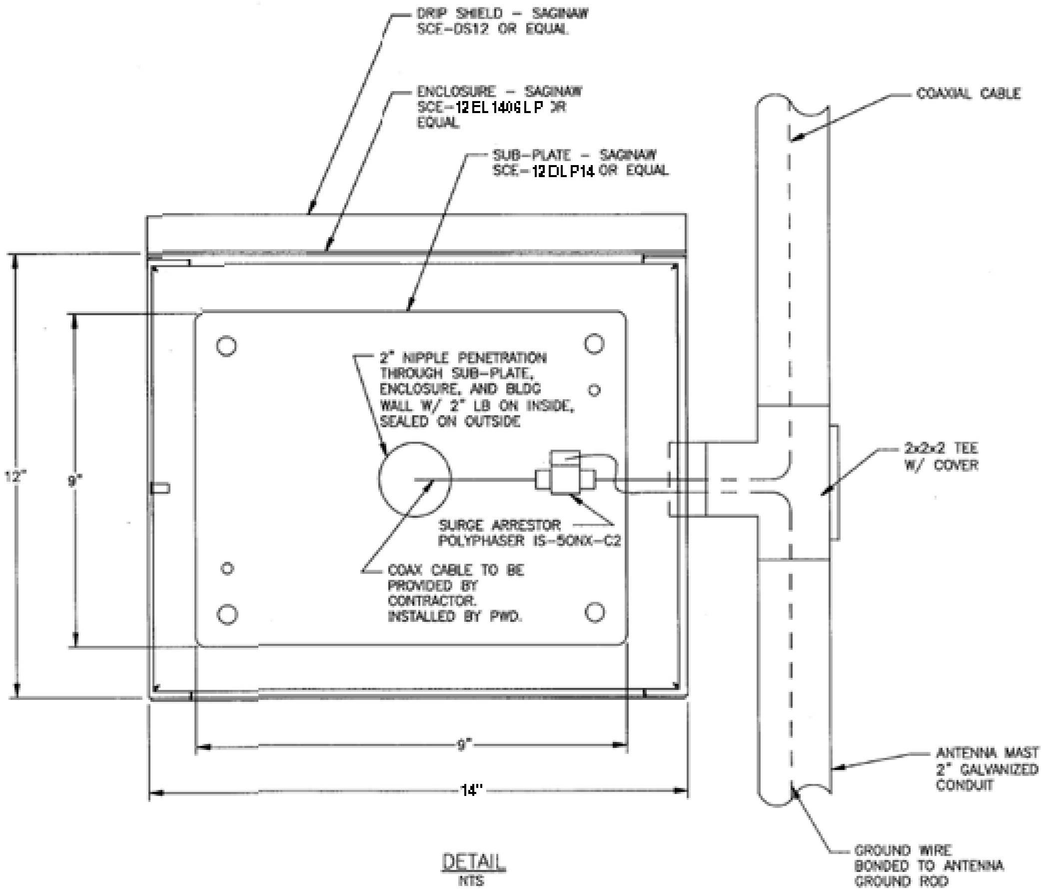


Figure 3.3.6-4 Surge Arrestor Panel Details

3.4. EQUIPMENT PANEL DESIGN STANDARDS

This section describes the types of control panels used by PWD as well as general requirements, materials of construction, and construction guidelines.

3.4.1. Panel Types

Panel types shall be specified to be compatible with and suitable for the environment of the installation location, and shall protect enclosed instruments and equipment. The choice of location for panels should attempt to minimize exposure to ambient temperature extremes, moisture, dirt and gaseous contaminants. Panels shall be specified to be designed, manufactured and tested in accordance with the latest applicable standards of NEMA, IEEE, NEC, UL and ANSI.

Only NEMA type 4 are to be used for SCADA related purposes in PWD facilities. Use of other NEMA types must be pre-approved by PWD. Outdoor panel shall have a drip edge installed over the panel door. See Section 6 for panel specifications.

PWD understands that some modifications required by this standard (i.e. laptop shelf for an RTU panel or cutting a hole to mount a CyberLock CAM lock) may de-rate a NEMA type 4 to NEMA type 1 rating. This is acceptable to PWD.

Local Control Panels (or LCPs) shall never be located in hazardous locations. Local Panels consisting of lockout or limited start/stop control may be located in a hazardous area only if all controls and the panel are rated for hazardous locations.

3.4.2. Panel Construction

Panels shall be designed to accommodate all necessary accessories such as power supplies, mounting hardware, terminal blocks and any signal conditioning or conversion equipment that may be necessary to make operational all monitored and controlled equipment to be mounted in the panel. Panels shall be designed with sufficient spare space to provide for future expansion of 25% of initial capacity (PWD reserves the right to waive this requirement).

Panel layout and equipment spacing should be designed to allow for device removal, calibration and maintenance without disassembly of adjacent devices. **Also there shall be plenty of peripheral space near the field terminals to provide enough room for the field wires entering the panel.** The panel layout should follow all necessary NEC requirements.

The panel design should minimize the Arc Flash potential. The rating for Arc Flash potential of the panel should be labeled on the front door of the panel (see figure 3.4.2-1 below).

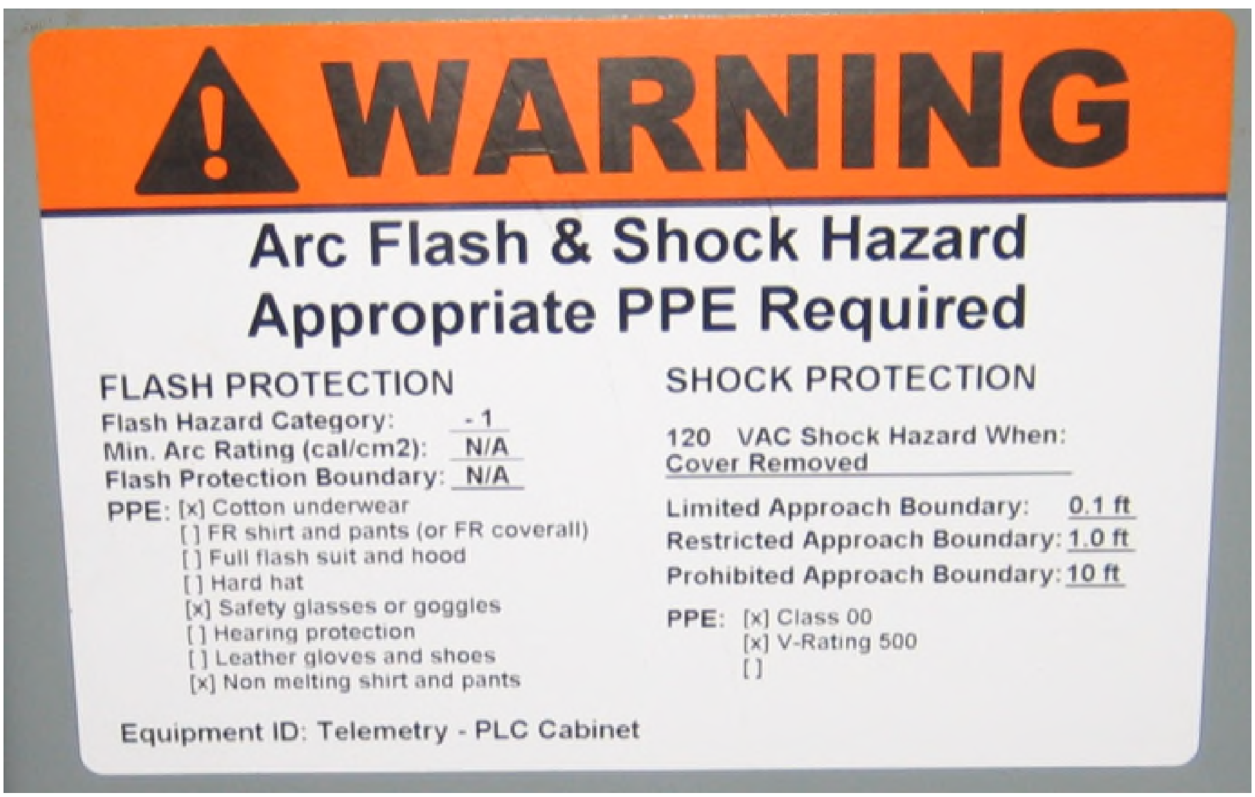


Figure 3.4.2-1 Example of Arc Flash Panel Label

The Arc Flash Label shall list the following information:

- Arc Flash Hazard Boundary in feet
- Incident Energy in cal/cm^2
- Working Distance in inches
- Shock Hazard Exposure in VAC
- Insulating Glove Class
- Panel Condition When there is a Shock Hazard (i.e. When the door is opened)
- Limited Approach Boundary in feet
- Restricted Approach Boundary in feet
- Prohibited Approach Boundary in feet
- Equipment Name
- Hazard Category
- Minimum PPE Requirements

Removable eyebolts must be provided to facilitate sling handling of large enclosures. Eyebolt mounting should be a part of the structural support bracing to distribute stresses and enclosure weight during installation.

Below is a list of general specifications that are applicable to all enclosures used at PWD (additional specifications can be found in Appendix D):

1. All panels shall have sufficient structural reinforcements to ensure a plane surface, limit vibration and to provide rigidity during shipment, installation and operation without distortion or damage to the panel or injury to any mounted instruments. All enclosure seams must be continuously welded and ground smooth to be undetectable after painting.

2. All panels shall be specified to be primed and finished with two coats of a factory finished (typically ANSI #61 light gray) lacquer finish on all exterior surfaces.

3. All panels that will be installed outdoors shall have a suitable enclosure heater with thermostat control for condensation and freezing protection. See Section 6.4 for specifications.

4. An interior incandescent or fluorescent light fixture and a duplex G.F.I. convenience outlet with on/off G.F.I. circuit breaker for maintenance purposes shall be specified for all panel enclosures.

5. All SCADA related enclosures (i.e. LCPs, Local Panels, SCADA PC Panels, OIT Panels, etc.) shall be specified to be provided with flush hinges and vault-type latch capable of accepting a 3/8-inch shackle padlock, and provide a Videx Cyberlock electronic security mechanisim (see Section 6.4). Enclosure doors 36" high and larger shall also require three point latch assemblies.

6. For Wall-Mounted Panels, single door, wall-mounted enclosures shall be specified up to a maximum of 48 inches high x 16 inches deep. These panels shall be constructed of a minimum of 14-gauge steel. All two-door panels shall be constructed of a minimum of 12-gauge steel.

7. Free-Standing Panels shall be specified to be constructed of a minimum of 12-gauge steel.
8. All PLC panel shall provide a folding laptop table on the panel door with a door stop to prevent the door from closing while the table is in use (see Section 6.4.2 table entry for “Folding Shelf” for specifications).
9. If panels require air exchange for cooling, fans drawing air into the panel must be filtered. The filter surface area should be sized three times larger than the fan intake area for each fan.

3.4.3. Panel Wiring and Terminations

All internal panel wiring and terminations shall be designed in accordance with the latest applicable standards of the NEC as well as applicable state and local electrical codes.

Signal wiring shall be segregated from control power wiring, grouped functionally and arranged neatly to facilitate circuit tracing. Low level analog signals of 100 millivolts or less shall not be combined with digital input or control output wiring nor shall they be intermixed within the same bundle, duct, or Panduit within a panel.

Plastic wiring wraps shall be used to bundle wires, except within wiring ducts. The bundles shall be securely fastened to the steel structure at suitable intervals, not exceeding 12 inches.

Where shielding is required, shields shall be continuous foil or metalized plastic providing 100% coverage. A drain wire in continuous contact with the shield shall be included. The drain wire shall not be used as a control signal conductor. **The shield will only be grounded inside the PLC Panel.**

All DC signal wiring shall be segregated from wire conducting AC signals.

Wiring shall not be spliced. Wire shall be run in continuous lengths from terminal to terminal. Wire service loops shall be provided to permit device removal (minimum length shall be 20 times the outside diameter of the wire or what is approved by PWD).

Field wiring terminal blocks shall be provided for interconnections with field instruments and other termination cabinets. It shall not be permitted to connect field wiring directly to PLC I/O module wiring terminals.

Field wiring terminal strip shall use Wago (or equal) spring type terminal blocks, as listed in Section 6.4.

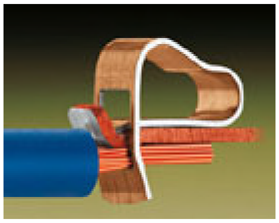


Figure 3.4.3-1 Internal Component of a Spring Type Connector

Wago ferrules shall be applied for all for multi-stranded wire ends (for both field and panel wires) regardless of the type of terminal block is used (screw or spring type). See

Table 6.4.1-5 for details. PLC terminations shall use un-collared ferrules to assist with the tight space of the I/O card terminal strip. All other terminations shall use collared ferrules. Only a Wago brand, four sided, crimping tool will be acceptable (the contractor is responsible for providing their own crimping tool). Round crimping tools are not acceptable because they do not produce the proper surface contact with the spring type terminal block. The crimping tool should provide a gas tight bond between the wire strands and the ferrule jacket.

Figure 3.4.3-2 Wago Crimping Tool and Collared Ferrules

Local Control Panel wiring shall be identified at **each** termination (see Section 3.2) to correspond with the diagrams and shall be color-coded as specified in Section 3.2 Color Coding.

All wires and cable terminated within local control panels, instrumentation junction boxes, local panels, OIT panels, equipment enclosures and termination cabinets shall be provided with identification tags to identify cables according to Section 3.2.

3.4.4. Panel Display Devices

Instruments or devices furnished for front of panel mounting shall be suitable for panel mounting and selected to match each other and present a coordinated aesthetically pleasing functional arrangement. The arrangement of devices on the panel shall be as symmetrical as possible and shall functionally group devices to enable operators to easily locate groups of devices or individual devices to control the process. Panel indication or display devices shall be mounted between 48 and 60 inches above the floor to be easily readable by the operator.

Display devices shall consist of rectangular panel meters, edgewise panel indicators, recorders, annunciators and graphic displays.

All display devices shall have scales that indicate the actual process value with the measured variable reading in engineering units (i.e., 0 to 3000 GPM). It is unacceptable for display devices to indicate the measured value as a percent of maximum (i.e., 0 to 100% full scale) except for those devices displaying position (i.e., percent valve open, percent valve closed).

3.4.4.1 Switches, Pushbuttons and Lights

Selector switches and pushbuttons shall be the type that are supplied with the add-on operator mechanisms so that the appropriate number of contact blocks and block type can be attached to the switch. Contact block terminals shall be labeled for identification purposes and contain not less than one single pole, double throw contact.

Contacts shall be specified as heavy-duty type, rated 10 amperes at 120 VAC breaking current.

In the case where the contact blocks are handling low level signal currents, the contacts shall be rated for electronic duty and provide mechanical self-cleaning action for reliable operation on electronic loads where thermal cleaning action is not present. The contacts should be rated at 1 amp at 28 Vdc and be constructed of gold or gold flashing over silver.

All selector switches, pushbuttons and indicating lights shall be oil tight NEMA Type 13. All pushbuttons and indicating lights shall be supplied by one manufacturer, shall be of the same series or model, and shall be heavy duty oil tight, Allen Bradley, or approved equal.

All indicating lights shall be oil tight type operating from either 24 VDC or 120 VAC, 60 Hz power source. Indicating lights operating on 120 VAC shall be transformer type with the indicating lamps operating on 6 to 8 VAC. Indicating lights operating on 24 VDC shall have lamps rated for 28 VDC for longer life. **The use of light emitting diodes (LED) is standard**. Removal and replacement shall be accessible through the front of the panel. A push-to-test-feature shall be employed on indicating lights to provide a positive test of light condition. The indicating lights shall be Allen Bradley, or approved equal.

Indicating lights shall be color-coded as followed:

LEGEND NOMENCLATURE	LENS COLOR
TROUBLE/MALFUNCTION	AMBER
STATUS	WHITE
RUNNING	GREEN
CONDITION OF SAFETY, INACTIVE STATE	RED
STAND-BY/ENERGIZED	RED
ON/RUN	GREEN
OPEN	GREEN
CLOSED	RED
NEITHER OPEN NOR CLOSED (TRAVELING)	RED AND GREEN LAMPS LIT

3.4.5. Relays and Timers for Instrumentation Panels

All interposing relays shall be supplied by the same manufacturer to assure similar appearance and uniform operating characteristics. All relays shall have a clear polycarbonate dust cover and internal light indication to show if the relay is energized. Refer to Section 6.4 for specific models of acceptable relays models.

All digital output signals shall have an interposing relay to isolate the PLC signal circuit from the field signal circuit. This relay shall reside within the PLC enclosure.

All electrical timing relays, (timers) shall be supplied by the same manufacturer to assure similar appearance and time setting procedures. Refer to Section 6.4 for specific make and models of approved devices.

3.4.6. Nameplates and Identification Tags

All equipment in PWD facilities must be identified as to the function each piece of control equipment provides, its name, and other information as outlined in this section of the SCADA System Control Standards. The equipment nameplate should also conform to the standards as defined in Section 2.3 of this standard.

3.4.6.1 Equipment Nameplates

Nameplates must identify the function, position, and/or condition indicated for each pushbutton, switch, indicating light or other control device. Nameplates for pushbuttons, switches, indicating lights, and similar control devices shall be the standard type furnished with the device.

Nameplates should be provided for each receptacle, designating the panel board and circuit number that supplies power to that receptacle.

Nameplates should be secured to equipment fronts using double-sided industrial tape. Tape may also be used for securing nameplates to the inside face of recessed panel board doors in finished locations or other type equipment that is enclosed in panels.

Nameplates made of embossed tape should not be permitted for any application, even temporary.

Equipment nameplates shall be made of laminated plastic approximately three thirty-seconds of an inch thick (3/32 inch), beveled edge, black with white engraved lettering, attached with corrosion-resistant machine screws with castellated nuts. Nameplates shall be a minimum size of one and one quarter (1-1/4) inches high by three and one-half (3-1/2) inches wide.

Nameplates for pushbuttons, switches, indicating lights, and similar control devices shall be the standard type furnished with the device.

Nameplates must be provided for the following equipment:

a) All electrical distribution and control equipment and loads served

b) Panel boards, Switchboards and Motor Control Centers with identification of voltage rating and source.

c) Individual Circuit Breakers, Switches, and Motor Starters in Panel boards, Switchboards, and Motor Control Centers, with identification of circuit and load served, including location

d) Individual Circuit Breakers, Enclosed Switches, and Motor Starters, with identification of load served

e) Transformers, identify equipment designation, with identification of primary and secondary voltages, primary source, and secondary load and location

f) Receptacles, with identification of panel board and circuit number.

3.4.6.2 Instrument Identification

All instrumentation should be identified with equipment and tag numbers in the same way as for equipment described above. However, in many field locations the use of nameplates would be impractical. Equipment tags made of plastic laminated paper tags is a more practical approach. The tag will have the instrument name. The tag has a hole for attaching it with plastic tie-wrap to the instrument. This type of tag provides the most indestructible and long lasting nameplate. Refer to Section 6.2.6 for an example of the tag layout.

3.5. ELECTRICAL DEVICE STANDARDS

This section describes the requirements for electrical devices, which may be mounted in panels depending upon scope of the project. These requirements apply to all devices, irrespective as to whether they are provided separately or as part of a complete assembly or process package.

The Control System supplier shall assume that equipment supplied shall be installed in an environment which is classified as harsh, possibly prone to chemicals, and condensing humidity, and low levels of free chlorine. As such, equipment shall be rated for installation in such environment or the system supplier shall provide the suitable protective enclosures.

Devices shall be rail mounted, rack mounted, panel door mounted. The total number of manufacturers shall be kept to a minimum by purchasing as types of devices as possible from the selected Manufacturers.

Electric style relays shall be used for control signals (analog and discrete).

3.5.1. Selector Switches

Selector switches shall be Allen-Bradley 800T, or equal.

3.5.2. LOR Switches (or Local Disconnect Switches)

All LOR switch will provide an auxiliary contact wired to the SCADA System (via a PLC DI channel) to indicate the switch position for both the Local and the Remote positions.

Revision Memo

Rev. 0	May 7, 2004	Draft Version for comments
Rev. 1	June 18, 2004	Final Version for comments
Rev. 2	July 23, 2004	General revision based on comments
Rev. 3	April 14, 2006	First PWD Revision
Rev. 4	February 27, 2009	Changes to all sections Major revisions to sections: 3.1.5, 3.2.2, and 3.3.6
Rev. 4.1	August 1, 2012	Minor Changes to all sections Significant Changes to sections 3.2 and 3.4
Rev. 5.0	September 20, 2016	Major Changes Related to the CompactLogic PLC Standards Change
Rev. 6.0	September 01, 2021	Minor Changes Throughout

TABLE OF CONTENTS

LIST OF FIGURES & TABLES

4. HARDWARE DESIGN STANDARDS

4.1. SYSTEM ARCHITECTURE

PWD's SCADA Systems shall conform to the four-level architecture shown functionally in Figure 4.1-1. The drawing does not show all required components, but defines the required hierarchy.

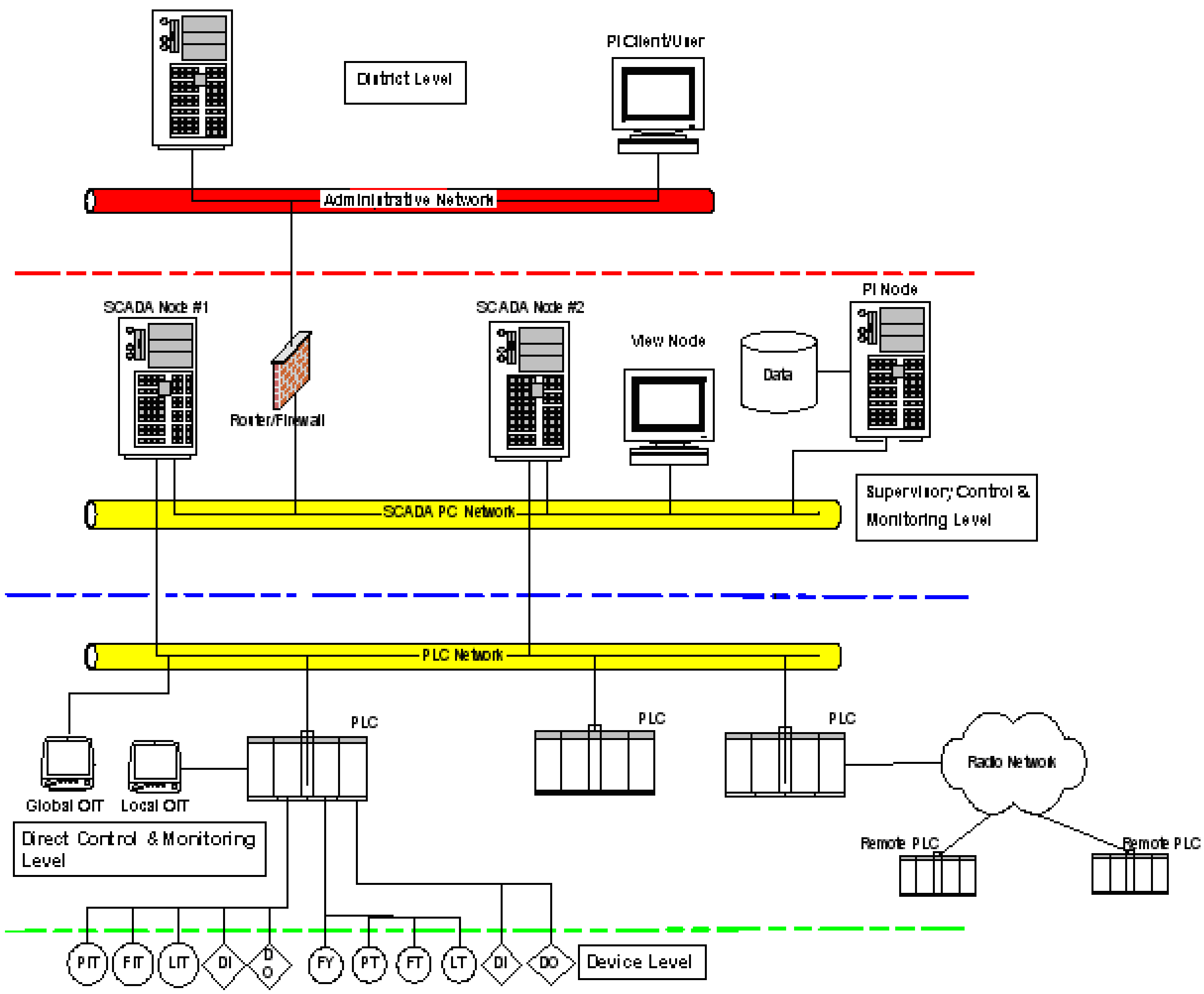


Figure 4.1-1 System Architecture

4.1.1. District Level

An enterprise-wide level is where the district's decision-making takes place. The DISTRICT level does not send commands or data of any sort to the SUPERVISORY level. PWD's SCADA Data needs are met by the OSISoft PI package.

4.1.2. Supervisory Control and Monitoring Level

A facility-based level is where the decision-making appropriate to the facility is required. The district has more than one facility. Requires accurate data with a time resolution sufficient to allow on-the-spot decisions regarding process operation. Usually requires data for at least one year. Sends commands to the DIRECT level. The SUPERVISORY level is met by two Intellution iFIX SCADA Nodes, configured in a hot-standby configuration, and also by one or more Intellution iFIX iClients (or View Nodes) shown in Figure 4.1-1.

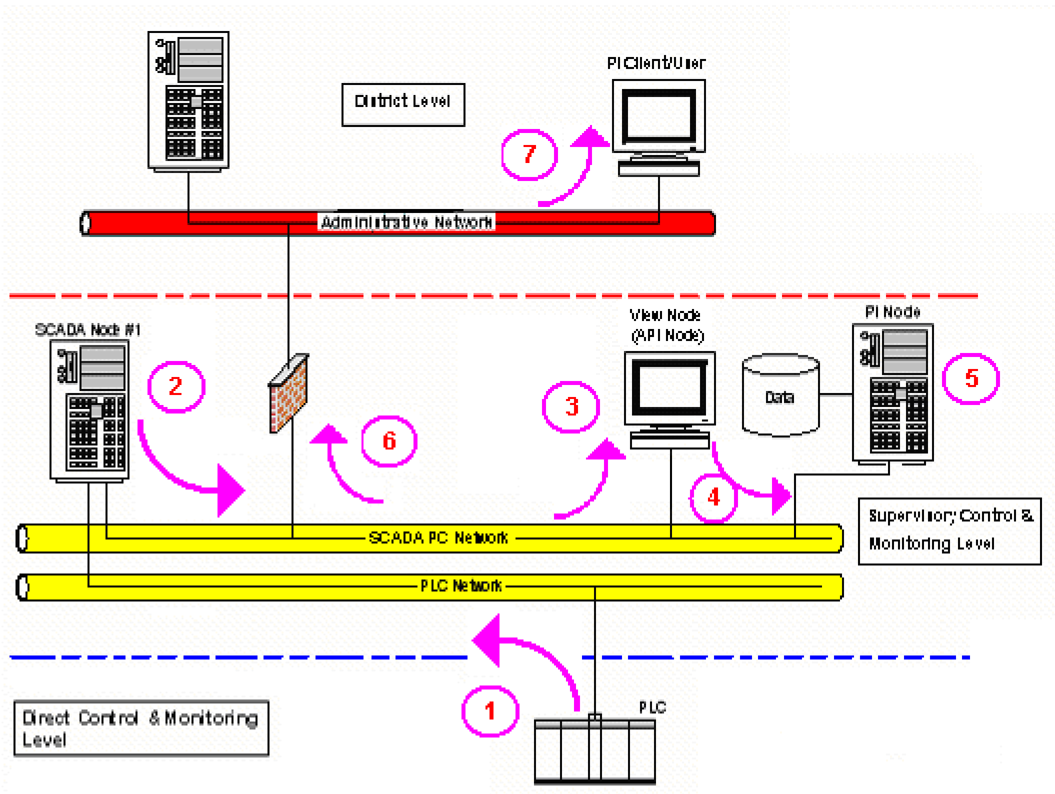


Figure 4.1-2 SCADA Data Path

It is critical that the SUPERVISORY level database be closely integrated with the PI System. A combination of SCADA components are required to provide information to where it is needed. Figure 4.1-2 illustrates the path of the data from the field source to a user on the administrative network. The following numbered list refers to the numbers found in Figure 4.1-2:

1. The source of field or plant information is the PLC which is connected to instruments that are monitoring the processes of interest to the PWD. From the PLC the data is polled, or collected by the GE Proficy iFIX SCADA Nodes. There are two SCADA Nodes that are independently gathering data, but only one of them are considered to be “Primary” making it the source of data for all of the View Nodes (or iClients). The other SCADA Node is considered to be the “Backup”.
2. From the “Primary” SCADA Node, the data is then available to the “SCADA PC Network” components, which is consisted of View Nodes.
3. Through the “SCADA PC Network” the View Node which has the PI API Node software, gathers data from the “Primary” SCADA Node. The API software has to run on a View Node because it is the only node that can recognize which of the SCADA Nodes is

"Primary" and which one is "Backup". This is critical to prevent the loss of data in the event that the "Primary" fails and the "Backup" takes over.

4. The data is then past from the API Node to the PI Node. The API Node can store (or buffer) the data in the event the PI Node is offline. There are three API Nodes (SLWTF, EEWWTP and Westbrook TP) which supply data to one PI Node, or Server, that is located at the PWD Douglass St Office.
5. The PI Node is the long term historian of the SCADA System and it provides SCADA data to all of the PWD staff and the Managed Data System (OPS).
6. The PI data is then past, on a demand basis, to users on the Administrative Network through the router. The router acts as a "firewall" to protect and limit access between the two networks. It also provides data for the Hach WIMS System that provides the operations staff reporting function and lab data history.
7. The administrative network user can use PI Client tools (ProcessBook and DataLink) to monitor processes, or to do data analysis work in a spreadsheet.

4.1.3. Direct Control Level

A process-based or remote site-based level is responsible for the overall coordination of control at a single process area or site and it is connected directly to the process devices. This level consists of a PLC and hardwired controls and requires instantaneous data for safe operation of the station. May receive commands from the SUPERVISORY level, and will act according to its program. It is capable of safe operation of the process even if the SUPERVISORY level is not available. Sends command signals to the DEVICE level, in the form of 4-20 mA signals, 120 VAC or 24 VDC signals, to activate equipment such as pumps and valves.

For all new or upgraded facilities, the PLC to be used shall be as defined in Section 4.3.

4.1.4. Device Level

The lowest level is at the process instrumentation or equipment level. Provides data to the DIRECT level, but usually contains some localized safety provisions in case of failure of the DIRECT level systems. Receives command signals from the DIRECT level to activate equipment.

4.2. NETWORK DESIGN STANDARDS

The following network standards shall be followed when new in-plant SCADA networks are being designed and installed or when existing networks are being upgraded.

SCADA systems transfer real-time critical data and require robust, reliable communications for PLC to PLC, server to PLC, and server to workstation data exchanges. Therefore, SCADA system network installations require reliable, high speed communications with consideration of utilization and capacity for future growth. Communications media to convey signals between network devices shall be fiber optic cables and copper cables. Fiber optic cabling shall be installed for all backbone network segments that run between process areas of the plant and between buildings. Copper cabling may be used for network segments that are completely within a single room, such as a control room, and between fiber optic network nodes and devices such as PLCs, subject to the maximum allowed distance for CAT5e cable of 100 meters (328 feet).

4.2.1. Fiber Optic Media

All PLC network installation and improvements shall use fiber optic media for backbone segments to support Ethernet communications for process monitoring and control, and other possible applications as indicated below. The backbone shall be installed using multimode fiber optic cable consisting of a minimum of 12 fibers. The fiber within each facility shall be configured to support connectivity as follows:

Number of Fibers	Network Application
TBD	PLC Ethernet Network communications (dependent on the number of star points)
2	Redundant PLC Ethernet Network (Site dependent)
2	SCADA PC Ethernet Network
2	Security (CCTV)
2	Administrative Network
2	Spare for future network upgrade

Table 4.2.1-1 Fiber Optic Cable, Fiber Strand Allocation

4.2.1.1. Fiber Cable Characteristics

Low-loss, glass type, fiber-optic multimode graded-index cables with the following operational and construction features shall be used:

1. Minimum number of fiber strands: 12
2. Fiber type (core/cladding): 62.5/125 microns
3. Cable Type: OFNP (Nonconductive optical fiber plenum cable)
4. Fibers within the cable shall be color-coded so that each fiber may be individually identified.
5. Ripcords shall be provided to simplify sheath removal.
6. Use Optical Cable Corporation DX24-075K-WLS-900, or equal

4.2.1.2. Terminations

Refer to Figures 4.2.1-1 and 4.2.1-2 Typical Fiber Optic Node for the following discussion.

1. A fiber termination panel shall be installed at each fiber-to-copper and fiber-to-fiber interface locations. Fiber termination panels shall include splice trays and patch panels.
2. Fiber optic pigtails shall be installed between each patch panel and the splice trays. One end of each pigtail shall be pre-connectorized at the factory with a Type ST connector. Field installed fiber connectors on the pigtails are not allowed.
3. Fibers shall be spliced using the fusion method. Mechanical splices are not allowed. Splices shall have a loss of 0.2 dB or lower. Spare fibers from cables (beyond those that are mentioned in Table 4.2.1-1) entering each patch panel shall be stored in an orderly manner inside the patch panel.

4. Where practical, pre-connectorized fiber optic jumper cables shall be installed between each patch panel and optical communication devices. Optical communication device connectors shall be Type ST, unless Type ST connectors are not manufactured for the device. Connections shall have a typical loss of 0.2 dB or better and shall provide stable optical performance after re-mating. Field terminations shall use a simple procedure requiring minimal training.
5. Single, unjacketed fibers shall not be used for terminations to optical communication devices. All fibers entering a patch panel shall be terminated and tested.
6. Fiber labeling guidelines:
    a. Fiber pairs shall be designated as TX or RX on both ends:

        TX ←-----------→ RX
        RX ←-----------→ TX

    b. Provide a fiber strand jacket color guide
    c. Provide a splice box identification label
    d. Provide fiber cable labels
    e. Provide patch panel labels

The PLCs are connected to the fiber optic network via a series of network switches, fiber-optic patch cords (or jumpers), Cat 5e cables, fiber-optic pigtails, and fiber-optic splices. The following diagrams represent the typical configurations adopted by PWD. In Figure 4.2.1-1, the following elements are found:

- The PLC and the network switch are located within 300 feet of each other.
- The PLC Network is configured as a star or multi-star point configuration. This means that there is only one fiber pair terminated on the switch. This means that the fiber strands are either continuous strands or fusion spliced strands originating from the central network switch.
- The network switch is usually located within the PLC enclosure, and is connected to a UPS (see Section 4.2.7).

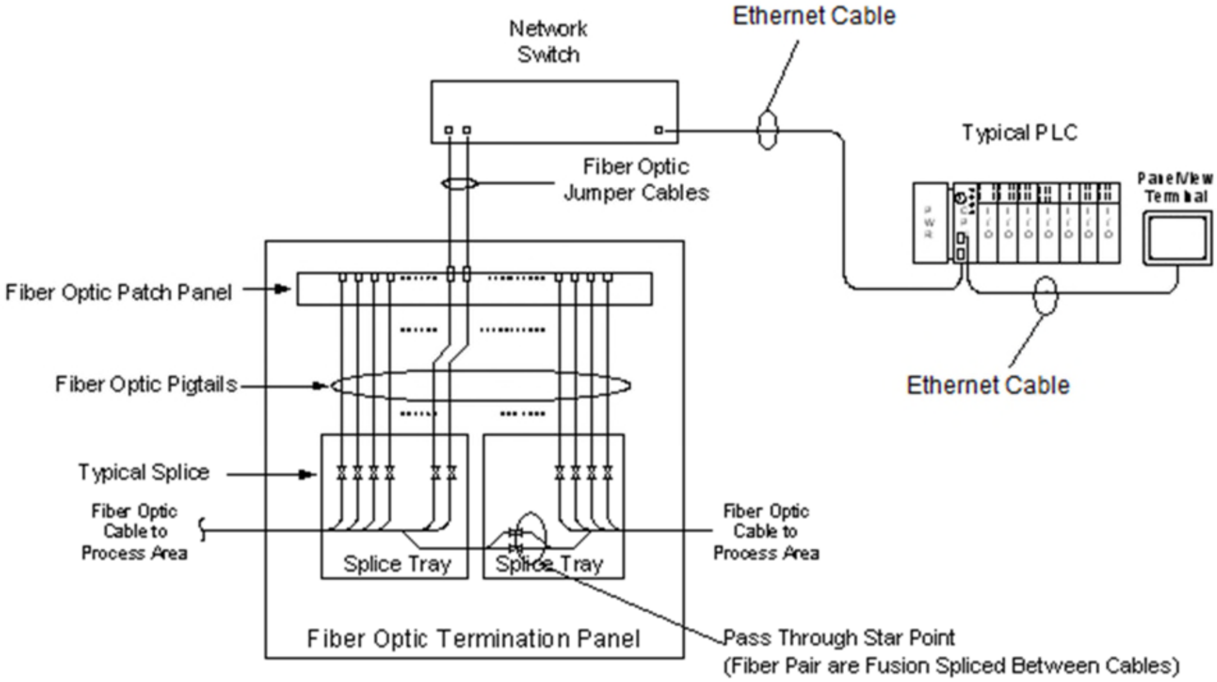


Figure 4.2.1-1 Typical Fiber Optic Star Point (single PLC)

4.2.1.3. Testing

Once the installation is complete, the fiber shall be tested and the results shall be documented. The test data must be provided to PWD for review and acceptance prior to connecting SCADA system equipment. The test results must provide adequate information to determine that the installation was successful and include the manufacturer's maximum allowable dB loss.

Using an OTDR (Optical Time Domain Reflectometer) tester is required. The test results shall be provided in both a hardcopy and computer file format.

4.2.2. Copper Network Cable

Copper cabling for network applications shall meet or exceed the specifications for Category 6e cables based on the EIA/TIA 568 Commercial Building Telecommunications Wiring Standard. All network devices including jacks, connectors, patch panels and jumper cables shall be rated for Category 6e use, or better.

All copper cabling for Ethernet services shall follow the cable colors below:

- Purple – PLC Network
- Yellow – SCADA PC Network
- Red – iFIX SCADA Node Servers Cross link Connection

- Blue – PWD Administrative Network

4.2.3. In-Plant Installation Requirements

All fiber optic cables shall be mounted or supported as required by the NEC and local codes. The installation location shall not interfere with the maintenance or operation of plant equipment and shall not create a safety hazard. If installation is in a hazardous environment, the fiber cable, conduit, pipe hangers, raceway, and fittings must be approved for the environment as certified by the manufacturer. At no time shall the fiber cable or conduit come in direct contact with high voltage current.

A minimum of four (4) feet excess cable shall be provided at each termination point to prevent tension on either end of the termination points. All conduits shall be installed with break-out boxes following local codes and compliances and shall not exceed the minimum bend radius specified by the manufacturer. At no time shall tension exceed the cable manufacturer’s rating and all cable lengths exceeding 25 feet shall be kept spooled with care not to twist, knot, or bend in a manner that will prohibit performance.

Appropriate wire management hardware shall be used to organize cross-connection routing and to ensure maintenance of vendor specified bend ratios. All cables and connectors shall be labeled. The connector on the cable end and the device into which the cable fits shall be labeled in a way that clearly identifies the proper cable and device connection. In-plant fiber optic cables shall be installed using one of the following four methods:

1. Within innerduct laid in cable trays
2. Indoors within conduit
3. Underground in innerduct within conduit.

Where installed in cable trays, innerduct shall be orange and corrugated.

Where indoor conduit is required, conduit shall be Schedule 40 steel.

4.2.4. Underground Installation Requirements

Where outdoor cable is required, 4-inch conduit shall be buried underground. Each conduit shall be installed with three innerducts. Each innerduct shall have a distinct color and one innerduct shall be orange. The fiber optic cable shall be installed in the orange innerduct. The other innerducts will be available for future cables.

A metalized leader or marker tape shall be placed directly above the cable or casing so it can later be detected. Above ground, industry standard fiber communications markers shall be placed directly above the cable route within line of sight from each other, at the intersection of changes in direction, and be clearly labeled as follows:

CAUTION: COMMUNICATIONS CABLE BURIED BELOW
Property of: Portland Water District
Contact: The Control Center at (207) 774-5961 Extension 3073 prior to digging or excavation

The label shall be installed within one (1) foot from the top of the marker, made of a water proof material, made to withstand extreme cold and heat, and have lettering large enough to be read from a distance of five (5) feet.

All underground fiber installations shall not exceed the minimum bend radius specified by the manufacturer. At no time shall tension exceed the cable manufacturer's rating and all cable lengths exceeding 25 feet shall be kept spooled with care not to twist, knot, or bend in a manner that will prohibit performance.

At all locations where installation is planned, all underground utilities must be marked prior to digging and all fibers must be tested and approved prior to breaking ground. In all cases following installation, the above ground surface conditions must be restored to their original condition.

4.2.5. Network Topology

The SCADA System includes PLCs, SCADA nodes, View nodes, PI nodes, a programming terminal and printers. In order to ensure performance of critical data communications between PLCs and the other nodes, the SCADA System will be implemented with two Ethernet networks:

1. SCADA PC Network
2. PLC Network.

4.2.5.1. General

For each new network installation or improvement, the topology should be evaluated as part of the design. The topology for the SCADA PC Network shall be a hybrid star/backbone configuration. For the PLC Network, the preferred topology shall be a star configuration. The network topology shall be evaluated for each project and the best design shall be identified. In each case, due attention shall be paid to achieving a level of system reliability at a reasonable expense. For each SCADA project, a Preliminary Design shall identify the benefits of the selected topology.

Additional general guidelines include:

- The choice of fiber vs. copper (i.e. Cat 6e) shall be based on the length of the connection and location. For connections that are greater than 300 ft, or that are located beyond the primary structure, shall use fiber optic cables.
- All networks (PLC or PC) shall favor a star point topology. This will maximize the resilience of the network with a reasonable cost.

4.2.5.2. SCADA PC Network Topology

The SCADA PC Network will include GE Proficy SCADA & View nodes, PI historian nodes, a programming terminal and printers in conjunction with a network switch, a router and firewall to the Administrative Network, see Figure 4.2.5-1.

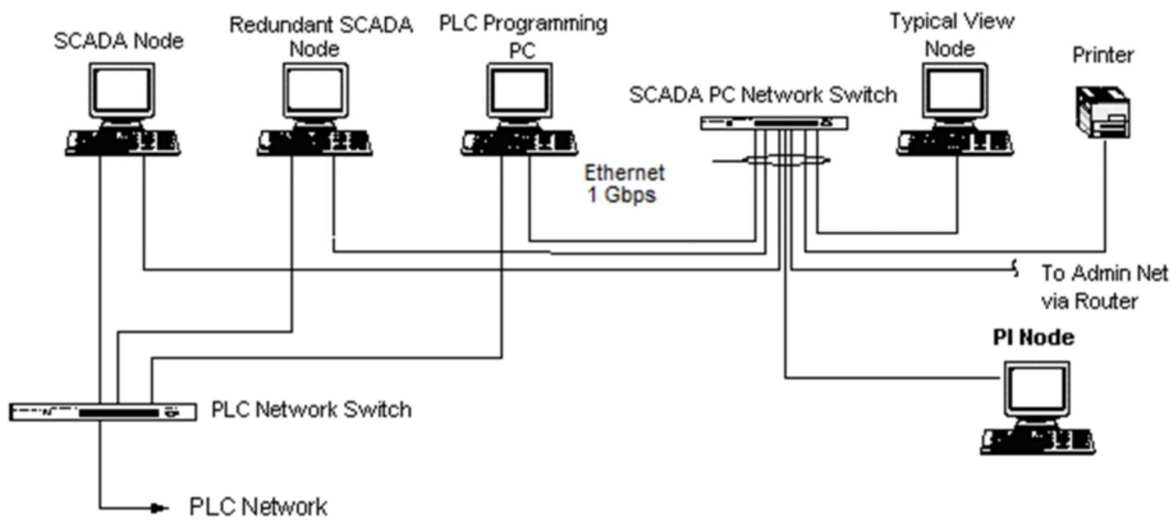


Figure 4.2.5-1 Typical SCADA PC Network Topology

4.2.5.3. PLC Network Topology

The PLC Network will provide, at minimum, 1 Gbps Ethernet communications between Allen-Bradley PLCs, GE Proficy iFIX SCADA nodes and the programming terminal. The topology will be a hybrid star topology. Fiber optic cables will extend from the PLC Network Ethernet switch to selected locations within the facility, as shown in Figure 4.2.5-2.

The network switches will also provide media conversion between the optical fiber and the copper 100BaseT (or greater) RJ45 port on the Ethernet switch at each PLC control panel.

Category 6 (or greater) cables will extend from the PLC's Ethernet switch to the PLC Ethernet port. The switches and optic modules will be configured to run at least 1 Gbps.

PLC control panels will contain at least one the Ethernet switch. This option may be waived at locations where PLCs are installed in separate cabinets that are in very close proximity. **In most cases managed switches shall be used for the PLC Network**. Exceptions may be granted with PWD approval for small wastewater pump stations with no OIT display.

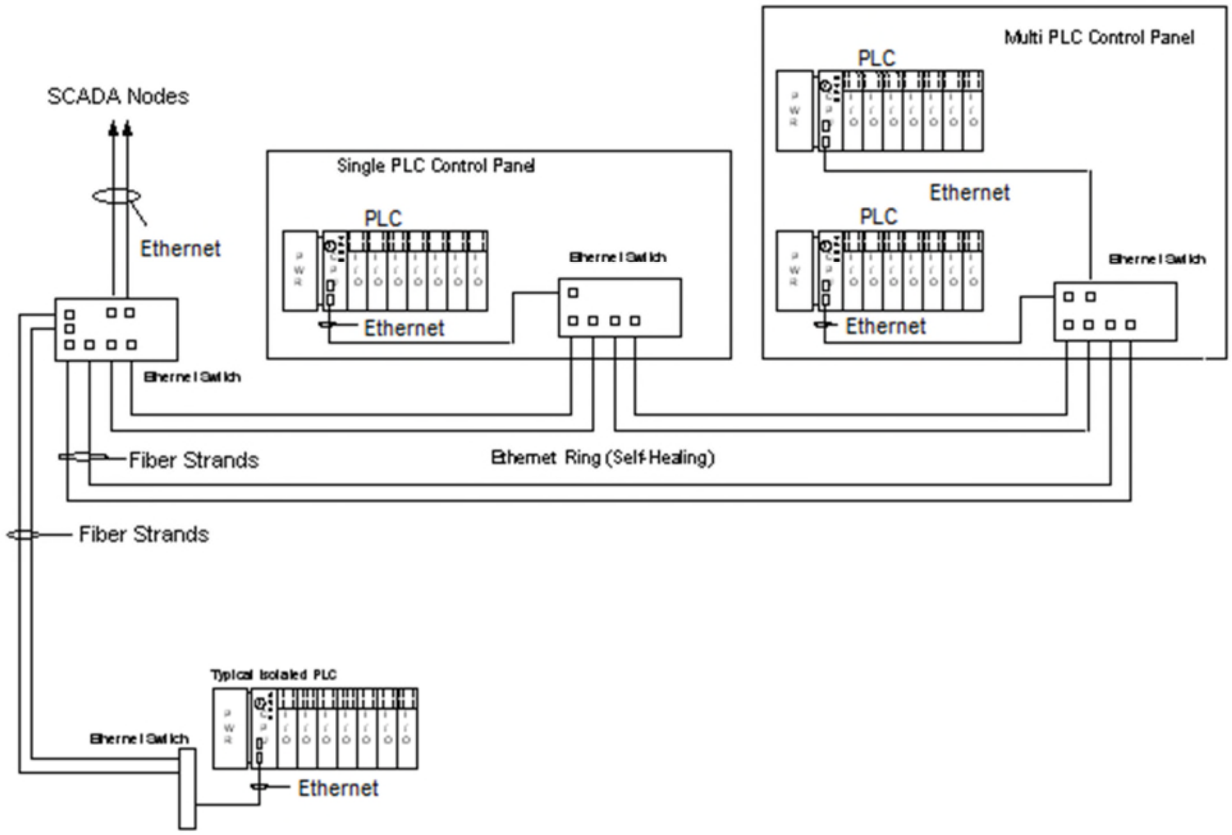


Figure 4.2.5-2 Typical PLC Network Star Topology

4.2.6. Network Performance and Protocol

All new installations and network improvements shall be standard Ethernet TCP/IP network protocol. Every network switch and router must at a minimum be capable of providing 10/1000 Mbps auto-switching communications rates. Where multiple paths exist, the network devices shall be attached to at least two paths to provide redundancy.

4.2.7. Network Hardware

4.2.7.1. PLC and SCADA PC Network Switches

Specific models of managed Ethernet switches preferred or required by PWD shall be found in Section 6.4. In general, the switches shall have the following features:

- Switches shall be DIN-rail mounted or 19 inch rack mounted dependent upon the type of cabinet the switch is located in.
- If required, switches should support any needed media conversion without a separate device.

- There will be sufficient Cat 6e (or greater) connections or fiber connections to support the required media to connection to the PLCs or PCs, plus 10% spare.
- All managed switches shall contain a minimum of 4 ports. One port shall be assigned to a portable programming terminal.
- All managed switches shall accept redundant power supplies.
- At least one of the redundant power supplies shall be connected to power via the UPS (see Figure 4.2.7-1).
- At least one of the redundant power supplies shall be connected to power via the direct line voltage. In the event that the UPS fails, the redundant power supply that is connected directly to the utility power will continue to operate the managed switch.
- All managed switches will be provided with the network monitoring option (i.e. N-View option for N-Tron managed switches).

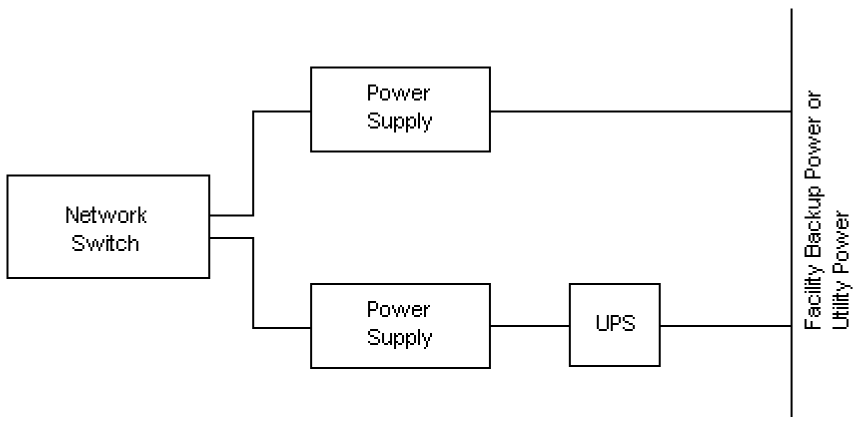


Figure 4.2.7-1 Network Switch Dual Power Supply Configuration

4.2.7.2. Computer Network Interface Cards

The PI Node, and View Nodes will be equipped with a single Ethernet ports. The PLC programming terminal shall have two Ethernet ports (one for the PLC Network and one for the SCADA PC Network). The SCADA Nodes shall have three Ethernet ports (one for the SCADA PC Network, one for the PLC Network and one for redundant pair).These ports will be connected to either the SCADA PC Network or the PLC Network, or both. The Network Interface Cards (NICs) shall meet the following specifications:

Link negotiation	Auto-negotiation between 10 and 1000 Mbps networks
Media	100BaseT (or faster)
Connectors	RJ45
IEEE compliance	802.3, 802.3x, 802.3u (or most recent)
Drivers	Latest version of Windows or Server used by PWD

4.2.8. PLC Communications

4.2.8.1. PLC-to-PLC Communication

PLCs shall be Allen-Bradley Compactlogix 53 series, Micrologix 1400 or an approved equal. Communication with each other shall be via at least 1 Gbps Ethernet or greater speed. Each PLC shall be assigned a unique TCP/IP address (assigned by PWD). PLC-to-PLC communication shall be via Message instructions incorporated into ladder logic programs (refer to Section 6.6 for details). Ladder logic programs shall be designed to optimize communication between PLCs by minimizing the number of messages and by arranging data tables within the PLC memory map to facilitate messaging.

The requirements for data transfer between PLCs shall be analyzed with respect to the need to initiate messages based on events (such as activation of an alarm condition) or on a regular timed interval. The 1 Gbps Ethernet (or greater) speed will enable individual message transactions to be completed in sub-second durations. Nevertheless, the ladder logic shall be designed to not exceed the response time of the process requirements, except by some nominal factor.

The data files shall be organized to easily add new data values to Message instructions.

4.2.8.2. SCADA Node Communication to PLCs

GE Proficy SCADA nodes will communicate with PLCs via the PLC Ethernet Network. The IGS Driver will be configured on GE Proficy SCADA nodes to meet vendor’s requirements.

4.2.9. Security on the SCADA Network

All default accounts and passwords shall be changed on all routers and network devices requiring configuration. Wireless connectivity to the SCADA Network should be avoided. Patches and software updates shall be maintained on each network device. If equipment is furnished by a Contractor the patches and updates shall be provided for a period of one year following project closeout.

At all locations where another LAN or WAN is connected to the SCADA network, a firewall shall be installed to prevent unauthorized access to the network, introduction of a virus, or to create a denial of service (DoS) attack. This network configuration should be reviewed and approved by the PWD Information Services Department.

The range of IP addresses shall be provided by PWD for the configuring the network devices. The Contractor shall secure all copies of all network IP addresses, network configurations, and project documentation.

All project related network documentation used by the Contractor for execution of the Work, shall be handled as “Confidential” and provided to employees on a “need to know” basis only. Prior to releasing any project related information a nondisclosure agreement must be signed and the Contractor must request, in writing, permission from PWD before providing project documentation to anyone not directly associated with the project.

4.3. PROGRAMMABLE LOGIC CONTROLLERS

The Portland Water District (PWD) has chosen Allen-Bradley's Compactlogix 5380 and Micrologix 1400 as the preferred PLC hardware platforms. Specific model numbers preferred by PWD can be found in Section 6.4. The PLC models used, the I/O quantities defined, and the I/O configurations are based on the following control requirements:

- Redundant PLC CPUs are not required
- Redundant power supplies are not required
- Whenever possible, removal of any single I/O card should not affect more than two major equipment items.
- Whenever possible, failure of any one I/O card shall not affect more than two major equipment items
- All PLCs shall be Allen Bradley Compactlogix (preferably 5380) or Micrologix 1400.
- Each In-Plant PLC shall be equipped with a local OIT (see Figure 4.3-1). The local OIT shall be connected directly to the PLC via ethernet. Within a treatment plant, the OIT will also be connected to local Ethernet switch for remote programming purposes only.
- Each RTU PLC shall be equipped with an OIT (see Figure 4.3-2). The OIT shall be connected to the PLC via an Ethernet communication link. This will require the use of an Ethernet switch mounted in the PLC Panel.

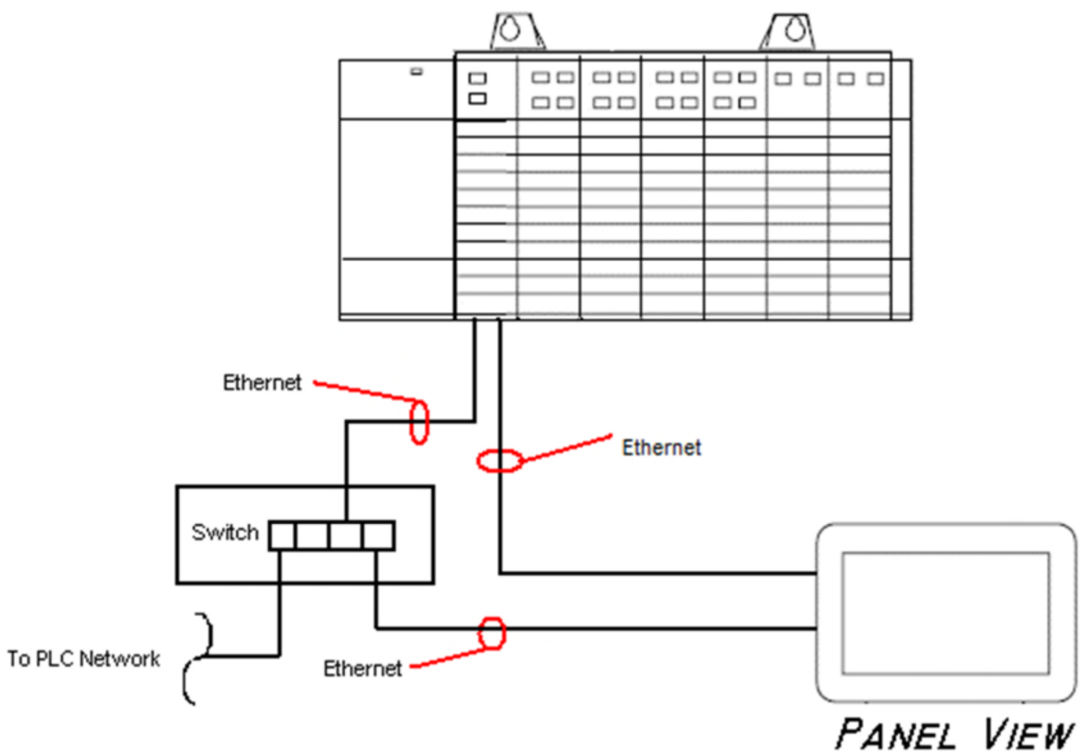


Figure 4.3-1 Typical In-Plant PLC and PanelView (Local OIT) Connection Configuration

Communications between the remote site and the central PLC shall a radio modem connected to the correct port on the PLC's CPU card. The PanelView will use the Ethernet communication port (see Figure 4.3-2).

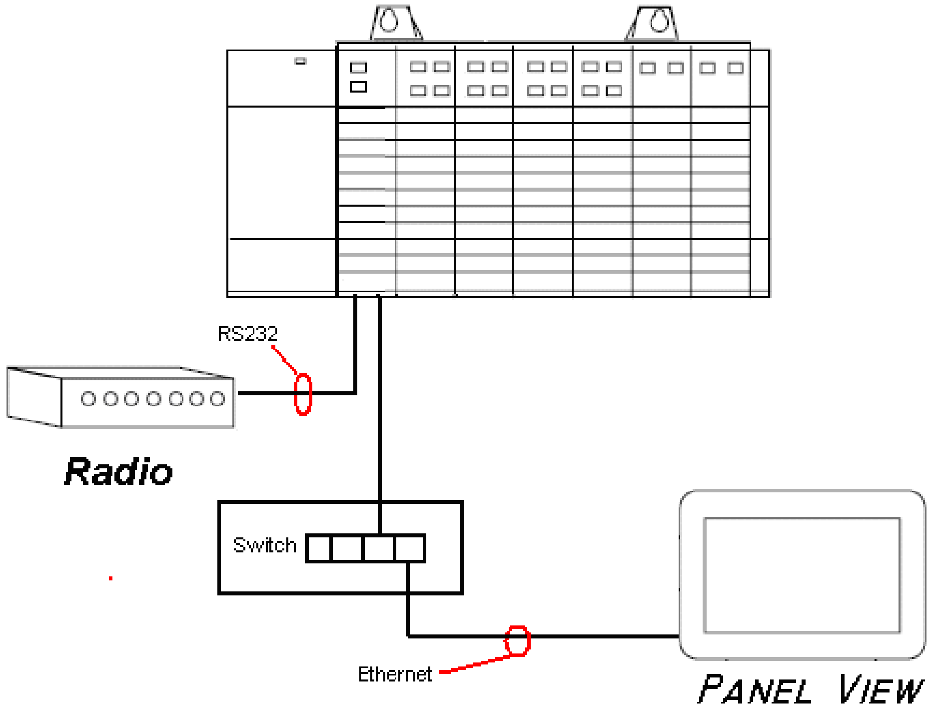


Figure 4.3-2 Typical RTU Communication Links between the SLC 5/05, the Esteem Serial Radio Modem and the PanelView

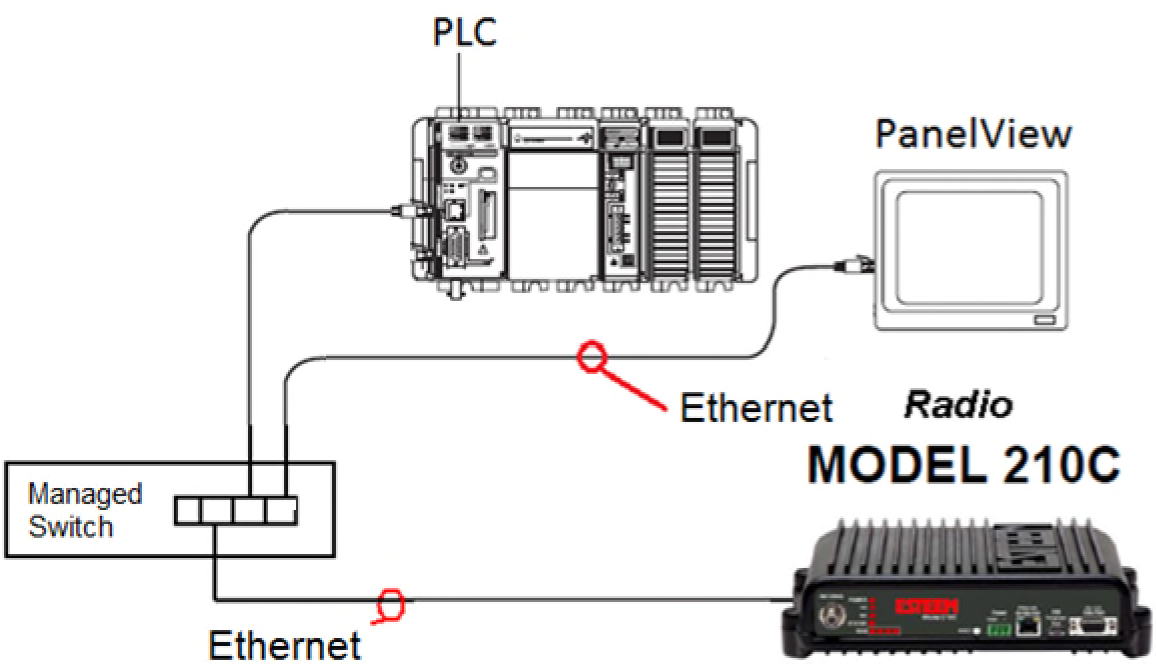


Figure 4.3-3 Typical RTU Communication Links between the PLC, the Esteem Model 210C Radio Modem and the PanelView

4.3.1. Module Arrangement

All of the slots for the Compactlogix PLCs, I/O cards shall be configured
in the following order:

- Analog input module(s)
- Analog output module(s)
- Digital input modules(s)
- Digital output module(s)

The arrangement of the individual points of the PLC I/O, should consider the placement of similar devices on separate cards or racks where ever it is practical. For example, for a two pump system, with two discrete output (DO) cards (which was required by the I/O count for this example system), would place the digital output for pump #1 on one DO card and the digital output for pump #2 would be on the other DO card.

4.3.2. I/O Modules

PWD preferences for I/O cards are listed in Section 6.4. Exceptions can be made on a case by case basis, with the approval of the PWD Project Manager.

4.3.3. Chassis Sizing

There are no racks used for the CompactLogix Series PLCs. They are directly mounted to the DIN rail.

4.3.4. I/O Wiring Requirements

Each I/O card in the PLC may be provided with an appropriate IFM Module with the fusible and LED Indicating options..

Analog signals, both inputs and output, require a means of breaking the circuit for testing which requires a WAGO 280-874 for both leg of the analog field wires. See Section 6.4.1 for details.

4.3.5. PLC Power Supplies

PLC configurations shall use Allen Bradley supplied power supplies for the corresponding PLC unit. The power supplies shall be configured for 120 VAC input (102-132 VAC, 47-63 Hz), and shall be fed from the facility's UPS.

4.3.6. PLC Programming Software Requirements

RSLogix 500 software shall be used to program the Micrologix 1400 models and RSLogix 5000 for the CompactLogix models. Refer to Section 5.3 for more details.

4.4. PANELVIEW DISPLAYS

The Portland Water District (PWD) has chosen Allen Bradley's PanelView line of operator interface terminals to provide touch screen interfacing capabilities local to a PLC.

4.4.1. Introduction

The PanelView Plus graphic terminals are rugged electronic interfaces designed to provide operations the ability to monitor PLC data locally at the panel. They replace traditional pushbuttons, switches, and gauges as the input and output mechanisms for operator interaction with a PLC and the process. All process data, setpoints, and commands available in the PLC should be provided at the local operator panel. The displays and functionality provided on the local operator panel shall mimic, within the capabilities of the PanelView unit, displays provided at the HMI in the control room. In particular, color and navigation schemes shall be as identical as possible within the limitation of the PanelView system. Each PLC shall have its own PanelView display (or Local OIT).

Some general features include, but are not limited to, the following:

- AC Powered
- Color touch LCD screen
- In Plant Local OIT shall use Allen-Bradley Ethernet protocol to communicate with the local PLC for all SCADA functions. The OIT will also be connected to the PLC Ethernet for programming purposes only.
- In Plant Global OITs shall use the Allen-Bradley Ethernet protocol to communicate with the PLC network.
- RTU OITs shall use the Allen-Bradley Ethernet protocol to communicate with the PLC.
- Provide the external storage SD Card (part number 1784-SD2) for storing the configuration file, with the OIT displays.

4.4.2. Model Selection

Contact PWD for specific model currently being used.

4.4.3. Software Requirements

Factory Talk View Studio Machine Edition or PanelBuilder32 shall be used to program the PanelView 550 and PanelView 1000 Standard terminals (these are legacy OITs that are currently in service, but they are no longer recommended by this standard). Factory Talk View Studio Machine Edition shall be used to program the newer models of PanelView terminals.

4.5. CONTROL DEVICE I/O INTERFACES

4.5.1. General

In addition to the specific monitoring requirements detailed in this section, and in Section 2.2 (the Control Philosophy), all controllable devices shall have the following status points monitored by the SCADA System:

- Run or Position Status (provided by auxiliary run contacts at starter or device)
- Interlocks or Alarms (where applicable)
- Local / Off / Remote Selector Switch Position (Indicate both the “Local” and the “Remote” positions as two inputs into SCADA)
- Auto/Manual Statuses (This mode selection is usually made in the PLC via the HMI/OIT and it shall be sent to the MTU from an RTU site)
- Any Additional Mode of Operation Indication (i.e. Forward/Reverse, Lead/Lag/Standby, etc.)
- Power-disconnect (For RTU Power Failure Indication, One Indication for the entire site)
- Emergency Stop Switch Indication
- General Failure Alarm (if Available)

The following minimum alarm status information shall be provided for all motors sized 100 HP and larger:

- General Failure
- Excessive Temperature
- Excessive Vibration.

4.6. INSTRUMENTATION

To achieve a high level of performance and reliability from control systems and to be consistent with the control philosophy of Section 2.2, PWD intends to ensure that instrumentation equipment provided for operating facilities will:

- Meet the District's performance requirements
- Enable implementation of changes and expansions over the next 15 years.

4.6.1. General Requirements

Instrumentation provided should be evaluated against the following assessment categories:

Performance Considerations

a) Applicability to the District's service/process areas
b) Record of successful performance in the water and wastewater industry
c) Verification of published performance figures
d) Reliability evidenced through MTBF and MTTR data
e) Quality assurance and control procedures
f) Warranty terms.

Installation Considerations

a) Ease of installation
b) Accessibility of servicing adjustments
c) Compliance with industry standards
d) Maintainability and availability of full servicing manuals

e) Servicing and maintenance support provided in the District's operating area.

Economic Considerations - Whole life cost, consisting of:

a) Standard equipment compatibility
b) Purchase price
c) Installation cost
d) Operating cost
e) Calibration cost
f) Cost of spare parts
g) Training/maintenance costs
h) Life expectancy.

PWD has identified certain instrument types that are suitable for its operating facilities to standardize equipment procurement. These approved instrument types should be selected for the appropriate application to ensure that PWD realizes the benefits of standardization.

The major benefits of standardization are:

- Reduced spare parts inventory
- Reduced training costs for O&M staff
- Reduced design and procurement costs
- Assurance of compatibility with existing systems.

Personnel responsible for design/specification of instrumentation for PWD projects will first consider the criteria contained in this section. If the recommended instruments are considered inappropriate for a specific application or superior instrumentation becomes available, then the alternative instrument should be submitted to PWD for approval.

It is the intent that the standard selections and recommendations for instrumentation contained herein be revised as new information and products become available. Alternative manufacturers or products should not be specified unless they have prior approval of PWD.

4.6.2. PWD Preferred Instrument List

To aid personnel in the understanding of instrumentation requirements for the water and wastewater industry, see PWD for the latest list of preferred instruments.

Revision Memo

Rev. 0	May 7, 2004	Draft Version for comments
Rev. 1	June 18, 2004	Final Version for comments
Rev. 2	July 23, 2004	General revision based on comments
Rev. 3	April 14, 2006	PWD's First Revision
Rev. 4	February 27, 2009	Numerous minor changes Major Revisions in section 4.3
Rev. 4.1	August 1, 2012	Numerous minor changes Removal of ring topology from section 4.2
Rev. 5.0	September 20, 2016	Numerous minor changes Addition of new specification to support the CompactLogix PLCs and the Esteem 210C Radios
Rev. 6.0	September 01, 2021	Updates to Standard PLC Components Updates to related PLC Configurations

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

5. CONTROL SYSTEM SOFTWARE STANDARDS

5.1. GENERAL SCADA SOFTWARE DEVELOPMENT STANDARDS

5.1.1. General Requirements

For any programming project involving the SCADA system, there are a number of items required to perform the work. For any PLC programming, HMI or OIT configuration, there are several items that are important to the overall understanding and knowledge of the work to be performed. Figure 5.1.1-1 is a flow chart that describes the order of these items, or tasks. This section is a general guideline, the PWD project lead shall outline the specific project delivery process for each project during the preliminary design. Some general description of these items is discussed below, but a more detailed description of them can be found in Section 6.3.

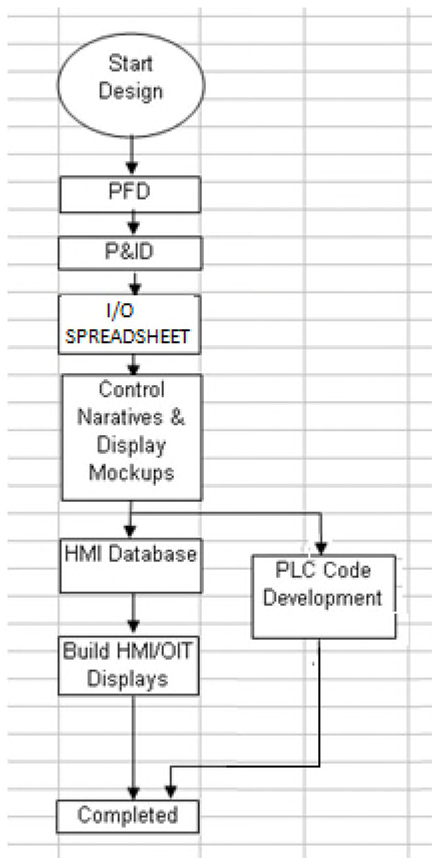


Figure 5.1.1-1 SCADA System Software Development Flowchart

- PFD and P&ID Drawings –These drawings are used to help the programmers layout process and overview screens. Information on these drawings help programmers understand how much information is needed to be displayed, and whether multiple screens are required to show all of the information. The loop number assignments and the asset tagnames are developed, and used through out the SCADA System.

- I/O Spreadsheet – This is a list of all of field I/O that is being monitored and controlled through the SCADA system. The spreadsheet organizes the information by the PLC I/O assignments. Tagnames for the I/O are assigned using the P&IDs. An example of this document is provided in Section 6.3.4.

- Control Narratives – Describes the process and how normal operation is to be performed. These are necessary for PLC programming to clarify to the programmer what instruments and signals are related to the control parameters and schemes that are to be programmed. The HMI/OIT displays are developed in this step as mock-ups of the final form. The mock-ups are jpeg files that are created and edited using programming tools like MS PAINT to create an image closely depicting the final version created using iFIX. These displays will be inserted in the control narratives. They help illustrate the data fields and buttons used to control the process. See Sections 2.2.6 and 6.1 for details.

- HMI Database and PLC Code Development – These stages build the actual project based on the information from the previous stages. A memory map should also be developed to document the tag mapping and registry. An example of a memory map can be found in Section 6.3.4 In Appendix D.

5.1.2. HMI Software Requirements

PWD has chosen GE Proficy iFIX process visualization, data collection and supervisory control software for HMI SCADA system functions.

5.1.3. Graphic Screen Development Process

As a general guideline, the following development process should be followed on each SCADA project for the development of process graphic screens.

- Mockups of the HMI Displays will be developed as part of the Control Narrative development described earlier in this section and detailed in Sections 2.2.6 and 6.1.
- The contractor / developer should develop develop all of the displays using the mockups as a guideline using the HMI Software and provide a submittal of screen captures in a PDF, or WORD document to PWD for review and comment.
- If necessary, the contractor / developer should hold a workshop to present the display design and finalize design details. The contractor / developer should provide PWD the submittal document of the screen captures of the displays that are being present at this workshop seven (7) days prior to the workshop.
- Following PWD review and comment of the submitted displays, the contractor / developer shall finalize the remaining displays to the 90% level, and provide them at the FAT for the final review.
- Following the FAT, the contractor / developer shall fully develop all the displays.

5.2. USER INTERFACE DEVELOPMENT STANDARDS

This section defines intent and overall philosophy of the standard elements implemented in the creation and the modification of the user interface for the SCADA system. The user interface is composed of two major components: the HMI (currently the GE Proficy SCADA System) and the OIT (currently the Allen Bradley PanelView). Throughout this section the user interface will be referred as the “HMI Display”. Unless otherwise stated, the HMI standards discussed below shall refer to both HMI and OIT standards. In addition to the display examples given in this section, there are more complete examples of HMI and OIT displays are given in Section 6.7.

The standards are structured to keep the conventions as simple as possible in an effort to minimize the learning curve on a system. It is imperative that a minimal amount of colors are chosen to signify events and that the colors remain consistent throughout the display hierarchy. All of the displays will be submitted for approval to PWD prior to implementation at a job site. The graphical symbols used in a display will be developed in accordance with this standard for representation and layout. The symbols shall represent the different states by changing color and/or orientation due to the nature of the state. PWD will use the standard symbols provided by the HMI software package, the use of any other symbols will require approval.

The PWD wants the OIT and HMI displays to look and act as similar as possible. We recognize that the two platforms are different.

PWD recognizes that the standards below represent the capabilities of our existing systems. If a new system were to replace any part of an existing system, then the whole system for a site would have to be revised to match the new system. PWD would need to provide extensive guidance for this type of change.

5.2.1. General Requirements

5.2.1.1 Hierarchical Structure

The HMI displays are built in a hierarchical structure (see Section 5.2.3), which allows for viewing a process without knowing the name of a particular display. The navigation of these displays is accomplished by using the mouse to “click” on the object on which more information is desired. For instance, from a display depicting the layout of a Water Plant, one would find the desired equipment area, and click on it. The display would now show specific processes within that area. Next, one may choose a specific process to monitor by clicking on it. The display would show that particular process animated to indicate current field status of equipment and data.

5.2.1.2 Process Visualization

Process displays shall be based closely on Piping and Instrumentation Drawings (P&IDs) in order that the system processes are accurately depicted in a consistent format and there is a minimal learning curve for the operators as the new system is brought online. The display layout should be as representative of the physical plant process as possible regardless of a standard format. Process displays shall include 2-D symbols; shown from a top or side view perspective; whatever best represents the process. Flow is usually directed from left to right and top to bottom on the displays whenever possible, unless it would lead to user confusion, or some other compelling reason. In the event of a large process in which there is too much information to fit onto one display, the process shall be divided over multiple displays at logical places.

5.2.1.3 Operator Interface

The interaction of the operator with the display is intended to be user-friendly and to be PC mouse, or touch screen, intensive. When clicking, or touching, on a symbol in a display, the associated action is executed upon the mouse button, or finger, being released.

5.2.1.4 Control Verification Actions

When issuing a command to a device, the operator must confirm the control action before the action is issued to the PLC. The purpose of this function is to eliminate inadvertently issuing incorrect commands. A scenario explaining this function is as follows for a start request to a pump:

1. The operator clicks on, or touches, the display symbol for the pump. If the operator is logged into the HMI, the Popup Display for the pump is opened and displays the operator actions for the pump.
2. The operator clicks on, or touches, the START command button on the display.
3. A confirmation pop-up display appears on top of the process display requiring the operator to acknowledge the start command, through clicking on, or touching, the EXECUTE button.

The output to the field device does not get energized until the initial request has been confirmed. Therefore, an operator must perform all three actions before the command is sent. This verification allows an operator to cancel the request before the command is even issued.

5.2.1.5 Display File Name Convention

Each display name will be assigned with a naming convention for ease of tracking and locating. The display file name is assigned based on the type of display (process, system, control, etc) and the process area monitored. As discussed above, the system users will navigate to screens using the hierarchical or process flow methods, and as such, it is not necessary for the user to know the file names.

The display file name shall be included in the lower right corner of the screen. The font shall be Arial style, 8 point in all capital letters. The color shall be dark gray (Gray50). Refer to Section 6.2 for the naming convention details.

5.2.1.6 Screen Resolution

All HMI displays shall be configured with a screen resolution of 1280 x 1024 pixels for a 19” CRT Monitor. Exceptions may be made for more up to date systems with PWD approval.

5.2.2. Display Layout

The current view for any screen shall consist of two parts; the Title Bar, and the Display Area.

5.2.2.1 Title Bar

A title bar shall be located at the top of each screen to display the current user, date, time, and the name of the current screen. Each section shall be divided by recessed gray boxes with blue and black text. Functions performed here include security login and access to the global navigation toolbox. Refer to Section 6.7 for examples.

5.2.2.2 Display Area

The area below the title bar is reserved for the display area. This area is reserved for overview and process screens, system displays (alarming and trending screens), and other displays used to convey information from the SCADA system.

5.2.3. Display Types

There are seven major display types: Overview, Sub Process, Pop-up, Trend, SCADA System, Alarm, and Menu. The first two types are structured to act together to give the user the impression of viewing a treatment plant, or a system, from different altitudes. The overview will be at the highest altitude, and sub processes will be at decreasing altitudes (see Figure 5.2.3-1). The pop-up displays are used for operator actions toward the process. The trends display are time based traces of pre-assign combinations of process variables that are primarily used for determining the performance of the process. Each system will have at least: one SCADA System display, one alarm display and one menu display. An example of each type of display can be found in Section 6.7.

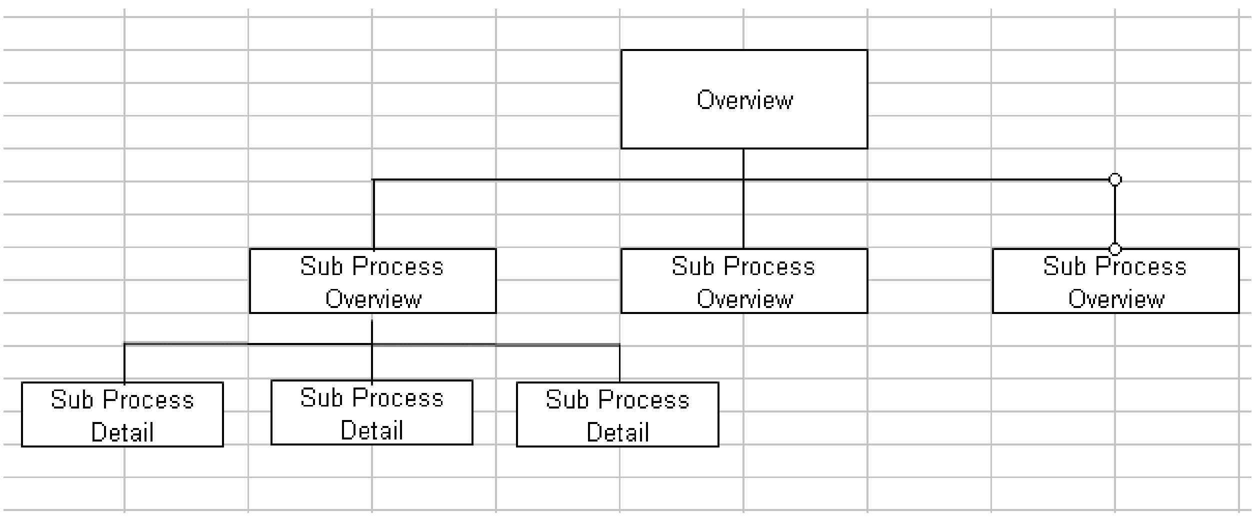


Figure 5.2.3-1 HMI/OIT Display Hierarchy

5.2.3.1 Overview Display

Overview displays are at the top of the display hierarchy (see Figure 5.2.3-1). The highest level is a map-like representation of the system or individual plant. Most elements on the overview display are smaller versions of graphical depictions found in the lower hierarchy displays. This is why the higher hierarchal displays are developed after the lower level displays are completed.

The next lower level consists of sub-overviews, which represents a smaller portion of the process. This could continue through several levels as required by the size of the process, until an individual sub process detail display is reached.

The overview displays allow permit a quick access of the various sub process. The operator can use the overview as a starting point to navigate to each of the sub processes included within a system or individual plant.

5.2.3.2 Sub Process Display

Sub process displays are composed of two types: sub process overview displays and sub process detail displays.

Sub process overview display is a level below the overview display within the display hierarchy. They are P&ID-like representations of specific processes. Displays shall be defined in accordance with PWD process and sub-process groups. These displays shall contain only information specific to that process, or information that is required from another process, to completely monitor and controls all aspects of that process.

Like the overview display, sub process overview displays allow quick access through the various sub process detail displays. The operator can use these displays as a way to navigate to each of the sub process detail displays included within the system.

Sub process detail display (including Settings and Statistics Displays) is a level below sub process overview display within the display hierarchy. They can also be like sub process displays with P&ID-like representations of specific processes. Displays shall be defined in accordance with PWD process and sub-process groups (see Appendix B for the sub-process naming convention element). These displays shall contain only information specific to that process, or information that is required from another process, to completely monitor and controls all aspects of that process.

There can be several hierarchy levels below the sub process detail display level that can be drilled down to a display with more details. The amount of levels required for the sub process detail display will be based on the complexity of the process being depicted by the displays.

There are also Settings displays that have various buttons and setpoint entry fields that are customized for the application. The settings displays usually require a security login above an operator level.

There are also Statistics displays for viewing data such as flow totals.

5.2.3.3 Control and Settings Pop-up Displays

Pop-up displays fall into two major types: Control Pop-ups and Settings Pop-ups. All sub process overview and sub process detail displays are designed to convey as much information as is practical, without over crowding the display or confusing the user. This is why PWD has standardized on the use of pop-up displays to get access to greater details of the equipment or controls within a sub process. Typically a user (except the “GUEST” account) is given privileges to access the control pop-up displays which requires them to login into their SCADA System user account.

A **control pop-up display** shall be created for each major piece of equipment to display detailed information, such as: runtimes, equipment performance information (i.e. motor temperature, vibration sensor data, interlocks, etc.), and alarms. Any operator action regarding that piece of equipment must be performed through the control pop-up display (i.e. Auto/Manual selection, Start/Stop commands, setpoint changes, etc.). The control pop-up display can be opened by double clicking on the equipment symbol within a sub process detail display. This pop-up display has specific format where different areas with the display are reserved for specific functions (see Section 6.7 for details), but exceptions are allowed if approval is given by PWD.

The control parameters of a group of controlled equipment, within a sub process, can be accessed through the **settings pop-up display**. Operation controls such as automatic pump sequencing, equipment runtime configuration, alarm limits configuration and sub process setpoints are among some of the functions available through this display.

Creation and design of a settings pop-up display is based on the needs of a sub process. The settings pop-up display is opened by clicking on the “Settings” button located on the upper right side of the sub process overview or detail display.

5.2.3.4 Trend Display

Most analog value that is in the iFIX database will be displayed on at least one trend display. Discrete values will be displayed on case by case basis. An example of the trend display is given in Section 6.7. The assignment of eight values of a given trend display will be determined by any combination of the following: PWD staff members, Engineers, or System Integrators. Assignments will be based on the sub process or facility needs.

Trend displays are opened by either clicking on a trend title on the “Trend Menu” display (see Section 6.7), or by clicking on an analog value. If the latter method is used, and if the analog value is on more than one trend display, a predetermined trend display will be opened.

5.2.3.5 SCADA System Display

The SCADA system display deals with the health of SCADA System at a site. These displays include the statuses of the major SCADA components, such as, but not limited to:

- SCADA Node Servers
- PI Node Server
- PLC’s

5.2.3.6 Alarm Display

The alarm display, or sometimes know as the alarm summary display, lists the current unacknowledged and current acknowledged alarms for the SCADA System for a given site. The display is a standard design where much of the functionality is included within the HMI or the OIT software packages. Some features, or options, within the display may be customized to achieve the needed PWD functionality.

5.2.3.7 Menu Display

The menu display is a display containing an organized list of display titles, or names. Each title is a hypertext element that links to the path of that display. When the display title is clicked on, the display will appear. There could be a specialty menu display that would list only trend displays

5.2.3.8 Display Hierarchy Navigation

The navigation amongst the hierarchy of displays can be done vertically downward by clicking a sub process element within an overview display or sub process display. This was described in detail in Sections 5.2.3.1 and 5.2.3.2. Navigation vertically upward is done by clicking on the “OV” or “up arrow” buttons (see Figure 5.2.3-2). The “OV” button is always linked to the overview display, and the “up arrow” button is linked to display above (within the display hierarchy) the currently being viewed. The user can also navigate horizontally with the display hierarchy using hyperlinked text with any given display (this also discussed below).

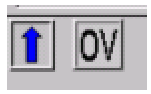


Figure 5.2.3-2 Image of the “OV” and “Up Arrow” Buttons that are on the Sub Process Overview and Detail Displays

Display navigation can also be done by clicking on any hyperlink text elements (Section 5.2.4.3) with the displays (i.e. sub process detail display, menu display, etc.). The hyperlink text elements are blue underlined text. The need to provide this type of navigation path within a sub process display will be based on the needs of the sub process or on the needs of the overall facility. An example of this would be to setup a series of display links to facilitate the startup sequence of the treatment plant.

Display navigation can also be done using the System Navigation Pop-up display that is accessed by left clicking on the display title located in the title bar of any given display.

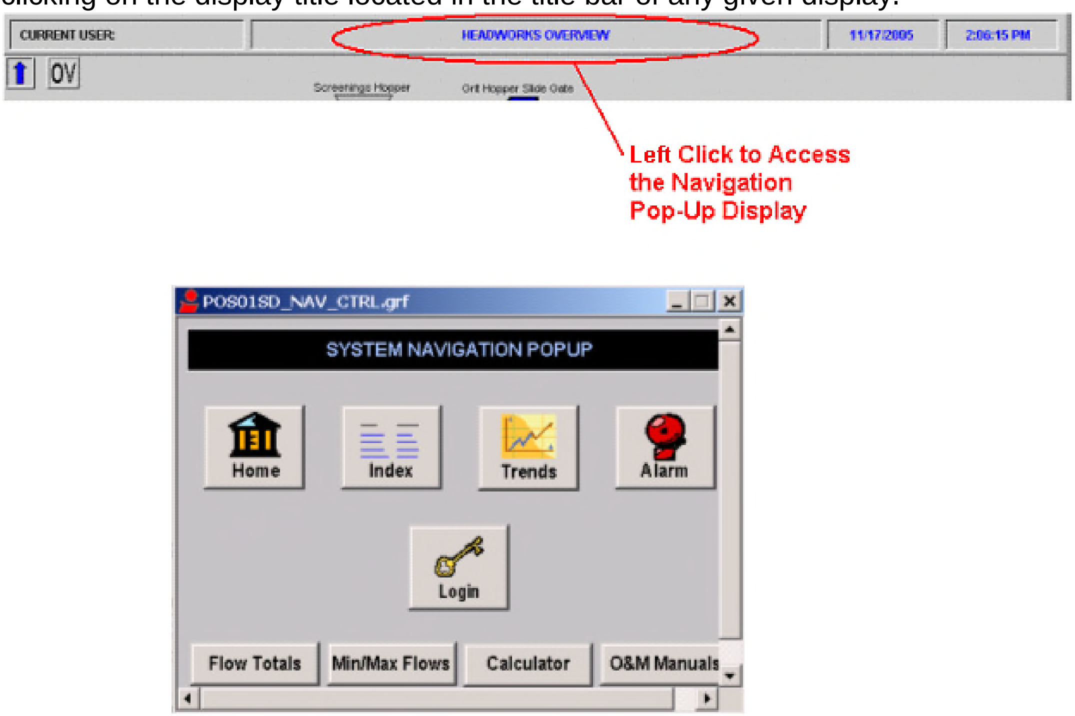


Figure 5.2.3-3 Access to the Navigation Menu

By clicking on the buttons of the system navigation pop-up display will take the user to the following displays:

- Home – Overview Display
- Index – Display Menu
- System – SCADA System Display
- Alarm – Alarm Display
- Security – HMI Login Pop-up
- LAN – Unassigned
- Trends – Trend Menu Page
- Print – Print Screen Command

5.2.4. Text and Data Representation

5.2.4.1 Analog Feedback Display

Analog inputs from field instruments or calculated within the PLC shall be displayed as recessed boxes with the analog value and units (or engineering unit abbreviations). The data is displayed as blue text and the engineering units are black (refer to Section 6.7 for color specifications). During alarm conditions, the alarm text will change color to yellow to show that the current value is in an alarm state. The box should be located near the associate equipment or pipe within the overview or sub process display layout.

5.2.4.2 Analog Setpoint Display

Analog values that are operator enterable, such as setpoints, are displayed on raised buttons. The button is gray with the functional description displayed as black (refer to Section 6.7 for color specifications). A black box with white outline displays the current value of the setpoint. Clicking the button will display an operator entered pop-up in which the operator will enter the new value to change the setpoint.

5.2.4.3 Hyperlink Text

Underlined, blue text on the process displays indicates navigation links to other displays (refer to Section 6.7 for color specifications). Users may navigate to the downstream process by clicking on the display navigation text on the right side of the displays, or may go to the upstream process graphic by clicking on the display navigation text on the left side of the displays. All hyperlinks will have the words “TO” in front if the link leads to another process or “FROM” if the link is coming from another process.

5.2.4.4 Static Text

Black text is static, and used to identify equipment or label a process (refer to Section 6.7 for color specifications).

5.2.4.5 Discrete State Text

Digital point values with only two or more states (no alarm state) are a displayed as white text when in the normal operating state, and in dark blue text when in any other state (refer to Section 6.7 for color specifications). For example, when a pump is in “Remote Auto” mode the text will be in white. When the pump is in “Remote Manual” or “Local” modes the text will be dark blue. The text is located near the equipment, or location of where the transmitter originates on the display layout.

5.2.4.6 Alarm Display

Specific textual alarms or equipment failure conditions are displayed when the alarms conditions occur. The alarming color sequence is as follows (refer to Section 6.6for color specifications):

- Normal — Not Visible or White (case by case)
- Unacknowledged — Flashing Yellow
- Acknowledged — Static Yellow

5.2.4.7 Structures

Buildings, channels, and other physical structures shall be displayed to assist in the conveyance of the process. These structures shall be closely depicted to show actual relative size and placement within a process.

5.2.4.8 Equipment

Pumps, valves, or any monitored or controlled devices are displayed on the screen and animated based on field I/O feedback. This allows the operator to fully monitor the current status of the equipment and consequently the process itself. The description of the device will be placed below the device whenever possible along with any analog feedback values. Due to the complexity of some displays, it is not possible for all of the descriptions and values to be placed in the same location due to piping and any other graphics, but equipment layouts need to be consistent on a page-by-page basis.

5.2.5. Operator Annunciation & Alarming

Annunciation is defined as a means of notifying the operator of an event. This event could be a detrimental event that could harm humans or equipment or a non-detrimental event that merely notifies the operator to do something.

Each point in the system database shall be configured independently for annunciating. Discrete points annunciate when they enter a pre-defined state, and analog points annunciate when the point value goes above or below pre-defined limits. **Annunciations are generated within the PLC** unless approved by PWD (i.e. OEM PLC’s are typically exempt and sometimes necessitates annunciation within the HMI).

Annunciations are configured for one of the four different levels (where Priority 1 is the most significant level). The differences between the priorities are summarized below:

	LATCH	WIN 911	STROBE LIGHT	PANEL LIGHT	HMI ACK	OIT ACK	LOCAL RESET	REMOTE RESET	PROCESS DISPLAY	AUDIBLE #1	AUDIBLE #2	AUDIBLE #3
Priority 1	O	O	Y	Y	Y	Y	O	Y	Y	Y	N	N
Priority 2	O	O	O	O	Y	Y	O	Y	O	N	Y	N
Priority 3	N	O	N	N	Y	Y	N	N	O	N	N	Y
Priority 4	N	O	N	N	O	N	N	N	O	N	N	N

Table 5.2.5-1 Operator Annunciation Summary (where Y=Yes, N=No, and O=Optional)

Priority 1 is the highest (most significant) level of annunciation. These annunciations are considered "alarms", and require the immediate attention of the operator. Priority 1 is usually assigned to events associated with life risk, or physical damage possibilities. Examples of this type of annunciation would be a fire alarm, gas detector, high high wet well alarm, or high vibration alarm on a pump.

Priority 2 is the process event type of annunciation. These are process events that could lead to improper conditions if left unattended by the operator. Examples of this would be a "failed to run" alarm from a pump but the standby pump started, a high level alarm for a storage tank, or a low pressure alarm.

Priority 3 is operator attention type of annunciation. These are events or activities that require an operator's attention, but not a process upset. Examples of this are: start the reservoir refill process, time to start the foam skimmer, or bypass event has started.

Priority 4 is the lowest (least significant) level of annunciation. As Table 5.2.5-1 indicates, this level does not produce an audible annunciation. This priority is considered an operator message to perform a non-time critical activity. This annunciation could be prompted by the HMI while the operator was absent from the control room and he may not know it has triggered until he returns. Examples of this are: remote site occupancy indicators, midnight reset of totalizer, or run the generator for the monthly PM.

Latching refers to the function of holding the active status state of an annunciation signal until a reset command is performed. From the table above, only priority 1 and 2 annunciations are latched. The latching is function is done in the PLC and requires a two step procedure to clear the alarm. The purpose of this is to require the operator to physically view the equipment or condition that triggered the alarm. The first step is to acknowledge (or silence the audible) the alarm in the "Alarm Summary Display" of the HMI or the OIT. The second step is to reset the alarm via an HMI/OIT display, or from a discrete hardwired pushbutton, or from any combination of pushbuttons and displays. The appropriate method of resetting the alarm will be dictated by safety, equipment and operation concerns.

Win 911 is the Districts alarm paging system. This option is available, and it is an extension of the HMI alarm management system. With this option and an alpha-numeric pager an operator can get text messages through the pager. The pager can not acknowledge the alarms back in the HMI.

The **Strobe Light** and the **Panel Light** are both located on the PLC enclosure. The strobe light is mounted on the top of the enclosure and it is visible 360 degrees around the enclosure. The panel light is mounted in the front enclosure door, usually near the OIT. Both of these indicators will activate only when an active priority 1, or optionally priority 2, annunciation occurs. Both of these indicators will deactivate when the active alarm condition clears, or the operator acknowledges the alarm from either the HMI or OIT. The strobe light or the panel light will only indicate alarms that are occurring within the PLC located inside the enclosure the light is mounted on.

HMI Acknowledgement refers to the operator clicking on acknowledge “button” located in the alarm summary display of the HMI. This action will silence the annunciation audible sound, and clear any non-latched deactivated alarms or messages.

OIT Acknowledgement refers to the operator clicking on acknowledge “button” located in the alarm summary display of the OIT. This action will silence the annunciation audible sound, and clear any non-latched deactivated alarms. Messages automatically clear themselves from the alarm summary display on the OIT so they don’t need to be acknowledged.

Local Reset refers to a “hardwired” push button that is pressed by the operator to clear the alarm latch once the alarm condition has cleared. These are used to require the operator to physically go to a specific site (i.e. an eyewash station) to investigate the cause of the alarm.

Remote Reset refers to the option to allow an operator to clear an alarm latch (once the condition is cleared) from a remote location. This could be from an HMI or an OIT. The HMI/OIT “Reset” button is found in two places: the Alarm Summary Display and the Control Popup Display.

The “Reset” buttons found on the Alarm Summary displays are “global” reset buttons which will reset all of the alarms needing to be reset. The term “global” refers to the entire system or plant.

The “Reset” buttons found on the Control Popup Displays are restricted to only resetting the alarms for the specific device on the popup display. If there are any other alarms needing to be reset, they will not be affected by activating these buttons.

Process Display refers to the visualization of the alarm, or message within the HMI or OIT process display. This could be done via text or symbol graphics. Most alarms will be displayed on the HMI/OIT displays by changing the equipment symbol’s color to yellow. This will be true for both analog and discrete signals. Discrete alarms from dedicated discrete alarm devices (i.e. high high level switches, eyewash flow switches, containment leak alarms, etc.) will be shown on the HMI/OIT displays.

Audible annunciation refers to the triggering of the treatment plant operator notification system (i.e. Public Address System). Three different audible sounds are indicated in the table. The operator is required to acknowledge the annunciation in order to silence the audible notification.

5.2.5.1 Annunciation Priorities

Alarms shall also be assigned a priority. Alarms with a low priority number are of higher importance (priority 1 – highest priority), and alarms with a high priority number are of lower importance. Four priority levels will be used, refer to Table 5.2.5-1.

5.2.5.2 Annunciation Groups

All annunciations in the HMI shall be assigned to an "Alarm Group" which is a function of the HMI operating system. The "Alarm Group" assignment is based on the PWD Organizational Structure. The Wastewater Organization has three Alarm Groups: Wastewater Systems (i.e. pump stations), East End Wastewater Treatment Plant (EEWWTP) and Remote Treatment Plants (Westbrook TP, Cape Elizabeth TP and Peaks Island TP). PWD's Drinking Water System has only one Alarm Group. **See PWD for the details related to the alarm group configuration.**

5.2.6. Historical Data and Trending

5.2.6.1 Historical Data Processing

The PI System shall capture and store data for analysis and report generation.

5.2.6.2 HMI/OIT Trending

The HMI/OIT shall be configured for trending any point within the SCADA system. The trends displayed shall be analogous to an XY strip chart plot, where the x-axis is time and the y-axis is the point value. Trends shall be made ad-hoc or pre-configured based on PWD pre-defined parameters.

Operations shall have the ability to track up to eight tags per trend display. Each data track shall be configured as a different color. I/O points shall be configured to trend values in both real-time or from locally stored archived files.

When defining real-time trend displays, it shall be possible to select various time periods, such a the previous 8 hours, previous 16 hours, previous 24 hours, and previous 168 hours. When trending archived data, the operator shall be able to select various degrees of time resolution although the time span available may be constrained by the minimum time resolution of archived data samples.

When viewing a trend, it shall be possible via a mouse pointer or vertical hard-line to select an individual sample and have the system display the time and value for that sample.

5.2.7. User Control

5.2.7.1 Peripheral Devices

The HMI/OIT interface shall utilize the mouse (single click only) for all navigational requirements of the SCADA system environment. There shall not be cases where special keyboard key combinations are required to navigate / operate the system; however, the keyboard shall be used for common tasks such as entering setpoints, scratch pad comments, security login procedures etc. It is intended that objects with functional attributes highlight denoting that actions are taken upon clicking the object.

5.2.7.2 Equipment Control

Controlling equipment in the field or changing parameters within the HMI/OIT are performed in a structured method. These types of actions shall be performed from a control pop-up display. Under no circumstances shall any field manipulation be performed from an overview, process, or system display. For instance, an operator needs to start Raw Water Pump #2. The user shall navigate to the Raw Water Pumps process display and clicks Pump #2. Pop-up containing pertinent pump information shall be display with control buttons, such as start and stop. The user may select the command, and upon verification, the command is sent. Executing all control from pop-ups not only provides a uniform method of operation, but also prevents process displays from being cluttered with informational feedback and control functions.

5.2.7.3 Confirmation of Action

All requested setpoint changes are required to be confirmed by the operator. After entering a new value in the setpoint field, an additional pop-up shall activate asking the operator to confirm their requested change.

5.2.8. HMI and PLC Database Naming Convention

Refer to Section 6.2.1 for the details.

5.2.9. Application Security

Security features of the HMI software allow classes of users to be defined, with specific privileges and restrictions placed on each class of user. Each individual user of the system will be assigned a username and password. The username will be linked to a group account that the user is assigned, and the proper restrictions will be in force.

As a default, the system will come up in a guest mode, so that operations displays can be viewed without requiring an operator login. No process or equipment changes can be made from the Guest Mode. The Guest Mode is also triggered when the screen saver mode is initiated.

Once the user is logged in and after a programmed period of time, if no actions are taken by the operator (such as acknowledging alarms, setting control actions, changing screens, etc.) the screen saver is active and the user is logged off and the system reset to guest mode. The PWD default for the screen saver (inactivity) logoff is 15 minutes. Each HMI can be programmed to open a unique display when the screen saver is activated. The usual screen saver display is the plant overview display.

The OIT “Configure Mode” button shall be located on its own display with a login requirement (see Section 6.7.11).

As an example, Table 5.2.9-1 defines the security settings for the different classes of users at the SLWTF:

Users	**Network (Domain) Accounts**		**iFix User Account**
WINDOWS ONLY ACCOUNTS			
PWDGUEST: Default Windows login for All View Nodes	Domain User Rights		None
WINDOWS & IFIX ACCOUNTS			
ADMINISTRATOR: Overall Windows and iFix admin account	Full Domain Administrative Rights		Full iFix Administrative Rights
Administrator: user name accounts	Full Domain Administrative Rights		Full iFix Administrative Rights (Plant Control and Alarm setting screens and iFix SCU)
Supervisor: user name accounts	Domain User Rights		iFix Supervisor Rights (Plant Control and Alarm setting screens)
Operator: user name accounts	Domain User Rights		iFix Operator Rights (Plant Control)
LOCAL IFIX ACCOUNTS			
GUEST: View only account	None		iFix View only Rights. For non-operations staff
OIT Configuration Mode			
Configure	INST		For entering the configure mode of the OIT

Table 5.2.9-1 User Accounts for SLWTF

5.2.10.1 User Classes

The following user classes, with the associated privileges, are defined for use at all HMI/OIT workstations. Each user will be provided with a username and password linked to one of these user classes.

- **Guest Mode** - This mode is intended for the default or screen saver mode of the System. An HMI in the guest mode shall not accept commands to actual field devices nor accept input data affecting the real-time or historical databases.

- **Operator Mode** - This mode is intended for the system operators engaged in the real-time operation of the SCADA System. Most displays shall be accessible, and commands may be sent to system devices.
- **Supervisor Mode** - This mode is intended for the Operation Supervisor, and is the same as the Operator Mode except that it has additional capabilities including system settings configuration.
- **Administrator Mode** - When operating in this mode, a programmer will have all the same abilities as the supervisor in addition to the ability to use the database edit and display generation and edit functions, or may perform background CPU functions. This mode also provides for overall maintenance and management of the system. Typical members to this type of account are the instrumentation staff members.

5.3. PLC PROGRAMMING STANDARDS

This section is intended to be a guideline for programming and configuring PLCs. It is intended to be a flexible standard that allows programmers to utilize custom techniques and methods that are straightforwardly identifiable and simple to understand for personnel with basic to intermediate programming experience. The standards that follow layout general guidelines and minimal requirements that are to be included throughout the PLC code.

The overall goal is to produce PLC code that follows a logical structure that facilitates the troubleshooting of the code and the equipment it operates. Supporting this goal is the use of documentation for the PLC code through an introductory comment (a.k.a. Routine, or Program, Header) in a ladder logic routine, or program file, which covers the overall purpose of the routine. This is also supported by liberal use of ladder rung comments throughout the routine. See section 5.3.6 for more details.

5.3.1. Software Requirements

Allen Bradley's Mini Edition of RSLogix 5000 shall be utilized to program and configure all of the Rockwell Automation CompactLogix PLCs used for monitoring and control. There are a few exceptions where an existing SLC 500 and models of Rockwell Automation MicroLogix PLCs that will require the use of RSLogix 500. **The latest version of the Mini Edition of RSLogix 5000 and RSLogix 500 supported by PWD shall be used to encompass the most current libraries and newest features.** It is the responsibility of the contractor to inquire PWD for the correct version of the software. If any other software is needed, its use must be approved by PWD and at least one licensed copy of the software must be provided to PWD for no charge.

5.3.2. Program Language

PWD's preferred PLC programming language is Ladder Logic (LL). Written approval from the Owner is required before another program editor is used.

5.3.3. Program Structure

Refer to Section 6.6.1 for the program structure description.

5.3.4. Programming Guidelines

In addition to the contents of Section 6.6, the following are general techniques and guidelines to follow through the program.

- **All programming will be done using ladder logic only.** This is the only programming language supported by the Mini Edition of the Rockwell Automation RS Logix 5000.
- All programming is to be performed as positive logic. (power flow indicates action)
- Predefined control functions that are part of the programming language are preferred over custom programmed blocks.
- Every logical process shall be programmed as a separate program block. As a precursor to each program block, a detailed comment shall be provided which describes in detail the control philosophy achieved by the programming within the block.
- Where more than one line of logic is required in order to perform a required function continuation contacts shall be used. Continuation logic, which uses the continuation contact, will immediately follow the line ending with the associated continuation coil.
- Where it is necessary to maintain an output instruction, control logic will use set & reset outputs. All lines of logic associated with the control of a common output (i.e. set/reset outputs) will immediately follow each other logic within the program and shall always reside within the same program block. Self-sealing control logic shall not be used.
- Outputs are to be used only once within the program. The only exceptions are those outputs controlled by set/reset logic which function in pairs and values which are initiated in the “run first” program block. Even under these unique circumstances, references within the program are not to exceed two (2).
- Output rung enabling conditions shall be grouped at the beginning of each rung followed by conditions that inhibit the output at the end.
- Latching and unlatching is usually done within the same rung. There are some exceptions from this guideline for common elements such as alarm horns and lights.

5.3.5. Standard PLC Program Modules

PWD has preference toward using standard program modules for use in all PLC programs and they will be provided by PWD upon request. These standard modules shall be used when designing and assembling PLC programs.

5.3.6. Program Documentation

All PLC programs shall be fully documented to explain and describe the logic within the program. Each section shall be documented to explain all functionality associated within the section. Documentation shall be, but not limited to:

1. Rung Comments (see Figure 5.3.6-2) – Rung comments shall provide a meaningful description of the purpose of the ladder rung.
2. Operand names and descriptions (see Figure 5.3.6-1) – The names and descriptions for the operands shall be the same as the iFIX database tagnames and descriptions.
3. Program, or Routine, Header (see Figure 5.3.6-3) – Header descriptions shall provide a meaningful description of the program, or routine. If possible, the descriptions should be extracts from the control narrative document (see Section 6.1).

Scope: MOCP Show: All Tags Enter Name Filter...

Name	Alias For	Base Tag	Data Type	Description	External Access	Constant
STW010A_LIT11430			Analog	LOX Tank No.1 Level	Read/Write	
STW010A_LIT11460			Analog	LOX Tank No.2 Level	Read/Write	
STW010A_PIT11211			Analog	Nitrogen Gas Pressure	Read/Write	
STW010A_PIT11430			Analog	LOX Tank No.1 Pressure	Read/Write	
STW010A_PIT11460			Analog	LOX Tank No.2 Pressure	Read/Write	
STW010A_PIT11711			Analog	GOX Header Pressure	Read/Write	
STW010A_PIT12111			Analog	Ozone Gas Header Pressure	Read/Write	
STW010A_TIT11500			Analog	Trim Heater Temperature	Read/Write	
STW010A_TIT11600			Analog	GOX Header Temperature	Read/Write	
STW010F_AIT17100			Analog	Off-Gas Header Ozone Concentration	Read/Write	
STW010F_AIT17210			Analog	Vent-Gas Header Ozone Concentration	Read/Write	
STW010F_DPIT17110			Analog	Ozone Destruct No.1 Catalyst Bed Differential Pressure	Read/Write	

Figure 5.3.6-1 Examples of PLC Program Documentation – Operand Names and Descriptions

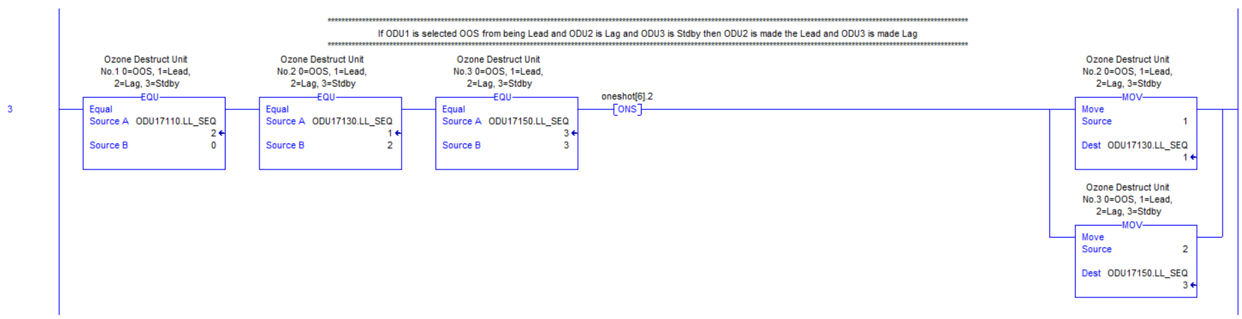
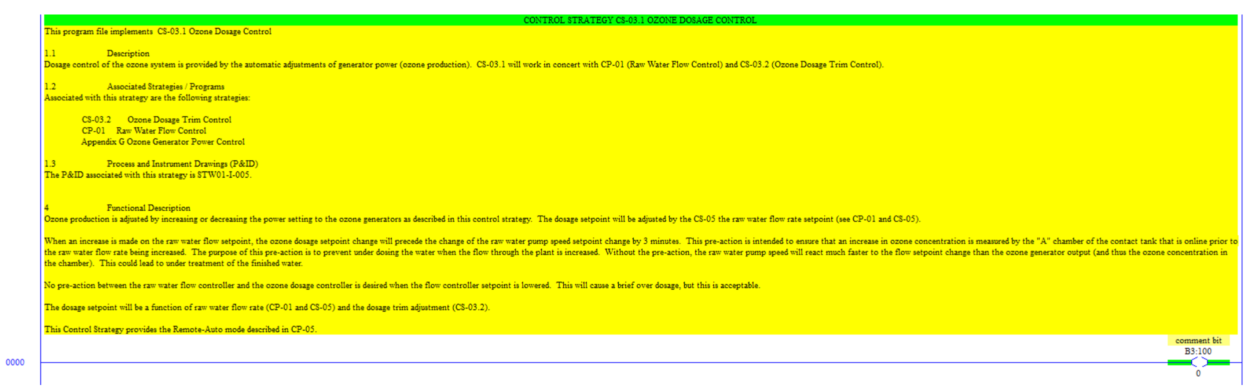


Figure 5.3.6-2 Examples of PLC Program Documentation – Ladder Rung Comments


CONTROL STRATEGY CS-03.1 OZONE DOSAGE CONTROL

This program file implements CS-03.1 Ozone Dosage Control

1.1 Description

Dosage control of the ozone system is provided by the automatic adjustments of generator power (ozone production). CS-03.1 will work in concert with CP-01 (Raw Water Flow Control) and CS-03.2 (Ozone Dosage Trim Control).

1.2 Associated Strategies / Programs

Associated with this strategy are the following strategies:

CS-03.2 Ozone Dosage Trim Control
CP-01 Raw Water Flow Control
Appendix G Ozone Generator Power Control

1.3 Process and Instrument Drawings (P&ID)

The P&ID associated with this strategy is STW01-I-005.

4 Functional Description

Ozone production is adjusted by increasing or decreasing the power setting to the ozone generators as described in this control strategy. The dosage setpoint will be adjusted by the CS-05 the raw water flow rate setpoint (see CP-01 and CS-05).

When an increase is made on the raw water flow setpoint, the ozone dosage setpoint change will precede the change of the raw water pump speed setpoint change by 3 minutes. This pre-action is intended to ensure that an increase in ozone concentration is measured by the "A" chamber of the contact tank that is online prior to the raw water flow rate being increased. The purpose of this pre-action is to prevent under dosing the water when the flow through the plant is increased. Without the pre-action, the raw water pump speed will react much faster to the flow setpoint change than the ozone generator output (and thus the ozone concentration in the chamber). This could lead to under treatment of the finished water.

No pre-action between the raw water flow controller and the ozone dosage controller is desired when the flow controller setpoint is lowered. This will cause a brief over dosage, but this is acceptable.

The dosage setpoint will be a function of raw water flow rate (CP-01 and CS-05) and the dosage trim adjustment (CS-03.2).

This Control Strategy provides the Remote-Auto mode described in CP-05.

0000 comment bit B3:100 0

Figure 5.3.6-3 Examples of PLC Program Documentation – Program, or Routine, Header Comments

For each PLC programmed and configured, the documentation provided shall include:

a) Hard copies of all project files required by the PLC.
b) Complete soft copies of entire program including process narrative descriptions on a rung to rung basis.
c) Identification of all acronyms used through program.
d) Complete listing of all registers and data tables (logic components) associated with the PLC programming environment in spreadsheet format.

Revision Memo

Rev. 0	May 7, 2004	Draft Version for comments
Rev. 1	June 18, 2004	Final Version for comments
Rev. 2	July 30, 2004	Final Version
Rev. 3	April 14, 2006	PWD's Version
Rev. 4	February 27, 2009	Minor changes throughout this section Major changes in section 5.2.9
Rev. 4.1	August 1, 2012	Minor changes throughout this section
Rev. 5.0	September 20, 2016	Many minor changes throughout this section Changes to standardize the use of RS Logix 5000 and the use of CompactLogix PLCs
Rev. 6.0	September 01, 2021	Minor changes throughout this section

TABLE OF CONTENTS

6 APPENDICES

6.1 APPENDIX A – CONTROL NARRATIVE STANDARDS AND EXAMPLE

The purpose of this section is to provide examples for each of the control narrative sections as outlined in Section 2.2.6.2. These examples provide general guidance for the development of new control narrative, and the updating of existing control narratives for the PWD SCADA system. The examples include: an Introduction (or General Information) section; a Control Program; and a Control Strategy.

- General Information: An introduction to the overall narrative and table of contents.
- Control Program: A write-up of the controls logic for elementary operation of process equipment, normally of a single type of equipment. Most control narratives are at this level.
- Control Strategy: A more complex write-up of the interconnectivity of several related process equipment and their respective control programs.

The following sections will provide a description and example of the contents for each of the three sections listed above. The examples provided within this document are from the PWD's standard Duplex Wastewater Pump Station Control Narrative.

Note, it is recommended that providers attain examples from recent similar projects are attained in order to develop a document which is as standardized and current as possible. These can be made available upon request from the PWD project lead, or the PWD SCADA Services Manager.

6.1.1 General Information

The General Information section contains several elements:

- Overview – A description of the goals of the project, or proposed process control changes, and how it fits into the overall SCADA system. It shall include interfaces to other process control programs or narratives which are affected by this project. It shall reference drawings, or auxiliary information required to interact with the control narrative.
- Details – This is a list of all the control programs and strategies that are described in Control Narrative Sections. A mockup of the subprocess overview display is presented if it is appropriate to the project. The Details section shall include, but not limited to, the following list of additional item:
    1. HMI/OIT display titles (popups and overviews)
    2. Description of PLC Hardware Changes (if needed)
    3. Description of Test Requirements (i.e. FAT, SAT, SAD, etc.)
- Description of the Project Execution Requirements

Below is an example control narrative, the PWD standard duplex pump station control narrative.

Generic Duplex Pump Station Narrative

Revision 2021

1 Overview and Description

Portland Water District operates and maintains over 75 wastewater pump stations throughout its system. Each one is slightly different due to site-specific requirements and decisions that were made throughout the years. The District has made a conscious effort to standardize on a "generic duplex waste water pump station" design going forward. Having a standard package, both for physical equipment and for controls, makes construction, operation, and long-term maintenance easier and more cost-effective for the District and its rate-payers.

The Duplex Pump Station Control Narrative contains the following Control Programs and Control Strategies:

- CP-01 – Submersible Pumps
- CP-02 – Ultrasonic Level Transducer/Level Transmitter
- CP-03 – Float Switches
- CP-04 – Standby Emergency Generator
- CP-05 – Misc. Instruments
- CS-01 – Waste Water Pumping System

Duplex wastewater pump station equipment includes two constant-speed submersible pumps, a standby emergency generator with an automatic transfer switch, and process instrumentation. Continuous level in the influent wetwell is measured by a Milltronics (typically) ultrasonic or radar level transducer and level indicating transmitter (LIT66111_LI). See *Control Program CP-02 – Ultrasonic Level Transducer/Level Transmitter* for more detail.

Point levels are detected by ball float switches, which are used as a backup to the ultrasonic level measurement and are wired through intrinsically-safe relays. See *Control Program CP-03 – Float Switches* for more detail.

Pump discharge flow rate is not typically measured, but when it is an electromagnetic flow meter and flow indicating transmitter (FIT66300-FI) are used. See *Control Program CP-05 – Misc. Instruments* for more detail.

PLC programs shall be configured to allow authorized Operators to modify process control set points, control logic parameters, alarm set points, dead bands, pump sequencing, timer settings, etc. readily by using the operator interface terminal (OIT) at the pump station and the SCADA human machine interface (HMI) software. However, the HMI interface typically has only minimal access to controls. The majority must be done locally at the OIT. PLC programs shall adhere to the requirements documented in the latest revision of the Portland Water District SCADA Standards.

Control logic, alarm logic and totalization calculations shall be executed via the PLC programs and not the SCADA HMI software. The PLC shall continue to operate properly in automatic mode upon loss of communications with the SCADA system or upon failure of the OIT.

When a power failure occurs equipment shall be restarted automatically. Equipment shall fail in last position, or a PWD determined safe position.

2 Process and Instrument Drawings (P&ID) and Other Related Documentation

- Process and Instrumentation Diagrams, or P&IDs have been developed for many of the individual pump stations across the District. A P&ID should be developed for all new pump stations and available as a supplement to this document.

- I/O list: the I/O list should be developed in Microsoft Excel utilizing the standard PWD I/O list template for each site. The I/O list includes the critical information about each PLC input and output including:
    - Tagname
    - description
    - PLC rack, slot point location
    - Units & allowable range
    - Etc.

- Memory Map: This document list should be developed in Microsoft Excel utilizing the standard PWD Memory Map Template. The primary function of the memory map is to provide the Tag addressing for the communication from the RTU to the MTU using message blocks. The memory map also includes all of the calculated values, setpoints, and alarms which are not present in the I/O list.

3 Document Organization

This document is organized as described in the PWD SCADA Standards section 2.2.6. Each section will contain a Control Program: (individual pieces of equipment) or a Control Strategy (groups of equipment working together). Each section will contain:

- Title
- Description: a summary of the goals of the Control Program or Strategy.
- Equipment Operation: Description of the local and PLC control of the equipment and/or instrument(s).
- Operator Adjustable Setpoints: Lists and describes the operator adjustable setpoints within the OIT and/or HMI.
- Alarms and Interlocks: Lists and describes the alarms and interlocks associated with the equipment and/or instrument(s).

Note that I/O tagnames are preceded with “ABC##,” and descriptions are preceded with “Site Name” because this document applies to a generic pump station. A specific pump station will require the proper site name prefix on the tagnames and descriptions. Engineer or PWD shall provide those prefixes.

4 Table of Contents

[End of Example]

6.1.2 Control Program Description

As previously mentioned, a control program is a section within the narrative which describes the control of a simple process or a single piece of equipment. The structure contains several headings:

- **Title** – This will include both the Control Program (CP) number and the name of the unit or system it will be controlling.
- **1 Description** – The description will describe in words a 5,000 ft overview of the unit or system controlled by the CP. This will describe, but is not limited to, the following items:
    - Description of the unit or system components
    - Purpose of the unit or system
    - Normal and non-normal operation of the equipment.
    - Major interlocks.
    - Significant associated CPs and Control Strategies (CS's).
    - A sketch of the popup HMI/OIT display and any other significant displays associated with the CP.
- **1.1 Process and Instrumentation Drawings** – Listing of the P&IDs depiction the unit or system. (optional)
- **1.2 Field I/O and Status Indicators** – A table listing the signals directly wired to the PLC's. The tagnames in the table are the complete name that is used in the HMI. The actual name used in the PLC code is shortened by removing the prefix before the first underscore. (*Note: Field I/O and Status Indicators can also be documented within the I/O list and memory map document. Check with project lead on your specific project.)*
- **1.2 Calculated Values** – A table listing the values calculated within the PLC's. The tagnames in the table are the complete name that is used in the HMI. The actual name used in the PLC code is shortened by removing the prefix before the first underscore.
- **2 Equipment Operation** – A description of the different operation modes of the unit or system:
        - 2.1 Local/Off
        - 2.2 Remote-Manual
        - 2.3 Remote-Automatic
- **3.1 Interlocks** – This section describes each individual hardwired and software based interlock.
- **3.2 Alarms** – This section describes each individual alarm for the unit or system.

Below is and an example of a Control Program Narrative. This control program narrative is from the PWDs Generic Duplex Wastewater Pump Station Control Narrative.

Control Program CP-01

Submersible Pumps

1 Description

There are two submersible pumps located at the bottom of the influent wet well of the typical duplex pump station. Typically the pumps are left in automatic control, and typically while in automatic control only one pump (lead pump) runs at a time, turning on when a lead-pump-on level setpoint is reached and turning off when the lead-pump-off level setpoint is reached. There are conditions in which two pumps will run simultaneously. These conditions and other automatic pump controls are described in more detail in *Control Program CS-01 – Waste Water Pumping System.*

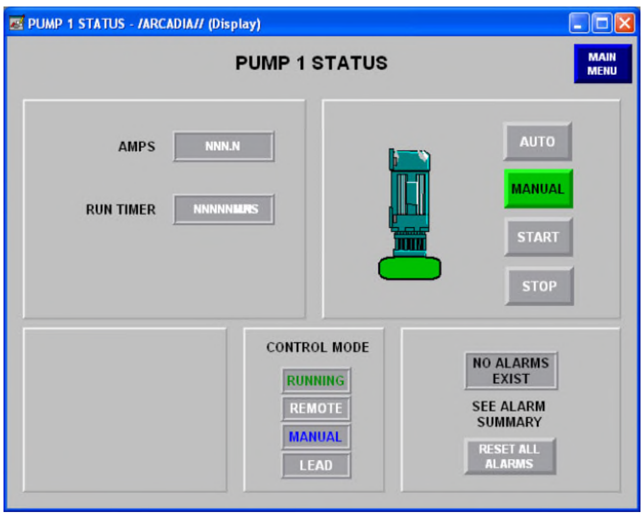


Figure CP-1.1 – Typical OIT Pump Control Popup

1.1 Process and Instrument Drawings (P&ID)

Duplex Pump Station P&ID (would be included here or as appendix)

2 Operation Modes

PWD prefers to use pumps with three-phase motors. However, three-phase power is not available at every site. For sites with three-phase line power, starters are installed in the pump control panel, one for each pump motor. For sites with single-phase line power, VFDs are installed in the pump control panel, one per pump motor. The VFDs change single-phase power into three-phase. The pumps are still operated at a constant speed.

Each motor starter or VFD has a Hand-Off-Auto selector switch (or Local-Off-Remote selector switch for the purpose of this document) which can operate in one of the following modes:

1. Local/Off
2. Remote-Manual
3. Remote-Automatic

2.1 Local/Off

In Local mode, pumps are manually operated when the Local/Off/Remote (LOR) selector switch on the pump control panel is in the “Local” position. The purpose of Local mode is for maintenance runs only. When the pump selector switch is placed in the Local position a pump start, via hard-wired logic in the pump control panel, will be initiated.

If an operator wanted to remove the pumps from all PLC control the pumps should be placed in Local position. All PLC interlocks will become inactive. The pumps should not normally be left in Local mode.

When the selector switch is in the Off position the pump will not run. All PLC interlocks are inactive when the LOR switch is in the Off position.

2.2 Remote-Manual

When the Local/Off/Remote selector switch on the pump control panel is in the “Remote” position, then Remote-Manual control or Remote-Automatic control is enabled through the PLC.

In Remote-Manual mode, the pumps are operated at the pump station OIT or the SCADA HMI by an operator, and the PLC controls the pumps. Using SCADA, an operator can start and stop the pump, reset alarms, and switch from manual to automatic modes using the *Pump Control Popup* display for that particular pump. All the PLC interlocks are active in this mode.

2.3 Remote-Automatic

In Remote-Automatic mode, the pumps are automatically operated by the telemetry panel PLC or hardwired logic, based on wetwell level. The specifics of how the pumps run in Remote-Automatic mode will be explained in detail in *Control Strategy CS-01 – Waste Water Pumping System*.

2.4 SCADA Setpoints

The OIT *Process Setpoints* screen is shown in *Figure CP-01.2 – Process Setpoints (Pumps)*. The setpoints related to the pumps are explained below. The setpoints can be adjusted by an operator as necessary. The *Process Setpoints* screen can be accessed via the *Main Menu (Figure A1 – Main Menu)*.

There are several default setpoint values which are not provided in this document because they are site-specific. PWD will provide those values.

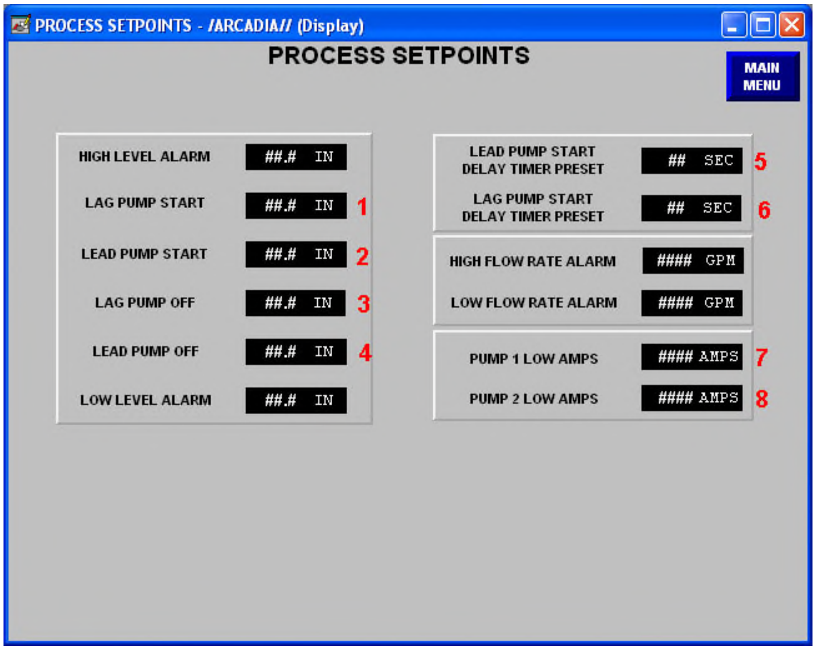


Figure CP-01.2 – OIT Process Setpoints (Pumps)

The following setpoints, related to the pumps, can be entered by an operator on the *Process Setpoints* screen. PWD shall provide starting values for these setpoints prior to pump station start up.

Lag Pump Start (1 – Figure CP-01.2)

This setpoint applies to whichever of the two pumps has been selected as the “Lag” pump on the *Pump Selection Matrix* (*Figure CS-01.1*) screen. This is the wet well level value, reported by the level transmitter, at which the lag pump will be commanded to start by the PLC. If the level that triggers the lag pump to start is reached that generally indicates that the lead pump is unable to keep up with influent flow. The level for this setpoint is site dependent, but it is typically set around 6 inches higher than the “Lead Pump Start Setpoint.”

Lead Pump Start (2 – Figure CP-01.2)

This setpoint applies to whichever of the two pumps has been selected as the “Lead” pump on the *Pump Selection Matrix* screen. This is the wet well level value, reported by the level transmitter, at which the lead pump will be commanded to start by the PLC. This value is site specific.

Lag Pump Off (3 – Figure CP-01.2)

This setpoint applies to whichever of the two pumps has been selected as the “Lag” pump on the *Pump Selection Matrix* screen. This is the wet well level value, reported by the level transmitter, at which the lag pump will be commanded to stop by the PLC. This setpoint is typically kept the same as the “Lead Pump Off” Setpoint for two reasons:

1. Stopping one pump before the other can result in a severe slamming shut of the check valve due to the pressure created by the running pump
2. If the Lead pump has a blockage or other reason for poor pumping performance it could continue to run for a long time due to its inability to drop the wet well level to the “Lead Pump Off” Setpoint. See *Control Strategy CS-01 – Waste Water Pumping System* for further explanation.

Lead Pump Off (4 – Figure CP-01.2)
This setpoint applies to whichever of the two pumps has been selected as the "Lead" pump on the *Pump Selection Matrix* screen. This is the wet well level value, reported by the level transmitter, at which the lead pump will be commanded to stop by the PLC. Both this setpoint and the "Lag Pump Off" setpoint are site specific.

Lead Pump Start Delay Timer Preset (5 – Figure CP-01.2)
This setpoint allows an operator to enter a time (in seconds) that the PLC will wait after the "Lead Pump Start" setpoint is reached until the start command is given to the Lead pump. A typical starting value of this setpoint is 0 seconds.

Lag Pump Start Delay Timer Preset (6 – Figure CP-01.2)
This setpoint allows an operator to enter a time (in seconds) that the PLC will wait after the "Lag Pump Start" setpoint is reached until the start command is given to the Lag pump. A typical starting value of this setpoint is 5 seconds.

Pump 1 Low Amps (7 – Figure CP-01.2)
This setpoint allows an operator to set the value of "Pump 1 Amps" (ABC##PS_MOT66210_II) that will trigger a "Pump 1 Low Amps Alarm" in the PLC. A typical starting value of this setpoint is 30 amps.

Pump 2 Low Amps (8 – Figure CP-01.2)
This setpoint allows an operator to set the value of "Pump 2 Amps" (ABC##PS_MOT66220_II) that will trigger a "Pump 2 Low Amps Alarm" in the PLC. A typical starting value of this setpoint is 30 amps.

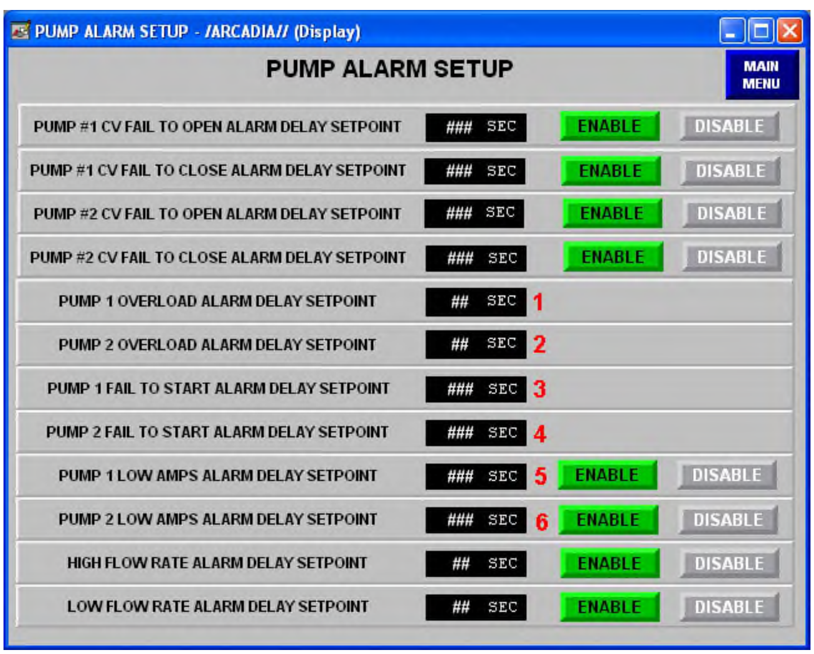


Figure CP-01.3 – OIT Pump Alarm Setup (Pumps)

The following setpoints, related to standard pump alarms, can be entered by an operator on the *Pump Alarm Setup* screen. The setpoints relate to the pump noted, regardless of whether the PLC considers that pump to be in the "lead" or "lag" position.

Pump 1 Overload Alarm Delay Setpoint (1 – Figure CP-01.3)
This setpoint applies to Pump 1. It allows an operator to delay a "Pump #1 Overload Alarm" (ABC##PS_MOT66210_YA3) by the number of seconds entered. A typical starting value of this setpoint is 5 seconds.

Pump 2 Overload Alarm Delay Setpoint (2 – Figure CP-01.3)
This setpoint applies to Pump 2. It allows an operator to delay a "Pump #2 Overload Alarm" (ABC##PS_MOT66220_YA3)by the number of seconds entered. A typical starting value of this setpoint is 5 seconds.

Pump 1 Fail to Start Alarm Delay Setpoint (3 – Figure CP-01.3)
This setpoint applies to Pump 1. It allows an operator to delay a "Pump #1 Fail to Start Alarm" (ABC##PS_MOT66210_YA) by the number of seconds entered. A typical starting value of this setpoint is 45 seconds.

Pump 2 Fail to Start Alarm Delay Setpoint (4 – Figure CP-01.3)
This setpoint applies to Pump 2. It allows an operator to delay a "Pump #2 Fail to Start Alarm" (ABC##PS_MOT66220_YA) by the number of seconds entered. A typical starting value of this setpoint is 45 seconds.

Pump 1 Low Amps Alarm Delay Setpoint (5 – Figure CP-01.3)
This setpoint applies to Pump 1. It allows an operator to delay a "Pump #1 Low Amps Alarm" (ABC##PS_MOT66210_YA1) by the number of seconds entered. An operator can also enable or disable the "Pump #1 Low Amps Alarm" by using the buttons next to this setpoint. A typical starting value of this setpoint is 20 seconds.

Pump 2 Low Amps Alarm Delay Setpoint (6 – Figure CP-01.3)
This setpoint applies to Pump 2. It allows an operator to delay a "Pump #2 Low Amps Alarm" (ABC##PS_MOT66220_YA1) by the number of seconds entered. An operator can also enable or disable the "Pump #2 Low Amps Alarm" by using the buttons next to this setpoint. A typical starting value of this setpoint is 20 seconds.

3 Interlocks and Alarms

This section describes the abnormal conditions that could occur when operating the pumps.

3.1 Interlocks

A pump will stop for the following reasons:

PLC Interlocks:

- It has a "Pump X Motor High Temp Alarm"
- It has a "Pump X Fail to Start Alarm"
- It has a "Check Valve X Fail to Open Alarm"
- It has a "Check Valve X Fail to Close Alarm"

Check valve alarms are described in Control Program CP-05 – Misc. Instruments.

Hardwired Interlocks:

- It has a “Pump X Overload Alarm”

If the faulted pump is the Lead pump, the Lag pump will then be called into service. It will start when the wet well level reaches the lag-pump-on setpoint.

In the case of PLC failure, there is a hardwired backup control system. Backup level control shall function independently of the PLC and level transducer/transmitter. It will use hard-wired controls to start and stop the pumps. If the wet well level activates the high level float switch Pump #1 will be started directly from the pump control panel. After a preset time delay (hard-wired) Pump #2 will be started. Both pumps will run until the wet well level drops to deactivate the low level float switch. Please note that because the PLC is not involved in the starting of the pumps the roles of “Lead” and “Lag” pump do not apply. The roles of “Lead” and “Lag” pump only apply during remote-automatic control of the pumps through the PLC.

3.2 Alarms

Below are typical alarms for a pump. Pump #1 alarms are described, but Pump #1 and #2 have similar alarms:

A **PUMP #1 OVERLOAD ALARM (ABC##PS_MOT66210_YA3)** occurs when:

- the Pump #1 VFD (or starter, depending on which was installed) sends an overload alarm to the PLC,
- and the “Pump 1 Overload Alarm Delay Setpoint” timer has elapsed.

Alarm Priority 2, High
This alarm will stop a pump whether in Local or Remote mode. It must be cleared on the OIT and manually reset at the pump control panel before the pump can run.

A **PUMP #1 FAIL TO START ALARM (ABC##PS_MOT66210_YA)** occurs when:

- A Pump #1 start command is sent by the PLC,
- Pump #1 is not running,
- And the “Pump 1 Fail to Start Alarm Delay Setpoint” timer has elapsed.

Alarm Priority 2, High

A **PUMP #1LOW AMPS ALARM (ABC##PS_MOT66210_YA1)** occurs when:

- Pump #1 is running,
- the “Pump #1 Amps” input to the PLC (ABC##PS_MOT66210_II) is less than “Pump #1 Low Amps Alarm Setpoint,”
- the “Pump #1 Low Amps Alarm” is enabled,
- and the “Pump 1 Low Amps Alarm Delay Setpoint” timer has elapsed.

Alarm Priority 2, High
This alarm will not stop a pump.

The following alarms are reported directly from the pump motor VFD or starter to the PLC:

PUMP #1 HIGH MOTOR TEMP ALARM (ABC##PS_MOT66210_TAH)
Alarm Priority 2, High
This alarm will stop a pump whether in Local or Remote mode. It must be cleared on the OIT and manually reset at the pump control panel before the pump can run.

PUMP #1 SEAL FAIL (ABC##PS_MOT66210_YA2)
Alarm Priority 2, High
This alarm will not stop a pump from running.

PUMP #1 FAULTED (ABC##PS_PMP66210_YA1)
Alarm Priority 2, High
This alarm indicates that the pump cannot run.

[End of Example]

6.1.3 Control Strategy Description

This is an example of a control strategy from the Peaks Island Wastewater Treatment Plant. The structure contains several headings:

- **Title** – This will include both the Control Strategy (CS) number and the name of the Control Strategy.
- **Description** – The description will describe in words a 5,000 ft overview of the CP's (Control Programs) controlled by the CS. This will describe, but is not limited to, the following items:
    - Purpose of the CS
    - Normal and non-normal operation of the CS.
    - Major interlocks.
    - Significant associated equipment, CPs and CS's.
    - A sketch of the popup and/or Settings HMI/OIT display and any other significant displays associated with the CS (if needed).
- **Process and Instrumentation Drawings** – Listing of the P&IDs depiction the unit or system.
- **Calculated Values** – A table listing the values calculated within the PLC's. The tagnames in the table are the complete name that is used in the HMI. The actual name used in the PLC code is shortened by removing the prefix before the first underscore. CS's usually don't have any I/O points directly associated with them. I/O is usually associated with CP's (lower level).
- **Control** – A description of the control mode, or modes, of the CS (Automatic Mode 1, etc.). CS's have to have more flexibility when designing control modes than CP's.
- **Power Failure Recovery Restart** – This section describes what settings or controller mode should be set as a default when power is restored.
- **Alarms** – This section describes each individual alarm for the CS.

Below is and an example of a Control Strategy. This project had 7 control programs and nine control strategies:

- CS-03 – SBR Sequence Control
- CS-04 – Static Fill Cycle
- CS-05 – Mix Fill Cycle
- CS-06 – React Fill Cycle
- CS-07 – React Cycle
- CS-08 – Settle Cycle
- CS-09 – Decant Cycle
- CS-10 – Waste Mix Cycle
- CS-11 – Idle Cycle

The CS-03 given as the example is the "Master" control strategy controlling all of the other eight control strategies.

Control Strategy CS-03

SBR Sequence Control

1 Description

The Sequencing Batch Reactor (SBR) provides the necessary treatment to the wastewater entering the plant. All of the processes performed by the SBR are identical to a conventional wastewater treatment plant except it is done in a single tank. The Peaks Island Plant has two SBRs that are operated sequentially. When one SBR is filling with raw wastewater, the other is treating the wastewater.

An SBR is equipped with:

- concrete tank
- air diffusers (combined with the blowers)
- floating mixer
- floating decanter
- fill valve
- decant valve
- level indicator
- influent flow meter

This Control Strategy (CS-03) supports the SBR sequences:

- CS-04 – Static Fill
- CS-05 – Mixed Fill
- CS-06 – React Fill
- CS-07 – React
- CS-08 – Settle
- CS-09 – Decant
- CS-10 – Waste (Mix & Pump)
- CS-11 – Idle

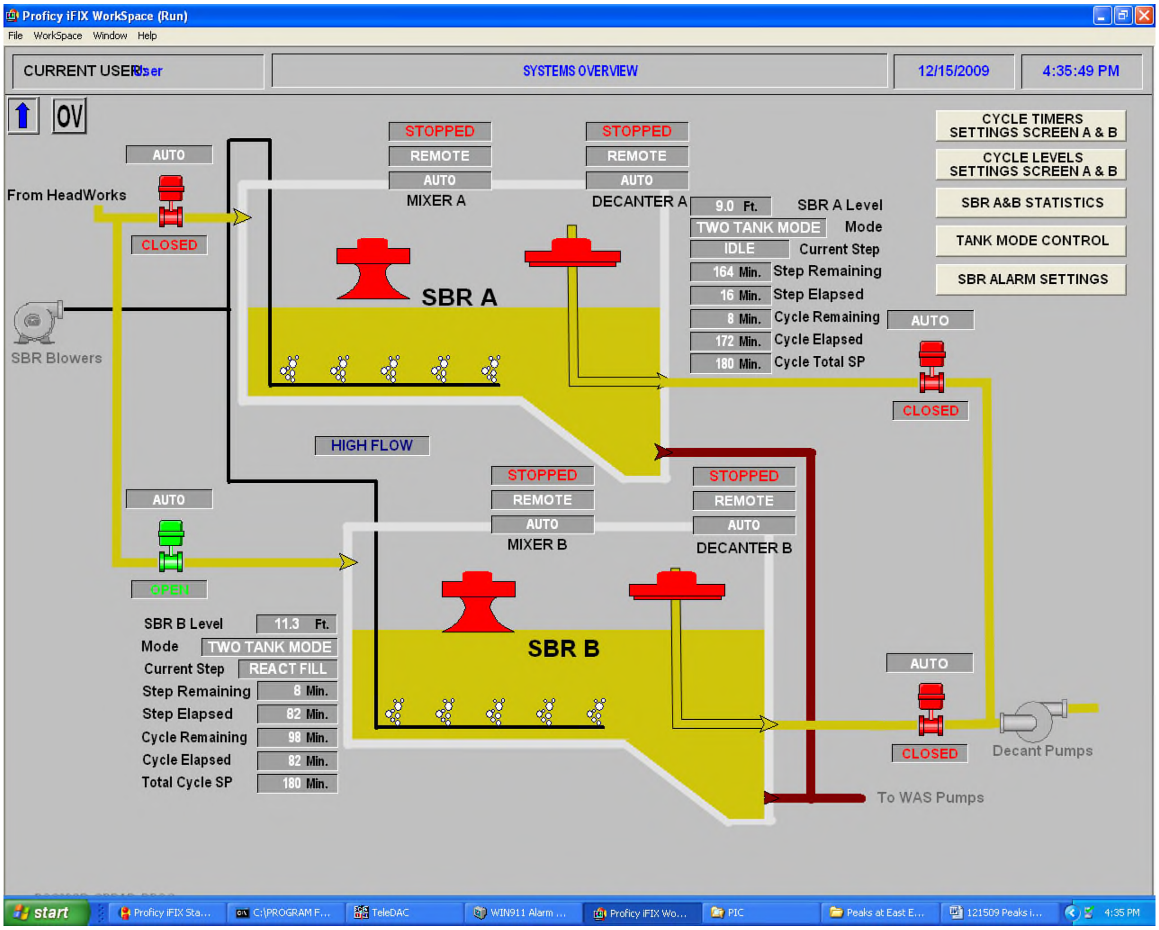


Figure CS-03-1 – HMI SBR System Overview Screen

With the SBRs in Automatic Mode 2 – Two Tank Mode, one SBR will be filling while the other SBR will be reacting and processing the waste. Figure CS-03-1, below, shows the processing cycle relationship between the two SBRs:

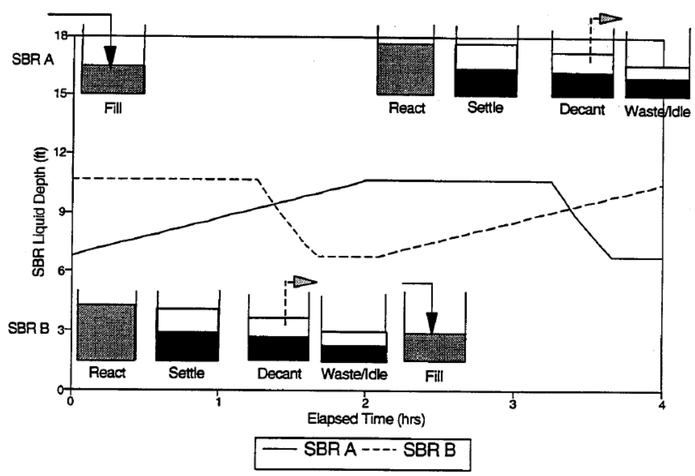


Figure CS-03-2 – Typical Cycles for the Two Tank Operating Mode

1.1 Process and Instrument Drawings (P&ID)

1. POS02-I-002
2. POS02-I-003
3. POS02-I-004

(Note: available for review upon request from PWD)

Terminology:

- Cycle: Period of time to **completely** process an SBR. Each cycle is made up of **several** steps, such as: REACT and FILL MIX.
- Cycle Step: A **portion** of the process cycle for an SBR. Example of individual cycles steps include: WASTE MIX and STATIC FILL
- Cycle Elapse Timer: The elapse time since the beginning of and SBR Cycle. This timer will start at zero minutes and count up until the end of the last Cycle Step.
- Cycle Time Remaining: A timer that will start with the Total Cycle Time Setpoint value and count down to zero.
- Total Cycle Time Setpoint: The sum total of all the cycle step timer values for a complete cycle.

1.3 Calculated Values

Totalized Total Influent Flow, to consist of nine independent totalizers:

POS02HW_FIT35110_FQY1	Today's total flow (since midnight). Value to be reset at midnight in GAL
POS02HW_FIT35110_FQY2	Yesterday's total influent flow in GAL
POS02HW_FIT35110_FQY3	1 Day ago in GAL
POS02HW_FIT35110_FQY4	2 Day ago in GAL
POS02HW_FIT35110_FQY5	3 Day ago in GAL
POS02HW_FIT35110_FQY6	4 Day ago in GAL
POS02HW_FIT35110_FQY7	5 Day ago in GAL
POS02HW_FIT35110_FQY8	6 Day ago in GAL
POS02HW_FIT35110_FQY9	Continuous total flow value or index counter (in MGAL) that will rollover and reset when 1,000,000 MGAL is tallied.

Perform totalizer calculations only when Influent Flow (POS02HW_FIT35110_FI) > 0.1 GPM

Totalized Total Effluent Flow, to consist of nine independent totalizers:

POS02DC_FIT15110_FQY1	Today's total effluent flow (since midnight). Value to be reset at midnight in GAL
POS02DC_FIT15110_FQY2	Yesterday's total effluent flow in GAL
POS02DC_FIT15110_FQY3	1 Day ago in GAL
POS02DC_FIT15110_FQY4	2 Day ago in GAL
POS02DC_FIT15110_FQY5	3 Day ago in GAL
POS02DC_FIT15110_FQY6	4 Day ago in GAL
POS02DC_FIT15110_FQY7	5 Day ago in GAL
POS02DC_FIT15110_FQY8	6 Day ago in GAL
POS02DC_FIT15110_FQY9	Continuous total flow value or index counter (in MGAL) that will rollover and reset when 1,000,000 MGAL is tallied.

Perform totalizer calculations only when Effluent Flow (POS02DC_FIT15110_FI) > 0.1 GPM

POS02HW_FIT35110_FI	Plant Influent Flow (GPM)
POS02HW_FIT35110_FY	Calculated average of the influent flow (GPM)
POS02SB_STR60110_KQI11	SBR A Current Cycle Step Time Remaining in Minutes
POS02SB_STR60120_KQI11	SBR B Current Cycle Step Time Remaining in Minutes
POS02SB_STR60110_KQI12	SBR A Cycle Step Elapse Time in Minutes
POS02SB_STR60120_KQI12	SBR B Cycle Step Elapse Time in Minutes
POS02SB_STR60110_KQI13	SBR A Total Cycle Time Remaining in Minutes
POS02SB_STR60120_KQI13	SBR B Total Cycle Time Remaining in Minutes
POS02SB_STR60110_KQI14	SBR A Total Cycle Elapse Time in Minutes
POS02SB_STR60120_KQI14	SBR B Total Cycle Elapse Time in Minutes
POS02SB_STR60110_KC10	SBR A Total Cycle Timer Setpoint in Minutes
POS02SB_STR60120_KC10	SBR B Total Cycle Timer Setpoint in Minutes
POS02SB_STR60110_HC10	Cycle Step Manual Advance
POS02SB_STR60110_HC11	Cycle Step Manual Hold
POS02SB_STR60110_YI2	SBR Cycle Low Flow Setting (0 = NORMAL, 1 = LOW)
POS02SB_STR60110_YI3	SBR Cycle High Flow Setting (0 = NORMAL, 1 = HIGH)
POS02SB_STR60110_YI	SBR A Current Cycle Step Number (See Table 2 Below)
POS02SB_STR60120_YI	SBR B Current Cycle Step Number (See Table 2 Below)
POS02SB_STR60110_HI11	SBR Tank Control Mode (0 = One Tank Mode, 1 = Two Tank Mode)
POS02SB_STR60110_HI13	SBR Tank Selector (0 = SBR A, 1 = SBR B)
POS02SB_LIT60110_LAL1	SBR A Level Limit for Emergency Mode
POS02SB_LIT60120_LAL1	SBR B Level Limit for Emergency Mode
POS02SB_STR60110_HI12	SBR Emergency Control Mode (0 = One Tank Mode, 1 = Emergency Mode)
POS02SB_STR60110_YA11	SBR One Tank Control Mode Alarm (0 = Two Tank Mode, 1 = One Tank Mode)
POS02SB_STR60110_YA12	SBR Emergency Control Mode Alarm (0 = Two Tank Mode, 1 = Emergency Mode)
POS02SB_STR60110_KQI11	SBR Emergency Mode Delay Timer (5 minutes)
POS02SB_STR60110_HI13	Initial SBR Cycle Step (See Table CS-03-1 Below)
POS02SB_STR60110_KQI15	SBR A Cycle Step Failed Delay Timer (5 Minutes)
POS02SB_STR60120_KQI15	SBR B Cycle Step Failed Delay Timer (5 Minutes)
POS02SB_STR60110_KC11	SBR A & B Static Fill Cycle Step Timer Setpoint (Two Tank) Low Flow
POS02SB_STR60110_KC12	SBR A & B Static Fill Cycle Step Timer Setpoint (Two Tank) Normal Flow
POS02SB_STR60110_KC13	SBR A & B Static Fill Cycle Step Timer Setpoint (Two Tank) High Flow
POS02SB_STR60110_KC14	SBR A & B Static Fill Cycle Step Timer Setpoint (One Tank)
POS02SB_STR60110_KC21	SBR A & B Mix Fill Cycle Step Timer Setpoint (Two Tank) Low Flow
POS02SB_STR60110_KC22	SBR A & B Mix Fill Cycle Step Timer Setpoint (Two Tank) Normal Flow
POS02SB_STR60110_KC23	SBR A & B Mix Fill Cycle Step Timer Setpoint (Two Tank) High Flow
POS02SB_STR60110_KC24	SBR A & B Mix Fill Cycle Step Timer Setpoint (One Tank)
POS02SB_STR60110_KC31	SBR A & B React Fill Cycle Step Timer Setpoint (Two Tank) Low Flow
POS02SB_STR60110_KC32	SBR A & B React Fill Cycle Step Timer Setpoint (Two Tank) Normal Flow
POS02SB_STR60110_KC33	SBR A & B React Fill Cycle Step Timer Setpoint (Two Tank) High Flow
POS02SB_STR60110_KC34	SBR A & B React Fill Cycle Step Timer Setpoint (One Tank)
POS02SB_STR60110_KC41	SBR A & B React Cycle Step Timer Setpoint (Two Tank) Low Flow
POS02SB_STR60110_KC42	SBR A & B React Cycle Step Timer Setpoint (Two Tank) Normal Flow
POS02SB_STR60110_KC43	SBR A & B React Cycle Step Timer Setpoint (Two Tank) High Flow
POS02SB_STR60110_KC44	SBR A & B React Cycle Step Timer Setpoint (One Tank)
POS02SB_STR60110_KC51	SBR A & B Settle Cycle Step Timer Setpoint (Two Tank) Low Flow

POS02SB_STR60110_KC52	SBR A & B Settle Cycle Step Timer Setpoint (Two Tank) Normal Flow
POS02SB_STR60110_KC53	SBR A & B Settle Cycle Step Timer Setpoint (Two Tank) High Flow
POS02SB_STR60110_KC54	SBR A & B Settle Cycle Step Timer Setpoint (One Tank)
POS02SB_STR60110_KC61	SBR A & B Decant Cycle Step Timer Setpoint (Two Tank) Low Flow
POS02SB_STR60110_KC62	SBR A & B Decant Cycle Step Timer Setpoint (Two Tank) Normal Flow
POS02SB_STR60110_KC63	SBR A & B Decant Cycle Step Timer Setpoint (Two Tank) High Flow
POS02SB_STR60110_KC64	SBR A & B Decant Cycle Step Timer Setpoint (One Tank)
POS02SB_STR60110_KC71	SBR A & B Waste Mix Cycle Step Timer Setpoint (Two Tank) Low Flow
POS02SB_STR60110_KC72	SBR A & B Waste Mix Cycle Step Timer Setpoint (Two Tank) Normal Flow
POS02SB_STR60110_KC73	SBR A & B Waste Mix Cycle Step Timer Setpoint (Two Tank) High Flow
POS02SB_STR60110_KC74	SBR A & B Waste Mix Cycle Step Timer Setpoint (One Tank)
POS02SB_STR60110_KC81	SBR A & B Waste Pump Cycle Step Timer Setpoint (Two Tank) Low Flow
POS02SB_STR60110_KC82	SBR A & B Waste Pump Cycle Step Timer Setpoint (Two Tank) Normal Flow
POS02SB_STR60110_KC83	SBR A & B Waste Pump Cycle Step Timer Setpoint (Two Tank) High Flow
POS02SB_STR60110_KC84	SBR A & B Waste Pump Cycle Step Timer Setpoint (One Tank)

Terminology:

- Cycle: Period of time to **completely** process an SBR. Each cycle is made up of **several** steps, such as: REACT and FILL MIX.
- Cycle Step: A **portion** of the process cycle for an SBR. Example of individual cycles steps include: WASTE MIX and STATIC FILL
- Cycle Elapse Timer: The elapse time since the beginning of and SBR Cycle. This timer will start at zero minutes and count up until the end of the last Cycle Step.
- Cycle Time Remaining: A timer that will start with the Total Cycle Time Setpoint value and count down to zero.
- Total Cycle Time Setpoint: The sum total of all the cycle step timer values for a complete cycle.

2 CONTROL

There are three Control Modes for the operation of the SBRs:

1. Automatic Mode 1 (One Tank)
2. Automatic Mode 2 (Two Tanks)
3. Automatic Mode 3 (Emergency Mode)

The control mode is determined by the value of the points:

POS02SB_STR60110_HI11 – SBR Two Tank Control Mode (0 = One Tank Mode, 1 = Two Tank Mode)
POS02SB_STR60110_HI12 – SBR Emergency Control Mode (0 = One Tank Mode, 1 = Emergency Mode)

The modes discussed here in CS-03 are found in the following section below.

Throughout SBR automatic mode (1 and 2), the operator has the ability to manually advance to the next cycle step or hold the current step. This is done using two hand controllers:

- POS02SB_STR60110_HC10 – Cycle Step Manual Advance
- POS02SB_STR60110_HC11 – Cycle Step Manual Hold

2.1 Automatic Mode 2 (Two Tank Mode)

The will be allow the operator to manually select the initial SBR cycle step when first selecting the “Two Tank” mode to run. The allowable selections for POS02SB_ STR60110_HI13 are:

1	=	SBR A: Mixed Fill	SBR B: React
2	=	SBR A: React Fill	SBR B: Settle
3	=	SBR A: React Fill	SBR B: Decant
4	=	SBR A: React Fill	SBR B: Waste
5	=	SBR A: React	SBR B: Mixed Fill
6	=	SBR A: Settle	SBR B: React Fill
7	=	SBR A: Decant	SBR B: React Fill
8	=	SBR A: Waste	SBR B: React Fill

Table CS-03-1: Initial Cycle Steps

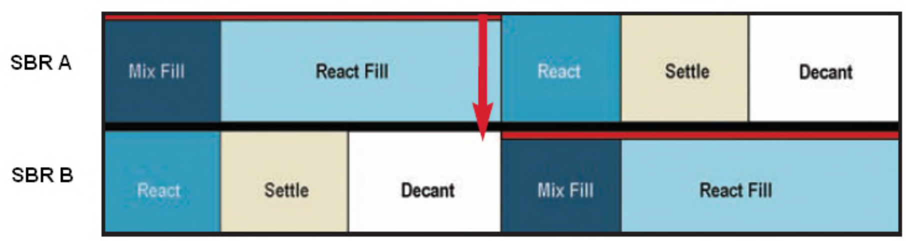


Figure CS-03-3 – Two Tank Mode Cycles (This is an approximate depiction of this running mode, with the red line showing which tank is filling up)

Cycle Step Number		Fill Valve	Decant Valve	Mixer	SBR Blower	Decanter	Decant Pump	WAS Pump	PID Valve
1	**Static Fill**	O	X	X	X	X	X	X	X
2	**Mix Fill**	O	X	O	X	X	X	X	X
3	**React Fill**	O	X	X	O	X	X	X	X
4	**React**	X	X	X	O	X	X	X	X
5	**Settle**	X	X	X	X	X	X	X	X
6	**Decant**	X	O	X	X	O	O	X	O
7A	**Waste Mix**	X	X	X	O	X	X	X	X
7B	**Waste Pump**	X	X	X	X	X	X	O	X
8	**Idle**	X	X	X	X	X	X	X	X

Table CS-03-2 – SBR Cycle Steps for the Two Tank Mode (X = Off/Closed, O = On/Opened)

When selected, the two SBRs shall be automatically controlled through the PLC to maintain the desired level of wastewater treatment. The two SBRs shall be run sequentially: One SBR is filling while the other SBR is treating the wastewater (see Figure CS-03-2 for an approximate depiction of this running mode). This is the normal operating mode for the plant.

Because of the requirement for keeping the varying influent flowing into one of the two SBRs, there is a need for some flexibility in the cycle steps. This is done by varying the amount of "Idle" and "React Fill" step time for an SBR. The "React Fill" step will end when the SBR is filled to a level setpoint value (i.e. 11 Ft)

To operate the SBR Control Mode in the "Two Tank" mode through the OIT/HMI, the following conditions must apply:

- SBR Control Mode = 2 (Two Tank Mode)
- SBR Cycle Flow Rate = LOW, NORMAL or HIGH
- CS-04 – Static Fill = READY (when this cycle set has initiated)
- CS-05 – Mixed Fill = READY (when this cycle set has initiated)
- CS-06 – React Fill = READY (when this cycle set has initiated)
- CS-07 – React = READY (when this cycle set has initiated)
- CS-08 – Settle = READY (when this cycle set has initiated)
- CS-09 – Decant = READY (when this cycle set has initiated)
- CS-10 – Waste = READY (when this cycle set has initiated)
- CS-11 – Idle = READY (when this cycle set has initiated)

The Cycle Step Timer Setpoints for each cycle step can be set by the operator and an initial setting is given in Table CS-02-3:

	Low Flow	**Normal Flow**	**High Flow**
	(minutes)	**(minutes)**	**(minutes)**
Static Fill	10	5	0
Mix Fill	50	25	0
React Fill	120	90	90
React	50	6	5
Settle	50	50	40
Decant	75	59	40
Waste Mix	2	3	3.5
Waste Pump	3	2	1.5
Idle			

Table CS-03-3: Cycle Timer Setpoints for Different Flow Rates (Two Tank Mode) (yellow highlight = tank filling; blue highlight = tank not filling)

Note that the time total for the first three fill cycle steps always equal the last five reacting/wasting cycle steps. This is true because the influent flow has to be fill one tank at all times.

Figure CS-03-4 – HMI SBR Cycle Step and Strategy Timer Setpoint Screen

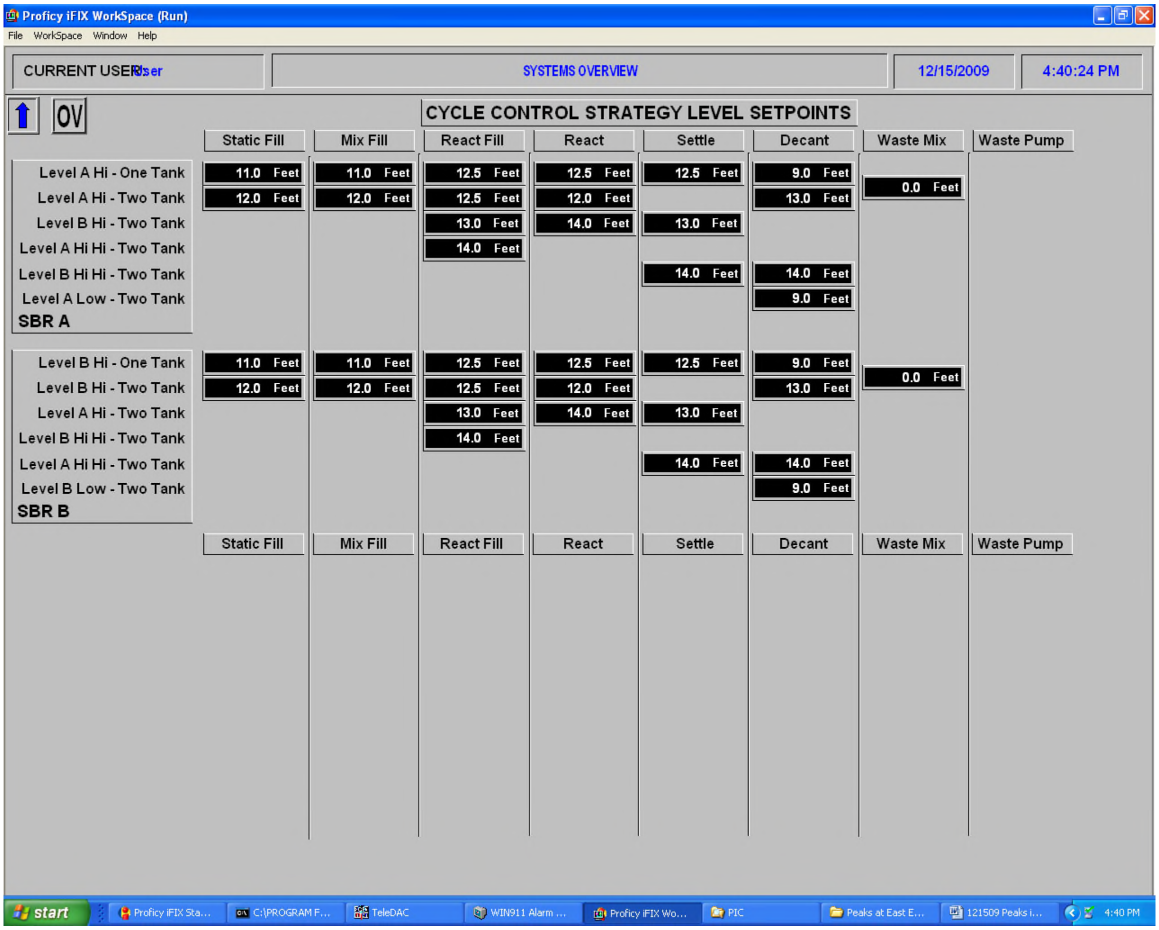


Figure CS-03-5 – HMI SBR Cycle Strategy Level Setpoint Screen

	<u>**Low Flow**</u>	<u>**Normal Flow**</u>	<u>**High Flow**</u>
Maximum Cycles per Day per SBR	**4**	**6**	**8**

Table CS-03-4: Cycles per Day for Different Flow Rates

The selection between Low, Normal and High Flow Settings will either be manual or automatically set by the influent flow set point settings.

In Manual, the Flow Setting is selected by the operator. The new cycle step timer settings will be used at the start of the next cycle.

In Automatic, the Flow Setting (POS02SB_STR60110_YI2) will be selected base on the calculated average of the influent flow (these flow setting can be changed by the operator):

- Low Flow = < 60 GPM
- Average Flow = 61 to 150 GPM
- High Flow = > 151 GPM

The average flow calculation (POS02HW_FIT35110_FY) shall be computed for the duration of the fill cycle for one SBR. Cycle step timer setpoints will be changed at the start of the next cycle.

2.2 Automatic Mode 1 (One Tank)

The One Tank Mode is triggered either by the Operator or by an equipment fault alarm. The operator can initiate this mode by selecting the tank he/she wants to put into this mode (opposite the one he/she wants to take off line) and executing the controller mode.

An equipment fault can trigger the One Tank Mode forcing the failed tank to be taken off line and the other tank being operated in One Tank Mode (for example: a "failed to open" condition will cause a fault alarm on Fill Valve A, which will in turn cause SBR B to be run in One Tank Mode). Any time the PLC looses ability to run the equipment normally, the One Tank Mode activated as a safety measure. The equipment faults are triggered by:

- Failed to Stop or Start
- Failed to Open or Close
- Motor Overload (if available to the PLC)
- LOR Switch in the Local or Off Position (if available to the PLC)
- Equipment in the Remote-Manual Mode
- Disconnect Switch in the De-energized Position (if available to the PLC)

When this automatic mode is selected, one of the SBR tanks is left "online" (A or B) and the other tank is taken out of service. This is illustrated in Figure CS-03-3 below where all of the raw sewage is directed to one SBR.

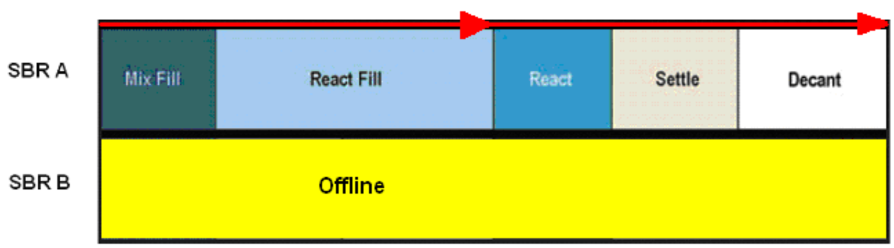


Figure CS-03-6 – One Tank Mode Cycles (Tank A Selected, Tank B Offline) (The Red Line Denotes the Raw Sewage Flow)

The "online" tank (SBR A or SBR B) will be stepped through an abbreviated SBR cycle step sequence (see table below) but the Fill Valve for that SBR will be left in the OPEN position for every cycle step. The cycles will have different timer settings than what are used during the "Two Tank" mode.

	Fill Valve	Decant Valve	Mixer	SBR Blower	Decanter	Decant Pump	WAS Pump	PID Valve
React Fill	O	X	X	O	X	X	X	O
React	O	X	X	O	O	O	X	O
Settle	O	X	X	X	O	O	X	O
Decant	O	O	X	X	O	O	X	O
Waste Mix	O	X	X	O	O	O	X	O

Waste Pump	O	X	X	X	O	O	O	O

Table CS-03-7 – SBR Cycle Steps for the One Tank Mode (X = Off/Closed, O = On/Opened)

To operate one of the two SBR (A or B) in the “One Tank” mode through the OIT/HMI, the following conditions must apply:

- SBR Tank Selector = SBR A or SBR B
- SBR Cycle Control Mode = AUTOMATIC MODE 1 – One Tank
- SBR Cycle Flow Rate = LOW, NORMAL or HIGH
- CS-06 – React Fill = READY (when this cycle set has initiated)
- CS-07 – React = READY (when this cycle set has initiated)
- CS-08 – Settle = READY (when this cycle set has initiated)
- CS-09 – Decant = READY (when this cycle set has initiated)
- CS-10 – Waste = READY (when this cycle set has initiated)

The Cycle Timer Setpoints for each cycle step are:

	Timer Setpoint (minutes)
React Fill	30
React	30
Settle	30
Decant	120
Waste Mix	3
Waste Pump	2

Table CS-03-8: Cycle Step Timer Setpoints for One Tank Mode

The operator must manually change the controller mode back to Two Tank Mode when he/she feels the situation that caused the One Tank Mode has been resolved.

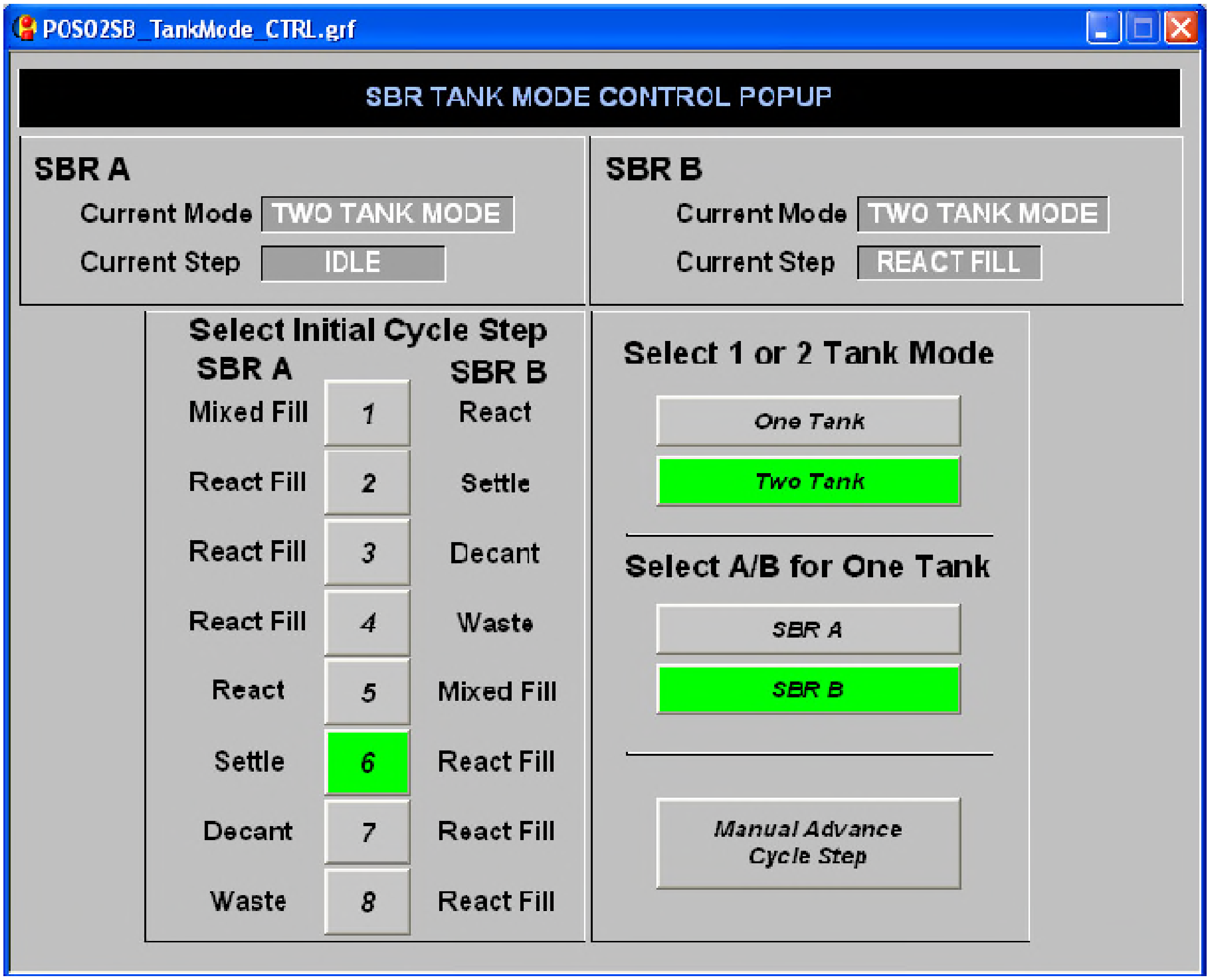


Figure CS-03-7 – HMI SBR Tank Mode Control Popup Screen

2.3 Automatic Mode 3 (Emergency Mode)

When this automatic mode is enacted, both of the SBR tanks are taken out of automatic cycle control (Automatic Modes 1 and 2). This is an event driven mode triggered by an abnormally high influent flow entering the treatment plant. The goal of this operating mode is prevent the overflowing of the headworks area and the SBR tanks. This is done by shutting down the blowers and mixers, opening all valves to both SBRs (fill and decant valves) and starting the decant pumps. This will allow water to run through the plant unabated.

To start the Emergency Bypass Event the following conditions must apply:

- SBR A Tank High Level Float Switch = ON
- SBR B Tank High Level Float Switch = ON
- Emergency Mode Timer (2 minute delay) = DONE

	Fill Valve	Decant Valve	Mixer	SBR Blower	Decanter	Decant Pump	WAS Pump	PID Valve
Emergency Mode	O	O	X	X	O	O	X	O

Table CS-03-9 – SBR A and B Configuration for the Emergency Bypass Mode (X = Off/Closed, O = On/Opened)

Once the Emergency Mode is triggered, the decant pumps will start draining both SBRs. The high level float switches will be turned off as soon as the levels in the tanks start to drop. This will require control logic to maintain the Emergency Mode status until both tanks are drained below a level setpoint from the level transmitters (POS02SB_LIT60110_LAL1 & POS02SB_LIT60120_LAL1).

Once the tanks are drained, the Emergency Mode will put SBR A into the normal “Fill” cycles steps (Static Fill, Mix Fill, & React Fill) with the appropriate flow rate timer settings based on the influent flow rates. SBR B will put in Idle until SBR A is filled.

Once SBR A is filled, the Emergency Mode is complete, and the control strategy will automatically switch to the Two Tank Mode. SBR B will then start filing while SBR A is put through the usual cycle steps.

3 POWER FAILURE RECOVERY RESTART

When the electric power utility has an outage, there will be a brief power loss to the plant until the backup generator starts up and the transfer switch provides power. The UPS will provide power to the PLC and PanelView throughout this process. Also the air driven valves will go to their fail safe positions. All motor driven equipment will stop. Once generator power is available, the plant will enter a recovery mode:

- If the PLC doesn’t loose power, all of the SBR equipment will be left in their last state and restarted where it left off before the power outage occurred.

- If the PLC looses power, the default settings within the PLC will be set.

    - SBR Control Mode = TWO TANK MODE
    - **Based on the SBR Level: the SBR with the highest level is selected to be in REACT and the SBR with the lowest level is in STATIC FILL**

4 ALARMS

The following alarm message values and time delays shall be provided:

1. POS02SB_STR60110_YA11 – SBR One Tank Control Mode Alarm (0 = Two Tank Mode, 1 = One Tank Mode)
2. POS02SB_STR60110_YA12 – SBR Emergency Control Mode Alarm (0 = Two Tank Mode, 1 = Emergency Mode)

[End of Example]

6.2 APPENDIX B – NAMING CONVENTIONS

6.2.1 Tagnames

This section is supplemental to Section 2.3, and it provides the details for tagnames needed by the PWD SCADA System. The SCADA tag names are rooted by the Asset Names. The “ISA” portion of the name (see Figure 6.2.1 below) is unique to the SCADA System. Every component to the left of the “ISA Code” portion is the AMAP asset name of the piece of equipment most closely related to the SCADA signal that is being represented by the tag name.

The tag names shall use the structure defined below:

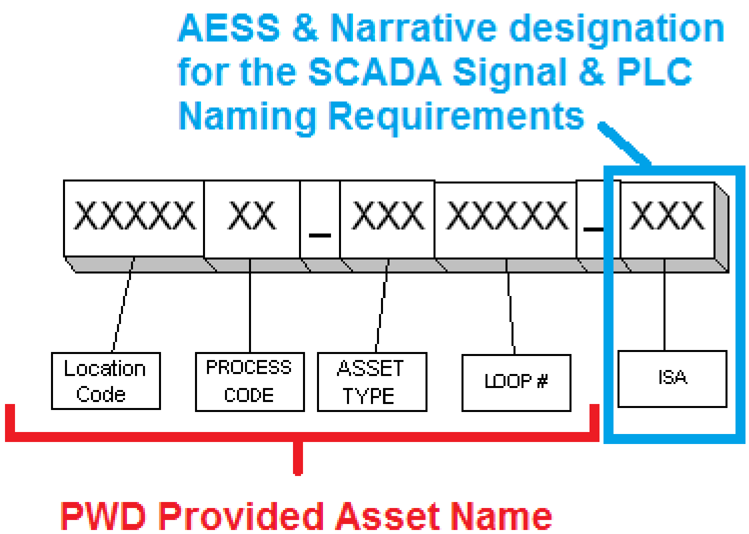


Figure 6.2.1-1 Tagname Components and Layout

PWD will provide the AESS with the Asset Names. The “ISA Code” component will either be assigned by the AESS or through the Control Narrative tagname tables. Below is a discussion of the details to the “ISA Code” component.

6.2.1.1 ISA Code

The **ISA** is a code based on the ISA S5.1-1984 codes for instruments (shown in Figure 6.2.1-11). This code provides a unique tag name for each signal needed for functions within the PLC and HMI/OIT databases.

As illustrated in Figure 6.2.1-11, The ISA Code is made up of letters and the position of the letter in the code will dictate the meaning of that letter. For example, an “A” in the first position means “Analyzer”. An “A” in the second position means “Alarm”. So for a code of “AA” this would mean “Analyzer Alarm” and not “Analyzer Analyzer” or “Alarm Alarm”.

	FIRST-LETTER (4)		SUCCEEDING-LETTERS (3)		
	MEASURED OR INITIATING VARIABLE	MODIFIER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	Analysis (5,19)		Alarm		
B	Burner, Combustion		User's Choice (1)	User's Choice (1)	User's Choice (1)
C	User's Choice (1)			Control (13)	
D	User's Choice (1)	Differential (4)			
E	Voltage		Sensor (Primary Element)		
F	Flow Rate	Ratio (Fraction) (4)			
G	User's Choice (1)		Glass, Viewing Device (9)		
H	Hand				High (7, 15, 16)
I	Current (Electrical)		Indicate (10)		
J	Power	Scan (7)			
K	Time, Time Schedule	Time Rate of Change (4, 21)		Control Station (22)	
L	Level		Light (11)		Low (7, 15, 16)
M	User's Choice (1)	Momentary (4)			Middle, Intermediate (7,15)
N	User's Choice (1)		User's Choice (1)	User's Choice (1)	User's Choice (1)
O	User's Choice (1)		Orifice, Restriction		
P	Pressure, Vacuum		Point (Test) Connection		
Q	Quantity	Integrate, Totalize (4)			
R	Radiation		Record (17)		
S	Speed, Frequency	Safety (8)		Switch (13)	
T	Temperature			Transmit (18)	
U	Multivariable (6)		Multifunction (12)	Multifunction (12)	Multifunction (12)
V	Vibration, Mechanical Analysis (19)			Valve, Damper, Louver (13)	
W	Weight, Force		Well		
X	Unclassified (2)	X Axis	Unclassified (2)	Unclassified (2)	Unclassified (2)
Y	Event, State or Presence (20)	Y Axis		Relay, Compute, Convert (13, 14, 18)	
Z	Position, Dimension	Z Axis		Driver, Actuator, Unclassified Final Control Element	

Figure 6.2.1-11 ISA Letter Assignments

Typical use of the ISA letter codes is presented in Table 6.2.1-3 below:

AI	Analyzer Indicator (i.e. Chlorine Residual, pH, Fluoride Concentration, etc.)
AAH	Analyzer High Alarm
AAL	Analyzer Low Alarm
AKA	Analyzer Rate of Change Alarm
FAH	Flow High Alarm
FAL	Flow Low Alarm
FI	Flow Indication
FKA	Flow Rate of Change Alarm
FQI	Flow Totalizer
FY	Flow Calculation/Conversion (i.e. Convert GPM to MGD)
HI	Hand Switch Indication (i.e. LOR Switch, Auto/Manual Switch, etc.)
IAH	Current High Alarm
IAL	Current Low Alarm
II	Current Indication
IKA	Current Rate of Change Alarm
KQI	Timer Indicator (i.e. Pump Run Hours)
LAH	High Level Alarm
LAL	Low Level Alarm
LCH	Level Limit High Setpoint
LCL	Level Limit Low Setpoint
LI	Level Indication
LKA	Level Rate of Change Alarm
LKA	Level Rate of Change Alarm
PAH	Pressure High Alarm
PAL	Pressure Low Alarm
PI	Pressure Indication
PKA	Pressure Rate of Change Alarm
SI	Speed Indication
SK	Manual Mode Speed Command
TAH	Temperature High Alarm
TAL	Temperature Low Alarm
TI	Temperature Indication
TKA	Temperature Rate of Change Alarm
UK	Controller Mode
VAH	High Vibration Alarm
xA	Analog Point Faulted (x= “L” for level, “F” for flow, etc.)
xA1	Analog Point Open Circuit (i.e. Broken Wire, Loose Connection)
xA2	Analog Point Out of Range Low (Less Than 4 mA)
xA3	Analog Point Out of Range High (Greater Than 20 mA)
xA4	Analog Point Bad Signal Status (Combination of 1,2,&3)
YA	Event Alarm (i.e. Motor Fault)
YAL	Alarm Strobe Light (Located on Some Control Panels)

YC	Start or Stop Command
YI	Event Indication (i.e. Motor Run Status)
YK	Manual Mode Run Command
YQI	Event Counter (i.e. Pump Start Counter)
ZI	Position Indication (i.e. Valve Limit Switches & Entry Door Switches)
ZIH	Position Indication Open (i.e. Valve Limit Switches & Entry Door Switches)
ZIL	Position Indication Close (i.e. Valve Limit Switches & Entry Door Switches)

Table 6.2.1-3 Typical Use of the ISA Letter Codes

The complete ISA code is a combination of three parts: the ISA letters, a multiple number (optional) and a modifier (optional). See Figure 6.2.1-12 for details. The multiple number is used to distinguish multiple similar elements and it only used when needed by the database.

Also a modifier code is sometimes used to provide database points for auxiliary functions required for alarm management.

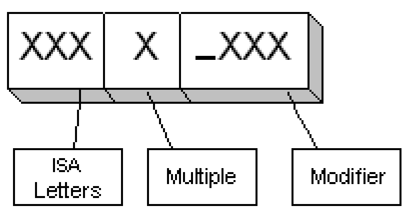


Figure 6.2.1-12 ISA Component of the Tagname

MOR	Manual Override
OR	Override
RS	Alarm Reset
SP	Setpoint

Table 6.2.1-4 Examples of Modifiers for the ISA Component

Table 6.2.1-4 shows some examples of modifiers for the ISA component for alarm handling features. These features are for resetting latched alarms, manually overriding (or “silencing”) alarms by an operator (see Section 6.6.1.3 for detailed use of the modifiers on page 6-84).

6.2.1.6 Tag Name Examples

Examples of some tag names are listed in Table 6.2.1-5:

STW01CL_FIT14100_FI	SLWTF Total hypo flow (GPM)
STW01CL_FIT14100_WQI	SLWTF Hypo use today- running total (LBS)
STW01CL_FIT14100_FQI1	SLWTF Hypo daily totalized flow (gallons)
STW01CL_FIT14100_FQI2	SLWTF Hypo use yesterday (gallons)
STW01CL_FIT14100_FQI3	SLWTF Hypo use 2 days ago (gallons)
STW01CL_FIT14100_FQI4	SLWTF Hypo use 3 days ago (gallons)
STW01CL_FIT14100_FQI5	SLWTF Hypo use 4 days ago (gallons)
STW01CL_FIT14411_FI	SLWTF Hypo pump #1 flow rate (lbs/day)
STW01CL_LIT14110_LI	SLWTF Hypo storage tank #1 level
STW01CL_PMP14410_YI	SLWTF Hypo pump #1 running indication to scada
STW01CL_PMP14412_HI	SLWTF Hypo pump #1 unavailable for automatic s
STW01HV_TIT72200_HC	SLWTF HVAC lobby temp sp (ac3)
POS01DC_FIC15200_FI	EEWWTP Bypass mode dechlor required application rate lbs/day
POS01PL_LIT01070_LI	EEWWTP Polymer aging tank
CUB01PS_PIT66100_PAL_SP	Blanchard Rd Booster Station low outlet pressure alarm setpoint
POP41PS_LIT66112_LA2	India St Pump Station Level Signal Out of Range Low (Less Than 4 mA)

Table 6.2.1-5 Examples of Tagnames

6.2.2 Wire Labels

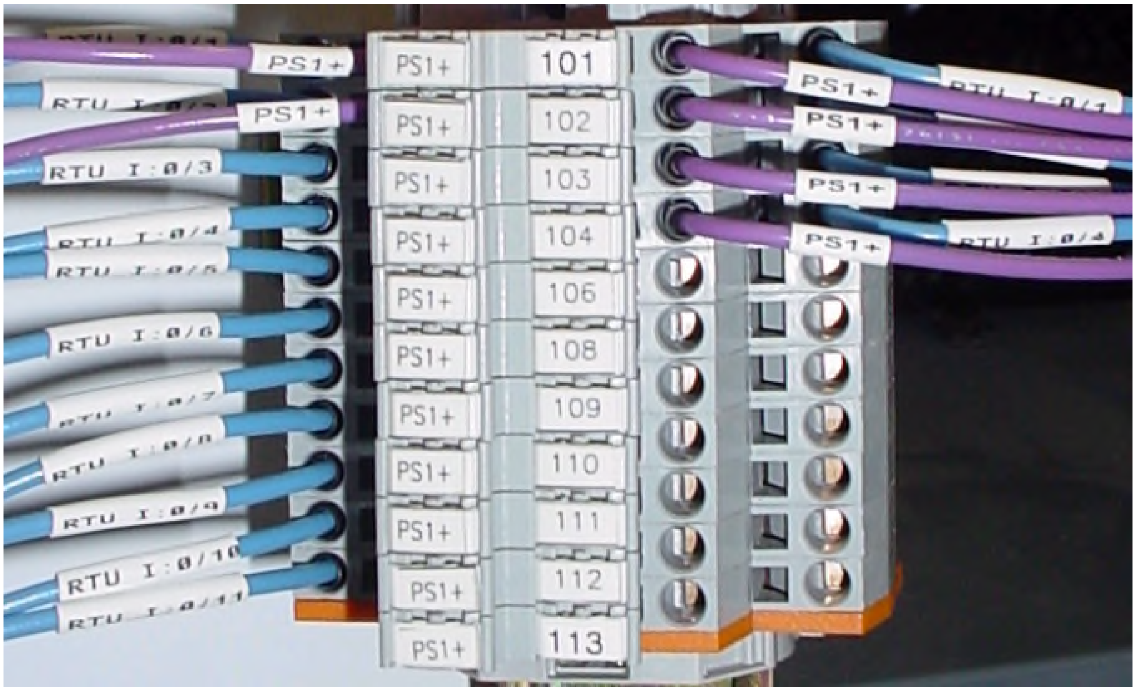


Figure 6.2.2-1 Photograph of Wire Labels

Wire Label Format: XXX Y:ZZZZ Q

Required BMP-41 Labels (Part Number – MC-XXX-342, using the bold size 13 brady fixed width (slash through zeros) Any exceptions to this must be pre-approved by the District.

Where :

XXX = PLC Identification (the first two letters are the Hansen sub process designation, and the number is just sequential)

Y = I or O

ZZZZ = Slot and channel designation

Q = + or - or S (for shield)

This standard is simply the PLC name in front of the I/O address (see Figure 6.2.2-1).

For example an analog input signal (Positive terminal) assigned to a card in slot 7, and channel 1, on the EEWWTP Hypo PLC would have a label of:

DS1 I:7.1 +

Another example would be a discrete output signal (negative terminal) assigned to a card in slot 13 (second rack), and channel 10, on the EEWWTP Dechlorination PLC would have a label of:

DS2 O:13/10 - (Note, no +/- sign for discrete signals)

The same cable number shall be applied to **all conductor lengths** (or segments) from the field device through the PLC I/O terminal.
Some other the PLC Identifications are:

- DS1 for the hypochlorite or chemical feed (SLWTF & EEWWTP)
- DS2 for the EEWWTP bisulfite
- RTU for the remote sites
- MTU for the master telemetry unit
- NE1 for the Northeast Pump Station
- SH1 for the EEWWTP rotary press
- SH2 for the EEWWTP dewatering
- SH3 For the EEWWTP GBT
- HW1 For the EEWWTP step screen
- HW2 for the EEWWTP grit removal
- SH4 for the EEWWTP WAS
- OC1 for the EEWWPT odor control CP1
- OC2 for the EEWWTP odor control CP2
- PC1 for the EEWWTP primary sedimentation basin
- PC2 for the EEWWTP Poly Chem panel
- ST1 for the EEWWTP AG Building
- RW1 for the SLWTF Raw Water
- UV1 for the SLWTF UV Reactor #1
- UV2 for the SLWTF UV Reactor #2
- UV3 for the SLWTF UV Interface PLC
- OG1 for the SLWTF Ozone Generator #1
- OG2 for the SLWTF Ozone Generator #2
- OZ1 for the SLWTF Ozone Interface PLC
- OZ2 for the SLWTF Master Ozone Control
- FW1 for the SLWTF Finished Water
- FW2 for the SLWTF T-Valves
- WE1 for the WGWTP Master PLC
- PW1 for the WGWTP Plant Water
- SS1 for the WGWTP Secondary Scum & Polymer System
- CN1 for the WGWTP Schwing Pump
- AR1 for the EEWWTP Aeration Blower #1
- AR2 for the EEWWTP Aeration Blower #2
- AR3 for the EEWWTP Aeration Blower #3
- AR4 for the EEWWTP Aeration Main Control

6.2.3 PLC Symbol Names

This section defines the naming convention to be followed when assigning PLC symbol names. By following a symbol naming convention, one can more easily sort and find an individual point or groups of points from the HMI database.

The PLC symbol names shall use the structure defined below:

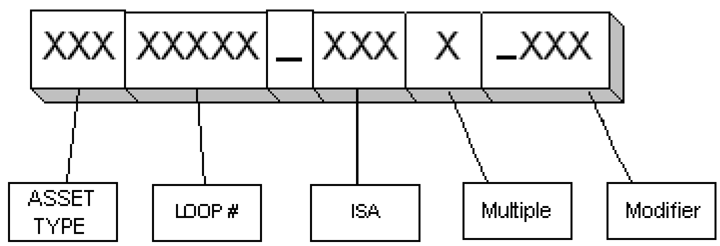


Figure 6.2.3-1 PLC Symbol Name Components and Layout

The components of the PLC symbol names are identical to the ones described in Section 6.2.1. **The prefix that contains the location and process code is omitted because of the limits allowed by the PLC.**

6.2.4 HMI Display Names

Display files shall be created as follows:

Location Code	Process Code	_	Description	_	Display type	.TYPE

Location Code and **Process Code** follow the same structure as for the Tag Names described in Section 6.2.1. For a project they will be provided by PWD.

Description is a free formatted text description of the process being displayed.

Display type is an abbreviation of the particular type of display

TYPE is either **.grf** for the standard iFIX graphic display extension, or.**PBA** for the standard PanelView display extension.

The following display types will be used:

OVR – Overview
CTRL – Control specific display, including pop-up displays
ALRM – Alarm Summary
TRND – Trend display
MISC – miscellaneous displays that do not fit any other category
PROC – general process display

Example:
POS01AR_AERATOR1_CTRL.grf

6.2.5 PLC File Names

PLC Program files shall be created as follows:

PLCID	**_**	**Date Code**	**.rss or .acd**

PLCID is PWD's standard PLC Identification code found in Section 6.6.2.

Date Code is the day the file was created or modified in the following format: MM-DD-YY.

.rss, or .acd is the standard RSLogix 500 (or 5000) PLC Ladder Logic extension.

Examples:

SH4 1-12-09.rss – EEWWTP WAS PLC version 1/12/09

HW1 1-7-09.rss – EEWWTP Step Screen PLC version 1/7/09

OA1 10-28-08.rss – SLWTF Air Compressor PLC version 10/28/08

UV1 11-15-14.acd – SLWTF UV Reactor PLC version 11/15/14

6.2.6 Loopsheet Drawing File Names

The Loopsheet files shall be created as follows:

Location Code	**_**	**PLCID**	**_**	**L**	**XXYY**	**.dwg**

Location Code follows the same structure as for the Tag Names described in Section 6.2.1. For a project they will be provided by PWD.

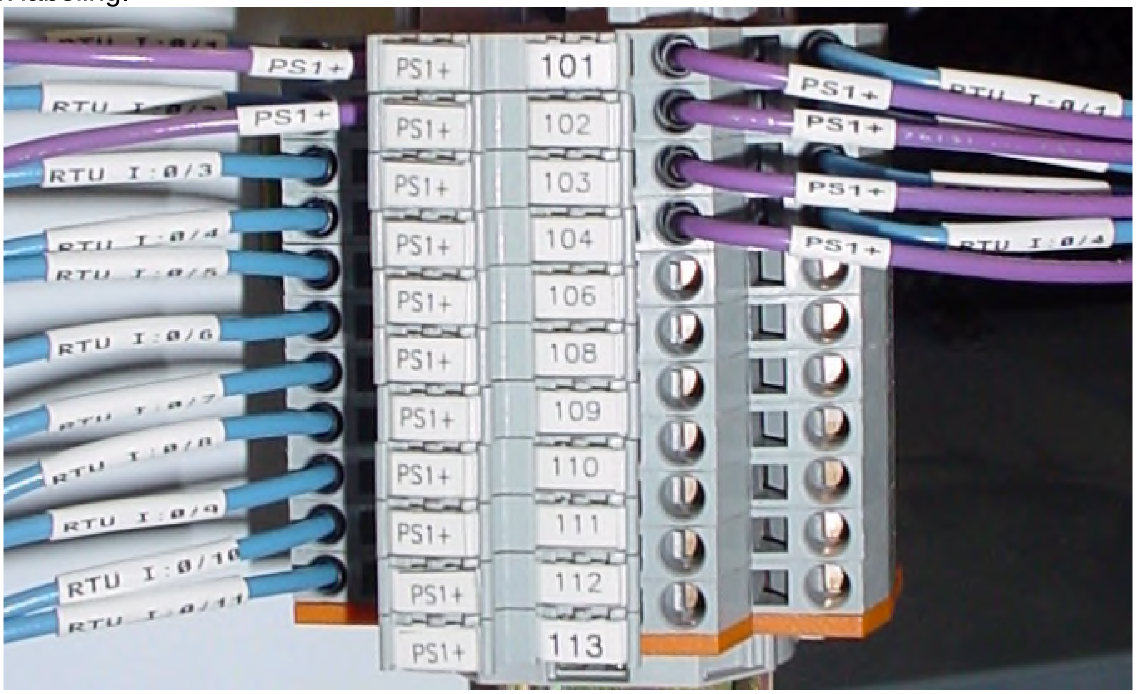
PLCID is PWD's standard PLC Identification code found in Section 6.6.2.

XX is the Process Code Number is a two digit number assigned to each process code. For example: SD=01, RW=05, and DS=10 (See Figure 6.2.1-2 for a complete list).

YY is the Loop Number that is assigned through the use of the P&IDs.

6.2.7 Terminal Block Labels

Terminal block labeling is required for all instrument panels. The labels shall correspond to the labels indicated in the loopsheets. The appropriate labels for the terminal blocks used in the panel, either WAGO WMB, WAGO WSB or equal, shall be used. Also the appropriate label carrier shall be used (i.e. WAGO 209-143) if needed. Figure 6.2.7-1 illustrates two examples of terminal block labeling.



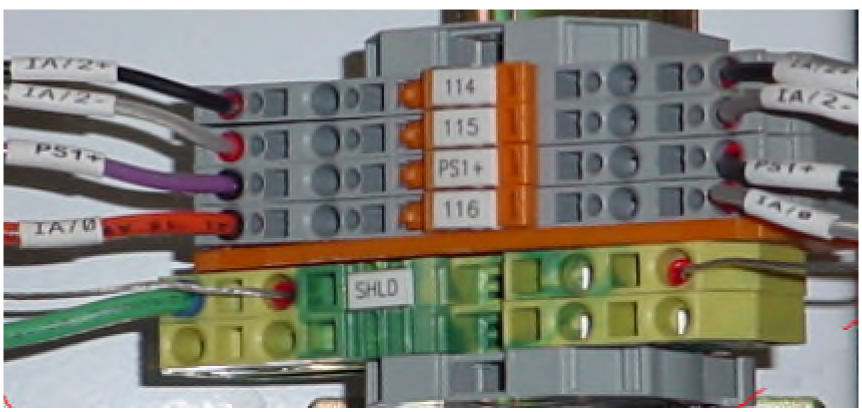


Figure 6.2.7-1 Terminal Block Labeling Examples

6.3 APPENDIX C – DOCUMENTATION STANDARDS

6.3.1 Loopsheet Drawings

The example below was extracted from the ISA standards 5.4-1991 and it represents the desired layout.

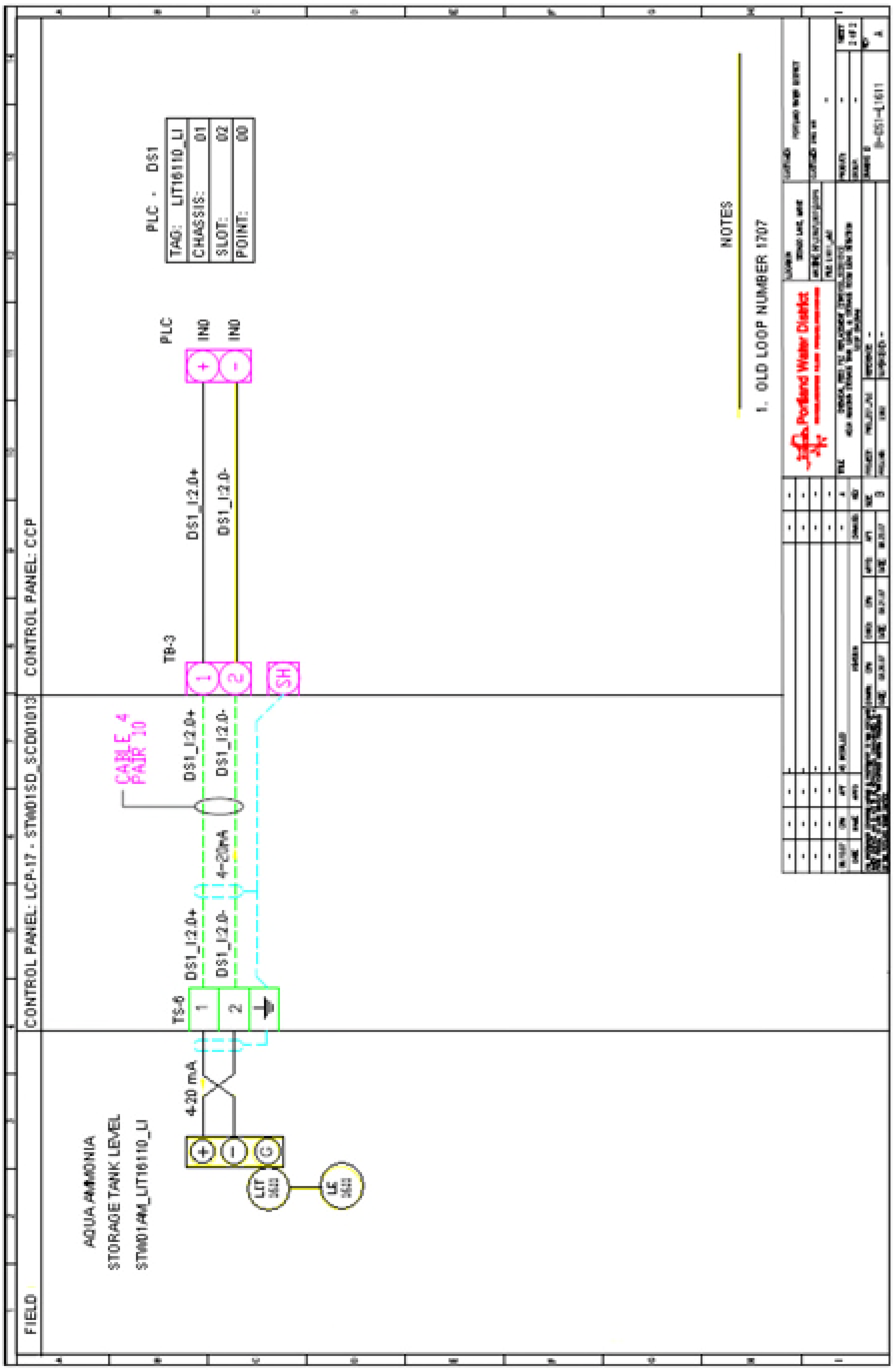


Figure 6.3.1-1 Loop Sheet Drawing Example

Loop sheets shall include, but are not limited to, the following elements:

1) Identification of the loop and loop components shown on the P&IDs. Other principal components of the loop to be shown and identified under ISA-5.1, “Instrumentation Symbols and Identification”.
2) Word description of loop functions within the title. If not adequate, use a supplemental note. Identify any special features or functions of shutdown and safety circuits.
3) Indication of the interrelation to other instrumentation loops, including overrides, interlocks, cascaded set points, shutdowns and safety circuits.
4) All point-to-point interconnections with identifying numbers or colors of electrical cables, conductors, and individual pneumatic and hydraulic tubing. This identification of interconnections includes junction boxes, terminals, bulkheads, ports, and grounding connections.
5) General location of devices such as field, panel, auxiliary equipment, rack, termination cabinet, cable spreading room, I/0 cabinet, etc.
6) Energy sources of devices, such as electrical power, air supply, and hydraulic fluid supply. Identify voltage, pressure, and other applicable requirements. For electrical sources, identify circuit or disconnect numbers.
7) Process lines and equipment sufficient to describe the process side of the loop and provide clarity of control action. Include what is being measured and what is being controlled.
8) Actions or fail-safe positions (electronic, pneumatic, or both) of control devices such as controllers, switches, control valves, solenoid valves, and transmitters (if reverse acting).These are to be identified in accordance with ISA-5.1, “Instrumentation Symbols and Identification”.
9) All wire or cable labels shall be shown on the loop sheet (see the example found in Figure 6.3.1-1).
10) General location of each device, such as area, rack or cabinet number, I/O location, etc.
11) Cross reference between loops that share a common discrete component, such as dual indicators, etc.
12) References to equipment descriptions, manufacturers, model numbers, hardware types, specifications or data sheets, purchase order numbers, etc.
13) Signal ranges and calibration information, including setpoint values for switches, and alarm and shutdown devices.
14) Engraving or legend information that helps identify the instrument or accessory.
15) Accessories, tagged or otherwise identified, such as power supplies, push buttons, selector switches, relays, signal converters, analog displays, etc.
16) References to manufacturer's documentation such as schematics, connection details, operating instructions, etc.
17) “Typical Details” **shall not** be used for loop sheets for the P&ID section of the loop sheet drawing. See Section 6.3.2 for information on the “Typical Details”.
18) Show all panel labels
19) Show all terminal blocks (both panel terminal blocks and device terminals) and the terminal block connection point labels.
20) Loop sheets shall be draw to present the clearest depiction of the wiring between the field and the final terminal points. Every effort shall be made to avoid confusing or conflicting information on the drawings.

6.3.2 P&ID Drawings

The ISA standard S5.1-1984 shall be followed. PWD will provide a template and a legend.

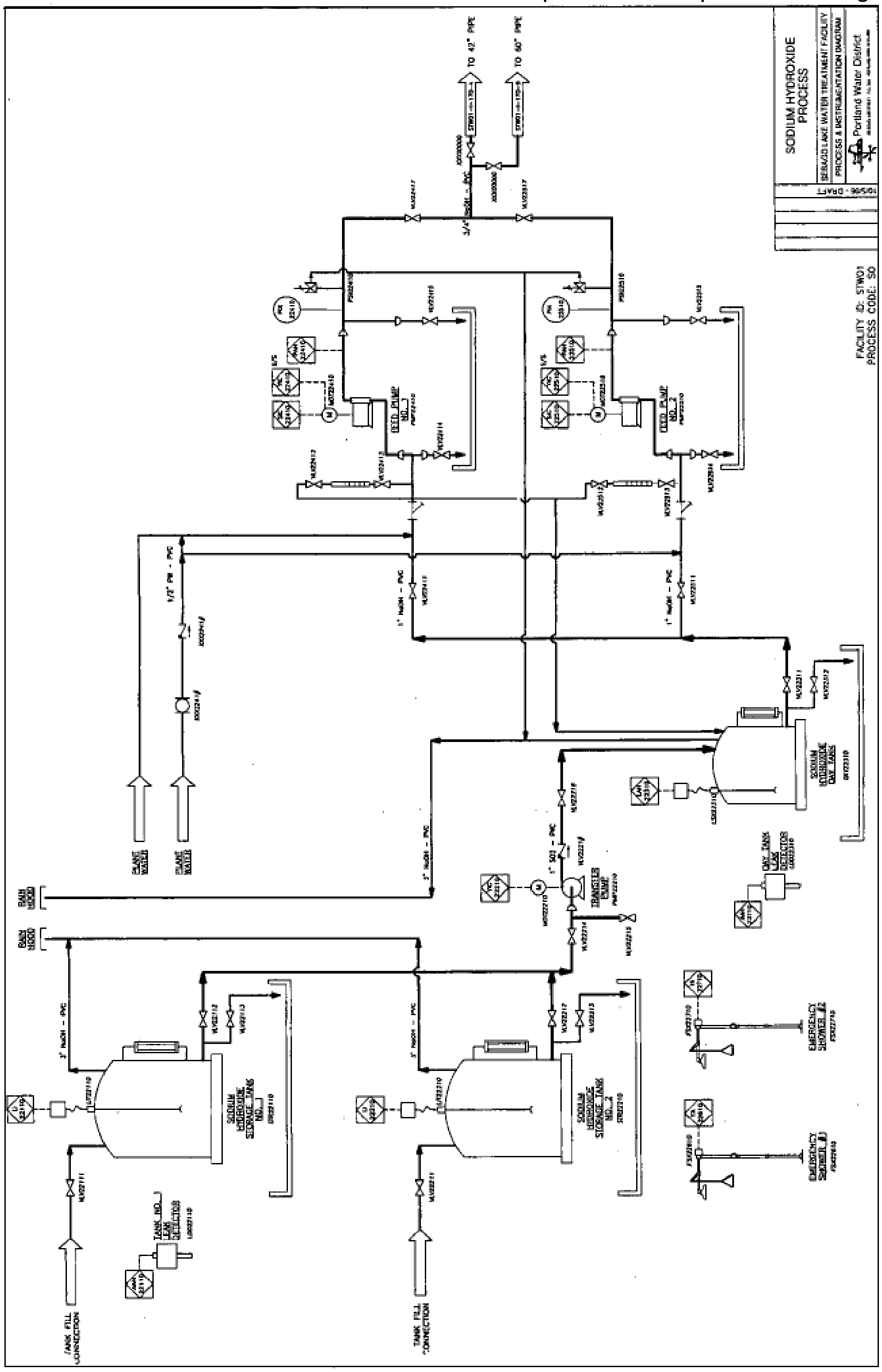


Figure 6.3.2-1 P&ID Example

As a general guideline, a good P&ID:

- Provides a visual reference to equipment configuration, valves, sensors, etc.
- Provides useful information to assist in analyzing process hazards.
- Supports development of operating procedures (and to a lesser extent, maintenance schedules and procedures).
- Communicates the configuration of equipment clearly and concisely to improve operator understanding of the process and reduce human errors.
- Records the current (as-built) state of the process so that changes can be planned safely and effectively.

A P&ID must include:

1. All process related equipment, including: tanks, pumps, compressors, presses, rotating equipment, screens, mixers, injectors, etc.
2. Essential valves, such as isolation valves and control stations, as well as all safety relief valves.
3. Controls (control valves, float switches, etc.) and solenoid valves.
4. Permanent instruments and sensors (pressure transducers, flow meters, etc.).
5. Legend to symbols and abbreviations.
6. Purge/gauge valves: not providing these details increases the time to write and verify equipment service procedures.
7. Equipment/valve numbering: equipment and especially valves should be labeled, both on the P&ID and on attached tags, to reduce the risk of operator error and simplify the writing of procedures. (Always be careful to ensure that valve tags match the P&ID!)
8. Line designations/purposes: such as electrical and process lines, have recognized systems for line designation. For others, use a system that explains the line's function.
9. Control loops: these can become confusing on some P&IDs, **but critical interlocks shall be shown using and interlock symbol (an "I" within a diamond).**
10. Flow direction: at a minimum, always show the permitted-flow direction on a check valve.
11. Line sizes/reducers; expansion tie-ins and block valves, etc.
12. Items included in other equipment: often, P&IDs show desiccant air driers packages and other complex equipment as a single symbol, even though the package includes motor, valves, tanks, and various controls/sensors. Include, at a minimum, all vessels or other "major" sub-equipment, as well as all valves connecting to the atmosphere and those separating portions of the package from one another.

Additional notes:

1. PWD uses "Typical Details" to "un-clutter" the P&ID, where typical detail for a pressure measurement device on a P&ID may intentionally omit some details which are then supplied in a general reference drawing with many other typical device installation details (see Figure 6.3.2-2 below some examples). PWD can provide a drawing showing all the "Typical Details" currently in use. "Typical Details" shall not be used for loop sheets.

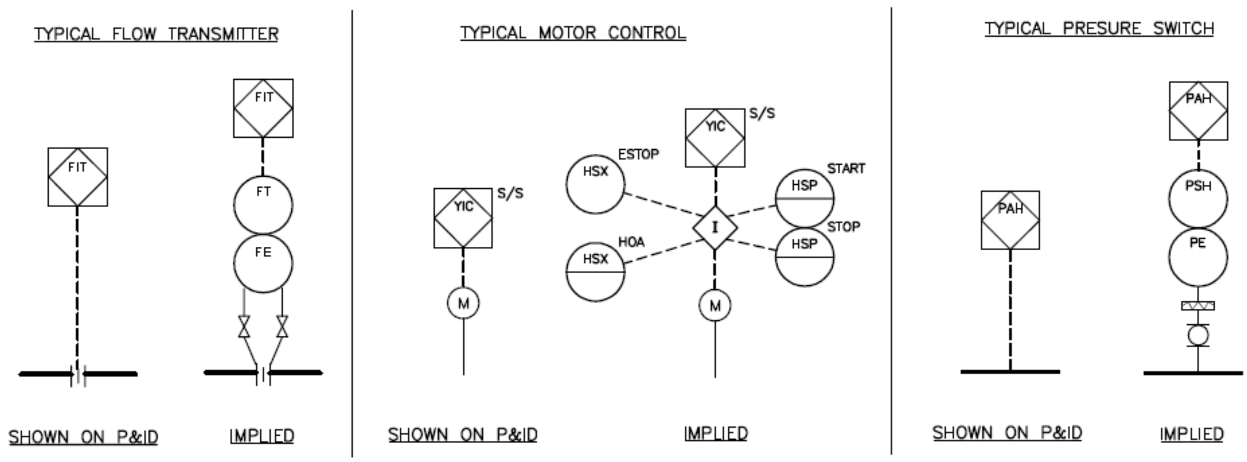


Figure 6.3.2-2 "Typical Details" Examples for P&IDs

2. Isometric-style ("3-D") drawings: these are very confusing and can obscure the key information in a P&ID – what's connected to what.
3. CAD/.dwg representations of equipment: a P&ID is intended to be a detailed schematic, not a true down-to-the-millimeter geometric representation.
4. Color: while small amounts of color are useful (e.g., color coding liquid/vapor lines), attempts to color each zone of a plant or each type of line (defrost condensate = canary yellow, while equalization lines = maize) become rapidly confusing. Color P&IDs are also difficult to copy, are vulnerable to fading when posted in the plant, and may be misread by colorblind employees.
5. Large amounts of text: it is not necessary to include complete specifications for every single piece of equipment on the P&ID. Complete specifications must, though, be available for reference. We recommend including in the P&ID sufficient information to rapidly locate specification data (which is why we recommend assigning ID numbers to equipment).

6.3.3 I/O Spreadsheet

The following procedures shall be implemented at a minimum when developing the SCADA I/O Spreadsheet:

a) The database shall be created in the newest 2010 version of Microsoft Excel.

b) The database shall be structured for quick sorting and filtering of any data field.

c) Any data field that has the same value for each point shall not be included within the database.

d) A separate tab or worksheet shall be included for statistics. The following statistics shall be included:

- Total point count
- Total point count by PLC
- PLC breakdown by point type.

e) Some of the fields below are concatenated using other fields (i.e I/O Tagname and Tagname Description). The following fields shall be included in the database:

- Tag name – I/O point name
- Point Type – AI, AO, DI., DO
- Tag name description
- Tagname subfields
- Equipment ID -
- Equipment Description
- Signal Function
- PLC
- Rack
- Slot
- Point
- I/O Register
- SCADA Register
- Reference Drawing
- Instrument Range Low
- Instrument Range High
- Instrument Units – Engineering Units of the point
- ON Text – Signal status when High
- OFF Text – Signal status when Low.
- Totalize
- Count Starts
- Rate Of Change Alarm
- Alarm LoLo
- Alarm Lo
- Alarm High
- Alarm HiHi
- Alarm Priority

- Inverted

f) The tag name shall be created / calculated through the CONCATENATION function with an individual field for each part of the tag name.

g) The equipment description shall have the site name before the signal description for consistency and sorting abilities.

h) In addition to the physical I/O for the PLC, the document shall include a listing of all other SCADA signals being sent to the SCADA system including calculated values, alarms, etc. This can be in a labelled section at the bottom of the spreadsheet, or as a separate worksheet in the excel document.

PWD has prepared a standard template file for preparation of the SCADA PLC Field I/O list. All SCADA projects shall use the standard template file. A sample is given below:

I/O Tag Name	Location	Sub-Process	Asset	Loop Number	Loop Suffix	SCADA Function	Equipment Description	Type	PLC	Rack	Slot	Point	Register	SCADA Register	Tagname Description	Signal Function	Ref. Drawing	Range Low	Range High	Units
PLC I/O RACK 1 - SLOT 0 (CPU)																				
PLC I/O RACK 1 - SLOT 1 (1746-NI8)																				
POP43SD-SCD01100-AI	POP43	SD	SCD	0110	0	AI	Utility Power Monitor	AI	POP43PS	1	1	0			Fore River Utility Power Monitor Indication	Indication		0	?	KW
POP43PR-MOT73100-AI	POP43	PR	MOT	7310	0	AI	Generator Power Monitor	AI	POP43PS	1	1	1			Fore River Generator Power Monitor Indication	Indication		0	?	KW
POP43HV-VFD72210-SI	POP43	HV	VFD	7221	0	SI	Dryside Supply Fan VFD Speed	AI	POP43PS	1	1	2			Fore River Dryside Supply Fan VFD Speed Feedback	Feedback		0	100	%
POP43HV-PIT72000-PI	POP43	HV	PIT	7200	0	PI	Dryside Differential Pressure	AI	POP43PS	1	1	3			Fore River Dryside Differential Pressure Indication	Indication		-25	25	" W.C.
POP43HV-TIT72100-TI	POP43	HV	TIT	7210	0	TI	Wet Side Temperature	AI	POP43PS	1	1	4			Fore River Wet Side Temperature Indication	Indication		0	125	Deg F

6.3.4 Memory Maps

A Memory map is a spreadsheet documenting all of the SCADA tags associated with the PLC program for remote sites. The purpose of this file is to document all tags within the program The Memory Map should include the necessary information for each SCADA tag regarding how the data is messaged back to the MTU. It should also include information about whether the points are floating, or digital, etc.

This information may change depending on the PLC's programming language, specifically between the two languages typically used by PWD which are Allen Bradley RSlogix 500 and RSlogix 5000.

For the **RSlogix 500** documents, the memory maps may include the following information:

- I/O Tagname
- Description
- Program I/O Address
- Telemetry I/O Address

	Description	Remote PLC Address	Master MSG Block Read Register	Master HMI Reg
POP46HV_TIT20000_TI	ARCADIA Building Temperature	F 28 : 6		F 53 : 6
POP46PS_LIT66110_LI	ARCADIA Wetwell Ultrasonic Level In	F 28 : 7		F 53 : 7
POP46PS_LIT66110_LI1	ARCADIA Wetwell Ultrasonic Level %	F 28 : 8		F 53 : 8
POP46PS_FIT66300_FI	ARCADIA Flow In GPM	F 28 : 9		F 53 : 9
POP46PS_FIT66300_FI1	ARCADIA Flow In MGD	F 28 : 10		F 53 : 10

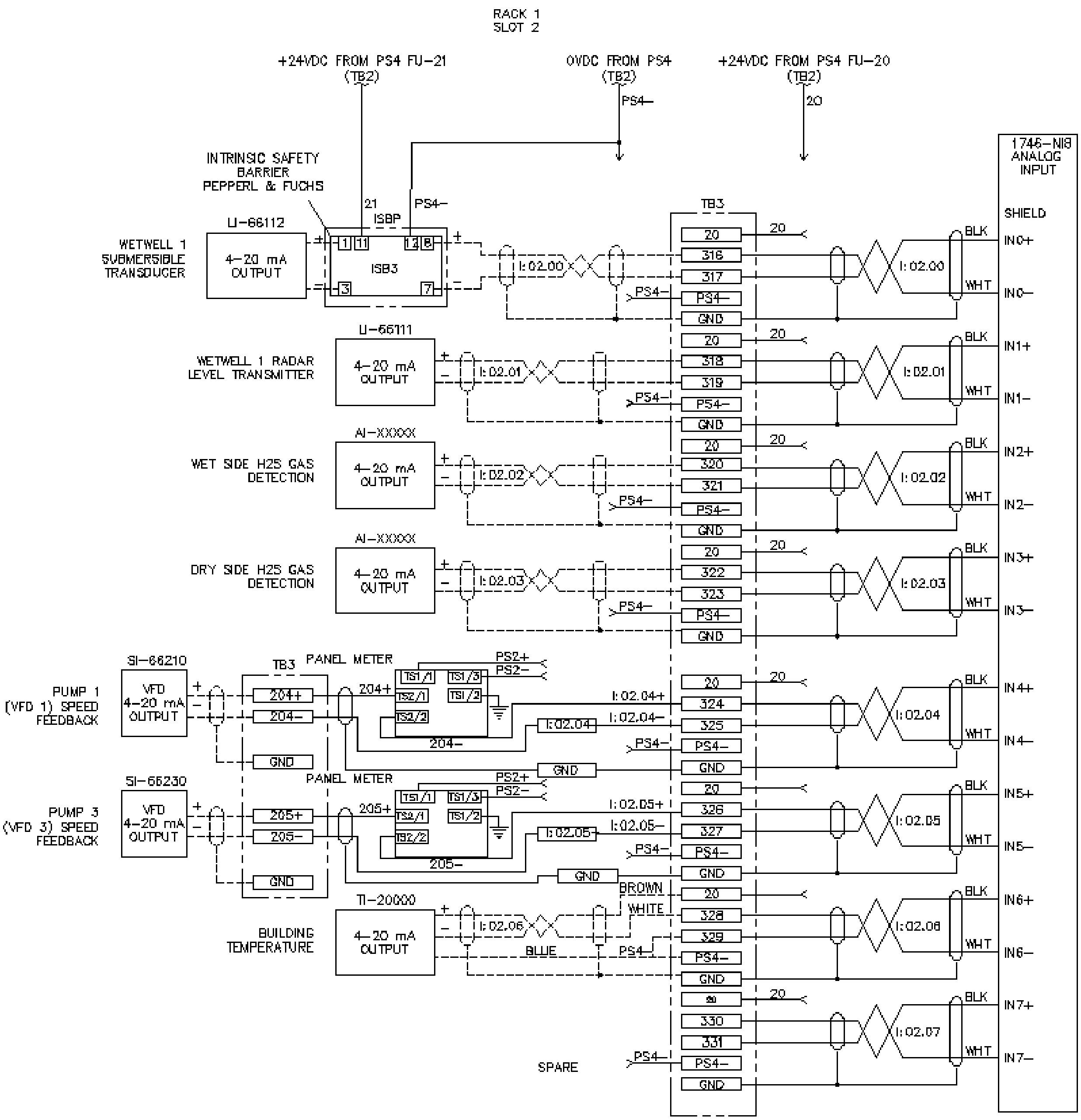
For the **RSlogix 5000** documents, the memory maps may include information related to its tag-based structure. See the example below:

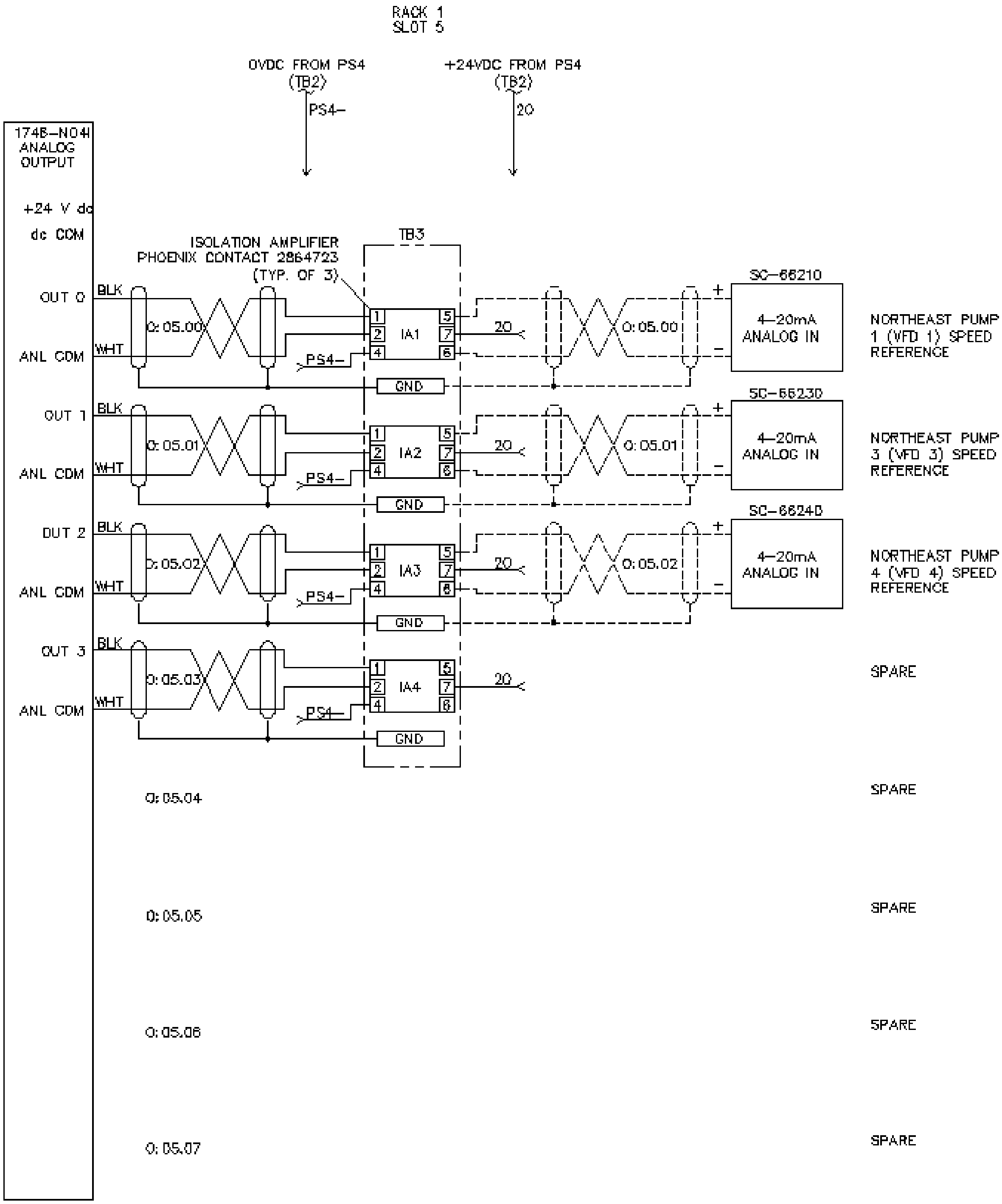
PLC Tagname	RTU Tagname Description	RTU Root Tagname	RTU PLC Address	MTU MSG Blo	iFIX Tagname	iFIX Description
WEP43PS_PMP66210_HI1	Pump 1 LOR in Remote for Telemetry	N30_0.0	F28:100.0	F65:0.0	WEP43PS_PMP66210_HI1	Dana Court Pump 1 LOR in Remote
WEP43PS_PMP66220_HI1	Pump 2 LOR in Remote for Telemetry	N30_0.1	F28:100.1	F65:0.1	WEP43PS_PMP66220_HI1	Dana Court Pump 2 LOR in Remote
WEP43PS_PMP66230_HI1	Pump 3 LOR in Remote for Telemetry	N30_0.2	F28:100.2	F65:0.2	WEP43PS_PMP66230_HI1	Dana Court Pump 3 LOR in Remote
WEP43PS_PMP66240_HI1	Pump 4 LOR in Remote for Telemetry	N30_0.3	F28:100.3	F65:0.3	WEP43PS_PMP66240_HI1	Dana Court Pump 4 LOR in Remote
WEP43PS_PMP66210_HI2	Pump 1 LOR in Local for Telemetry	N30_0.4	F28:100.4	F65:0.4	WEP43PS_PMP66210_HI2	Dana Court Pump 1 LOR in Local
WEP43PS_PMP66220_HI2	Pump 2 LOR in Local for Telemetry	N30_0.5	F28:100.5	F65:0.5	WEP43PS_PMP66220_HI2	Dana Court Pump 2 LOR in Local
WEP43PS_PMP66230_HI2	Pump 3 LOR in Local for Telemetry	N30_0.6	F28:100.6	F65:0.6	WEP43PS_PMP66230_HI2	Dana Court Pump 3 LOR in Local

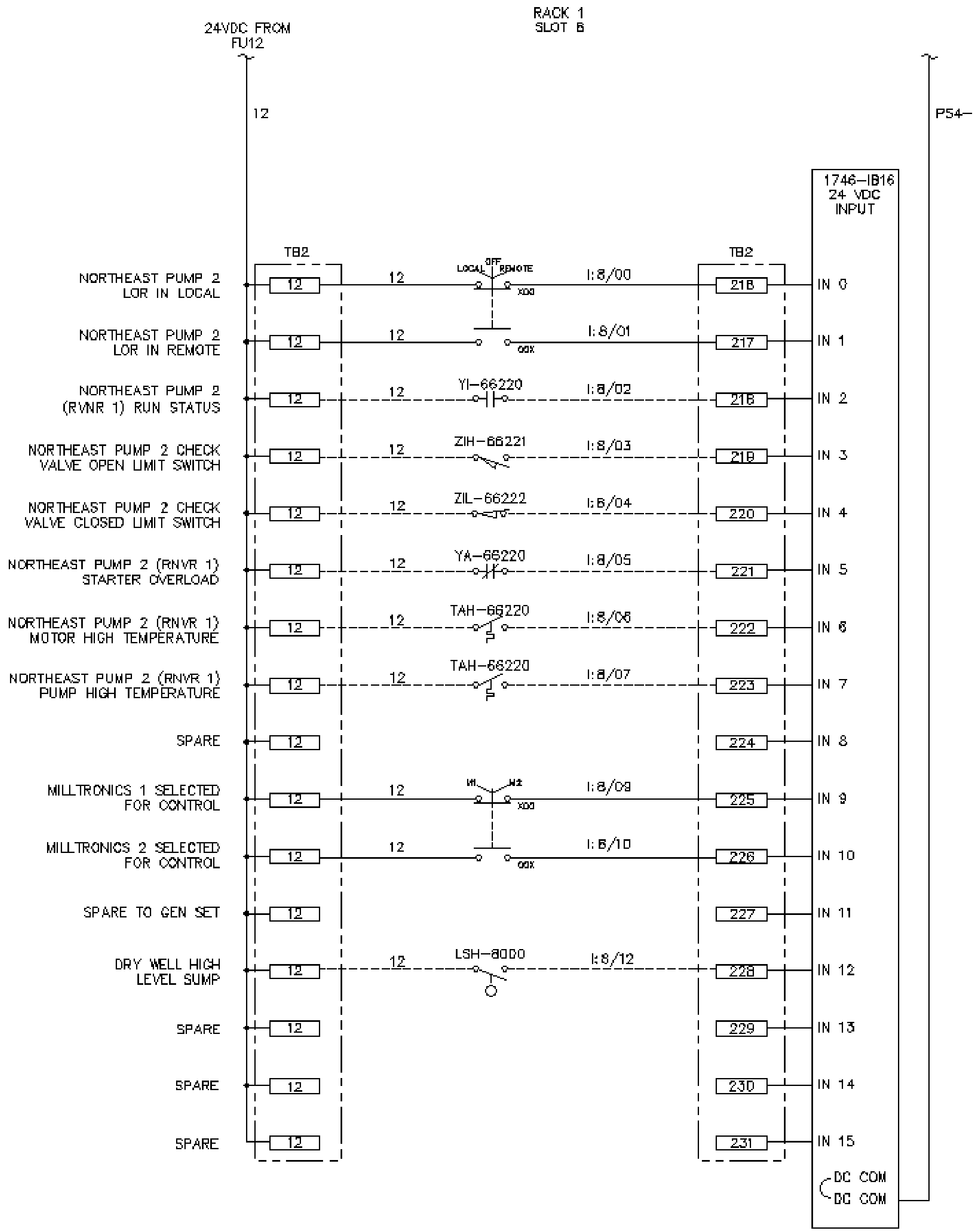
6.3.5 Interconnect Drawings (or Panel Schematics)

This drawing is sometimes referred as the Panel Schematic Drawing. There is usually one Interconnect Drawing sheet per PLC I/O. Each I/O card depicted in the drawings shall accurately depict the terminal marking of the actual card (i.e. an analog input card should look like an analog input card, a discrete output card should look like a discrete output card, etc.).

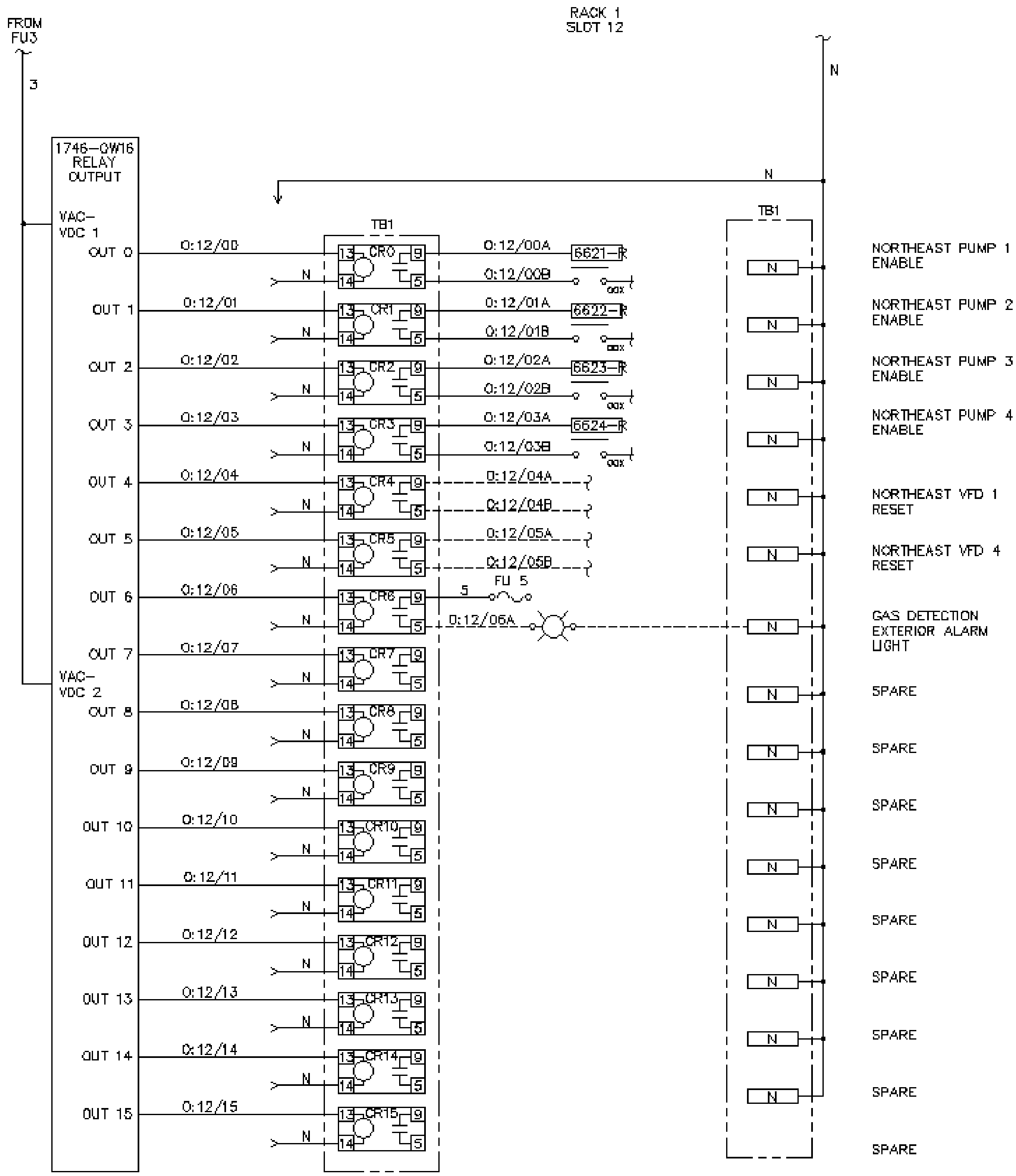
Below are examples of an Interconnect Drawings for analog inputs, analog outputs, discrete inputs and discrete outputs:


RACK 1
SLOT 2
+24VDC FROM PS4 FU-21 (TB2)
0VDC FROM PS4 (TB2)
+24VDC FROM PS4 FU-20 (TB2)
1746-NI8 ANALOG INPUT
INTRINSIC SAFETY BARRIER PEPPERL & FUCHS
LI-66112
WETWELL 1 SUBMERSIBLE TRANSDUCER
4-20 mA OUTPUT
ISBP
ISB3
TB3
SHIELD
LI-66111
WETWELL 1 RADAR LEVEL TRANSMITTER
AI-XXXXX
WET SIDE H2S GAS DETECTION
DRY SIDE H2S GAS DETECTION
SI-66210
PUMP 1 (VFD 1) SPEED FEEDBACK
VFD 4-20 mA OUTPUT
PANEL METER
SI-66230
PUMP 3 (VFD 3) SPEED FEEDBACK
TI-20000
BUILDING TEMPERATURE
SPARE
BROWN
WHITE
BLUE
IN0+
IN0-
IN1+
IN1-
IN2+
IN2-
IN3+
IN3-
IN4+
IN4-
IN5+
IN5-
IN6+
IN6-
IN7+
IN7-


RACK 1
SLOT 5
0VDC FROM PS4
(TB2)
PS4−
+24VDC FROM PS4
(TB2)
20
1746−NO4I
ANALOG
OUTPUT
+24 V dc
dc COM
OUT 0
ANL COM
OUT 1
ANL COM
OUT 2
ANL COM
OUT 3
ANL COM
BLK
WHT
ISOLATION AMPLIFIER
PHOENIX CONTACT 2864723
(TYP. OF 3)
TB3
IA1
IA2
IA3
IA4
GND
PS4−
20
O:05.00
O:05.01
O:05.02
O:05.03
O:05.04
O:05.05
O:05.06
O:05.07
SC−66210
SC−66230
SC−66240
4−20mA
ANALOG IN
NORTHEAST PUMP
1 (VFD 1) SPEED
REFERENCE
NORTHEAST PUMP
3 (VFD 3) SPEED
REFERENCE
NORTHEAST PUMP
4 (VFD 4) SPEED
REFERENCE
SPARE



RACK 1
SLOT 8
24VDC FROM
FU12
12
P54–
1746–IB16
24 VDC
INPUT
TB2
TB2
NORTHEAST PUMP 2
LOR IN LOCAL
LOCAL
OFF
REMOTE
I:8/00
218
IN 0
NORTHEAST PUMP 2
LOR IN REMOTE
I:8/01
217
IN 1
NORTHEAST PUMP 2
(RVNR 1) RUN STATUS
YI–66220
I:8/02
218
IN 2
NORTHEAST PUMP 2 CHECK
VALVE OPEN LIMIT SWITCH
ZIH–66221
I:8/03
219
IN 3
NORTHEAST PUMP 2 CHECK
VALVE CLOSED LIMIT SWITCH
ZIL–66222
I:8/04
220
IN 4
NORTHEAST PUMP 2 (RNVR 1)
STARTER OVERLOAD
YA–66220
I:8/05
221
IN 5
NORTHEAST PUMP 2 (RNVR 1)
MOTOR HIGH TEMPERATURE
TAH–66220
I:8/06
222
IN 6
NORTHEAST PUMP 2 (RNVR 1)
PUMP HIGH TEMPERATURE
TAH–66220
I:8/07
223
IN 7
SPARE
224
IN 8
MILLTRONICS 1 SELECTED
FOR CONTROL
I:8/09
225
IN 9
MILLTRONICS 2 SELECTED
FOR CONTROL
I:8/10
226
IN 10
SPARE TO GEN SET
227
IN 11
DRY WELL HIGH
LEVEL SUMP
LSH–8000
I:8/12
228
IN 12
SPARE
229
IN 13
SPARE
230
IN 14
SPARE
231
IN 15
DC COM
DC COM


FROM FU3
3
RACK 1 SLOT 12
N
1746–OW16 RELAY OUTPUT
VAC– VDC 1
VAC– VDC 2
TB1
OUT 0
O:12/00
CR0
O:12/00A
6621–R
O:12/00B
OUT 1
O:12/01
CR1
O:12/01A
6622–R
O:12/01B
OUT 2
O:12/02
CR2
O:12/02A
6623–R
O:12/02B
OUT 3
O:12/03
CR3
O:12/03A
6624–R
O:12/03B
OUT 4
O:12/04
CR4
O:12/04A
O:12/04B
OUT 5
O:12/05
CR5
O:12/05A
O:12/05B
OUT 6
O:12/06
CR6
5
FU 5
O:12/06A
OUT 7
O:12/07
CR7
OUT 8
O:12/08
CR8
OUT 9
O:12/09
CR9
OUT 10
O:12/10
CR10
OUT 11
O:12/11
CR11
OUT 12
O:12/12
CR12
OUT 13
O:12/13
CR13
OUT 14
O:12/14
CR14
OUT 15
O:12/15
CR15
NORTHEAST PUMP 1 ENABLE
NORTHEAST PUMP 2 ENABLE
NORTHEAST PUMP 3 ENABLE
NORTHEAST PUMP 4 ENABLE
NORTHEAST VFD 1 RESET
NORTHEAST VFD 4 RESET
GAS DETECTION EXTERIOR ALARM LIGHT
SPARE
SPARE
SPARE
SPARE
SPARE
SPARE
SPARE
SPARE
SPARE

6.4 APPENDIX D – STANDARD COMPONENTS

6.4.1 Standard PLC Panel Components

Description	Part Number	Comments
CPU for most applications	5069-L330ER	Controller, CompactLogix 5380, 3 MB User Memory, 31 I/Os, 60 EtherNet/IP Devices
Secure Digital Card	1784-SDHC8	8GB High Capacity SD Card
Power Supply		AC Power Supply for Expansion Modules & CPU
Analog Input	5069-IF8	8 Channel, VDC, 4-20 mA
Analog Output	5069-OF8	8 Channel, VDC, 4-20 mA
Discrete Input	5069-IB16	16 Channel, 24 VDC
Discrete Output	5069-OB16	16 Channel, 24 VDC - Signal sent directly to an interposing relay which will transfer the signal to the field device wiring
Right End Cap	5069-ECR	
Left End Cap	5069-ECL	
PLC DIN Rail	2010-112	WAGO DIN Rail (needs to heavy duty to prevent the PLC cards from sagging it down)
I/O		Choose the Appropriate IMF Modules with the Fusible and LED Indicator options
CPU for smaller applications	1766-l32AWA	MicroLogix 1400 with 20 DI and 12 DO
Analog Input for the 1400	1762-IF4	
Analog Output for the 1400	1762-OF4	

Table 6.4.1-1 Standard Allen-Bradley PLC Related Components

Description	Model or Part Number	Manufacturer
OIT - 10” PanelView, touch screen, color, w/ Ethernet communications, AC Powered	See PWD for latest part number	Allen-Bradley
External Memory Card 2 GB SD Card	1784-SDHC8	Allen-Bradley
General Purpose Relay, SPDT, 16 Amps, Pilot Light, 120 VAC	700-HK36A1	Allen-Bradley
DIN Rail Mount Socket for above relay	700-HN121	Allen-Bradley
Uninterruptible Power Supply, 1000 VA	See PWD for latest part number	APC
Power Supplies for the I/O: 0.6A, 24 VDC (for I/O)	S82K-01524	Omron (or equal)
Surge Arrester for the Panel Power, 120V AC	DTK 120/240 CM	DITEK (or equal)
PLC & SCADA PC Network Managed Ethernet Switch	See PWD for the latest Model Numbers	N-Tron

Table 6.4.1-2 Standard Panel Related Components

Application	WAGO terminal	WAGO end/sep (orange)	WAGO stops	Color
Analog Input	280-874	280-373	249-116	Grey
Analog Output	280-874	280-373	249-116	Grey
Discrete Input	281-619	281-341	249-116	Grey
Discrete Output	281-619	281-341	249-116	Grey
Line AC Power	281-629	281-341	249-116	Blue
24 VDC Power	281-663	281-335	249-116	Red
DC Common	281-664	281-335	249-116	Black
System Ground	281-657	281-335	249-116	Yellow-green
Intrinsic Safe Analogs	281-695	209-191	249-116	Light grey
Intrinsic Safe Discretes	281-695	209-191	249-116	Light grey
Intrinsic Safe System Ground	281-657	281-335	249-116	Yellow-green

Table 6.4.1-4 Wago Terminal Part Numbers

The appropriate Wago ferrule for a specific wire size is listed below:

Application	WAGO #	Color
12 AWG	216-207	Grey
14 AWG	216-205	Yellow
16 AWG	216-204	Black
18 AWG	216-203	Red
20 AWG	216-202	Grey
22 AWG	216-201	White
14 AWG For PLC Terminations	216-106	
16 AWG For PLC Terminations	216-124	
18 AWG For PLC Terminations	216-123	
20 AWG For PLC Terminations	216-122	
22 AWG For PLC Terminations	216-121	

Table 6.4.1-5 Wago ferrules

All wiring terminating on Wago terminal strips shall be fitted with ferrules by using the appropriate crimping tool, Wago part number 206-204 (for 24-12 AWG) or 206-216 (for 10-6 AWG).

Figure 6.4.1 –1 Wago Grounding Terminal Block, Part Number 281-657

6.4.2 RTU Telemetry Panel Bill of Materials

The table below lists the components to the telemetry panel for a “generic” wastewater pump station. This parts list is not applicable to any type of RTU beyond the generic or typical wastewater pump station (i.e water booster pump station, major wastewater interceptor pump stations, telemetry repeater site, etc.). Any application beyond the generic pump station will need a unique design to meet the unique requirements of that site.

See PWD for the latest revision of this list.

6.4.3 Standard Instruments and Components

PWD does have a list of preferred instrument related components used in the SCADA System and the specifications for them will be provided upon request.

All pressure and differential pressure transmitters shall provide a means of field verification. This is typically done by installing an integral manifold unit. The unit provides a means of isolating the transmitter from the process while allowing the connection of a field pressure source and calibration gauge. It also provides a means of venting the diaphragm.

6.5 APPENDIX E – FAT/SAT DOCUMENTS

This section provides examples of documents related the Factory Acceptance Test (FAT) and Site Acceptance Test (SAT). The details of these tests are provided in Section 2.7.

6.5.1 FAT Criteria Document Example

Peaks Island WWTP Controls Upgrade Project
Factory Acceptance Test

TEST PLAN

FAT IO CHECKOUT PHASE

The first phase of the FAT is the IO Checkout. This test though is substantially more than just a check of the physical IO and is more of an IO based checkout, testing all parts of the software that are based upon specific IO points. During this phase of the checkout, all IO points, whether used or not, will be injected into the IO terminals. We will be checking that these signals are properly received in the PLC, and for those points which are used, all the associated alarming and logic associated with those alarms, trending, statistics and indication is correct on both the OIT and the HMI as appropriate. An FAT IO Checkout Spreadsheet will be used to document the testing which is an extension of the IO List developed for the project.

Analog Input (AI) Test Procedure

The AI Checkout test is the most involved test procedure of all of the IO checkouts.

- AI-1. Inject a 12mA signal into the input.
- AI-2. Verify that both HMI and OIT see an indication that is 50% of the Engineering unit range as specified in the IO List and check off on the Checkout spreadsheet.
- AI-3. Verify at the PLC programming software that the HMI system can adjust and set the alarm deadband and each of the 4 alarm limits (LL, L, H, HH). Check off on checkout spreadsheet.
- AI-4. If this signal is outside of the normal operation range (i.e. the signal is either causing a High or Low Alarm), adjust the signal to not be in alarm. Verify that both OIT and HMI show the signal as not being in alarm.
- AI-5. Increase the signal to a point between the H and the HH alarm limits. Verify that a High Alarm occurs at both the OIT and HMI. If this alarm can be disabled, verify that the HMI can disable the alarm. Check off on checkout spreadsheet. Indicate Horn Priority in the Horn column of spreadsheet.
- AI-6. Increase the signal to a point above the HH alarm limit. Verify that a HH alarm occurs at both the OIT and HMI. Verify that a High Alarm occurs at both the OIT and HMI. Check off on checkout spreadsheet. If this alarm can be

disabled, verify that the HMI can disable the alarm. Check off on checkout spreadsheet.

- AI-7. Increase the signal to 20mA. Verify a proper full range indication at both OIT and HMI. Check off on checkout spreadsheet.
- AI-8. Increase the signal to approximately 20.8mA (105% of full range). This should show an above full range indication at both OIT and HMI (it will actually be somewhere around 103.5% of full range as the IO card caps off at that point). Verify that a Bad Signal alarm occurs at both OIT and HMI and that a Priority 2 alarm horn is indicated at DS1. Check off on checkout spreadsheet.
- AI-9. Bring the 4-20mA signal back down to a normal operating range. Verify that the OIT can reset any level 2 or 1 alarms and that the indication returns to a white or normal state. Check off the Reset column for the OIT. AI-10. Bring the 4-20mA signal down to below the L alarm limit. Verify that a High Alarm occurs at both the OIT and HMI. Verify the proper horn priority output at the DS1 PLC rack. Check off on checkout spreadsheet. If this alarm can be disabled, verify that the HMI can disable the alarm. Check off on checkout spreadsheet.
- AI-11. Bring the 4-20mA signal down to below the LL alarm limit. Verify that a High Alarm occurs at both the OIT and HMI. Verify the proper horn priority output at the DS1 PLC rack. Check off on checkout spreadsheet. If this alarm can be disabled, verify that the HMI can disable the alarm. Check off on checkout spreadsheet.
- AI-12. Bring the 4-20mA signal down to 4 mA. Verify a proper full range indication at both OIT and HMI. Check off on checkout spreadsheet.
- AI-13. Bring the 4-20mA signal down to 3.2mA (-5% of full range). This should still give azero reading at the OIT and HMI. Verify that a Bad Signal alarm occurs at both OIT and HMI and that a Priority 2 alarm horn is indicated at DS1. Check off on checkout spreadsheet.
- AI-14. Bring the 4-20mA signal back to a normal operating value. Verify that the HMI can reset any priority 1 or 2 alarms and that the value returns to a normal or white state.
- AI-15. During the course of generating these alarms, the OIT and HMI will alternately be used to acknowledge the alarms. In each case, the horn shall be shut off. In the case of the HMI, an acknowledge will also acknowledge the OIT alarm handler and close the alarm pop-up. The OIT acknowledge does not acknowledge the HMI. Check off on checkout spreadsheet.
- AI-16. If this analog value is being totalized, verify proper totalizing in the PLC and if included on OIT or HMI screens, that they are properly indicated. If there are resets provided on the screens, they will be exercised and proved that the total is reset.
- AI-17. If the IO list indicates the value is being trended, the HMI trends will be verified to show the proper trend.
- AI-18. At this point, the analog signal will be removed. Both OIT and HMI should indicate the last known good value. Verify that a Bad Signal alarm occurs at both OIT and HMI and that a Priority 2 alarm horn is indicated at DS1. Check off on checkout spreadsheet.

Notes:

Any of the functions above that are not used (as indicated on the IO List), these columns in the checkout list will be greyed out. Also, if the AI is a spare point, it will be exercised from 4 to 20mA and verified that the PLC receives in its input image table the proper raw value. This will be indicated in the OIT column for 0%, 50%, 100% even though it never shows up on either the OIT or HMI.

For some Analog Input points, in order for alarms to occur, certain pieces of equipment must be in certain states. Forces within the PLC will be used to simulate that these pieces of equipment are in those states.

Analog Output (AO) Test Procedure

- AO-1. A multi-meter is connected to the specified AO point to verify proper 4-20mA operation of the output.
- AO-2. If the point is not a spare, there is most likely a device control pop-up associated with that output such that if the piece of equipment is put into manual, the user may enter directly the desired output. Alternating between the HMI and the OIT, command the output to 0%, 50%, 100%, 50%, and finally 0% outputs. Check off on checkout spreadsheet that the output behaves properly at each level, and that both the OIT and the HMI can control the output if appropriate.
- AO-3. If the point is a spare, the commanded output can be entered into the SCP instruction in the PLC programming software.

Discrete Input (DI) Test Procedure

- DI-1. A jumper will be used in this test to connect V+ to each DI point.
- DI-2. If shown on an HMI and/or OIT screen, verify a proper change of state of the DI point. This may be indication of the input itself, or an indication of an associated DI alarm. Check off on checkout spreadsheet that the proper state changes occurred (if the proper state change occurs on both HMI and OIT, it is also proved that the change occurs at the PLC level.
- DI-3. If there is a defined DI alarm associated with the point, verify the proper alarming in both the OIT and HMI alarm handlers. Verify also that the proper horn priority is indicated at DS1. Check off on checkout spreadsheet.
- DI-4. Verify also that both HMI and OIT can acknowledge the alarm, and reset where appropriate. Check off on checkout spreadsheet.
- DI-5. If the alarm can be disabled, verify that the HMI can disable the alarm. Check off on checkout spreadsheet.
- DI-6. If there is a Run Time accumulator associated with the DI, verify in the PLC that the accumulator is timing. Verify that both the OIT and HMI are indicating the proper value. By adjusting the runtime accumulator timer, the value may be forced to change (i.e. 2.3 hours to 2.4 hours). Verify that both the OIT and HMI

see the change. Verify that the HMI can also reset the accumulator (if provided). Check off on checkout spreadsheet.

- DI-7. If there is a Start Counter associated with the DI, verify that each time the signal is injected, the start counter increases at both the OIT and the HMI. Verify that the HMI can reset the counter (if provided). Check off on checkout spreadsheet.

NOTE: If the point is a spare DI point, it is verified in the Image table of the PLC to change state and checked off on the PLC column of the checkout spreadsheet.

Discrete Output (DO) Test Procedure

- DO-1. A multi-meter is used in this test to detect a closed circuit on each DO point when energized at the IO terminal.
- DO-2. Using the Force feature of the SLC, force each DO point on one at a time and verify with multimeter that the output turns on. Check off on checkout spreadsheet.
- DO-3. If associated with a device control screen, energize the output also from both the OIT and the HMI. (Some interlocks may need to be forced – at this point we are not verifying interlock operation). Check off on checkout spreadsheet.
- DO-4. If there is an associated “Fail To” alarm, verify that this alarm occurs at both the HMI and OIT and has a proper Horn Priority at DS1. Verify that both HMI and OIT can acknowledge and reset as appropriate. Check off on checkout spreadsheet.

This concludes the IO based FAT checkout.

FAT FUNCTIONAL CHECKOUT PHASE

The second phase is the Functional checkout and will involve both a simulation program as well as simulator screens running on a computer in the staging area that will allow a person to turn on individual input tags in the PLC or set analog input values without having to inject them through the hardware. At this stage of the testing, the functional Control Program and Control Strategy write-ups will be hi-lited to indicate proper operation of each function listed as they are tested. Additionally, the Device Control Checkout spreadsheet will be used to verify proper operation of each Device Control routine.

Device Control Routine Test Procedure

Each piece of equipment in the system has an associated device control screen/pop-up on HMI and OIT as well as an associated PLC routine. The purpose of this test is to verify proper operation of each Device Control Routine. This test does not check for any automatic control of the device other than that the device is controllable from the

Automatic routine. At this point in the testing process, the physical IO has been tested and proved. Simulator software in each PLC will be used to conduct test.

- DC-1. Verify that the IO cards have been disabled and that the simulator program in the PLC is operational.
- DC-2. Verify that all device interlocks are in the OK to operate position using the simulator screens.
- DC-3. With the device Remote input in the off state (indicating not in Remote), verify that the device is not operatable from the OIT or HMI device control screen. Verify that the proper Remote/Not in Remote indication is shown on both the overview screen and the device control screen on both the OIT and the HMI. Check off on checkout spreadsheet.
- DC-4. Place the device into Remote through the simulator screens.
- DC-5. Verify that in Remote Manual, the device may be started/stopped, open/closed. Verify a proper indication of Manual indication as well as device status (Run/Stop, Open/Close etc) on both the overview and device control screens of the OIT and HMI stations. Check off on checkout spreadsheet.
- DC-6. If there is an analog command associated with the device, verify the Remote-Manual analog operation of the device as well as feedback. Check off on checkout spreadsheet.
- DC-7. Verify that each device interlock will shut off the device or prohibit its operation. Where such interlocks originate from other PLC's, they will be triggered in the originating machine to verify proper peer-to-peer communication. Check off on checkout spreadsheet.
- DC-8. Verify that device specific faults are properly indicated on the device control pop-up and that the device will show yellow.
- DC-9. Verify that the device may be placed in Remote Automatic (if appropriate) and that there is proper indication of Automatic on both the overview and device control screens of both the HMI and OIT.

Automatic Analog Control – PID control Test Procedure

- PID-1 If a manual PID operation is provided (separate from the Device Control Pop-up control), it will be verified that this manual command may be entered in both the
- OIT and the HMI.
- PID-2 When placed into Automatic, it will be verified that the PID output will start controlling from the previously entered manual command (i.e. bumpless transfer).
- PID-3 When in Automatic, a setpoint will be entered at both the OIT and the HMI.
- PID-4 Proper operation of the PID control will be verified in automatic, i.e. proper direction of the output based upon the PV and SP.
- PID-5 Tuning Parameters – Tuning parameters for use in this simulated FAT will be used. As part of Transition Acceptance Test, actual control tuning parameters will be entered. These tuning parameters will require input from PWD in the choice of initial parameters and follow-on tuning at transition time.

FAT Testing Summary and signoff

1. Complete IO Checkout
....
2. Complete Device Control Checkout
....
3. Complete Remote Automatic Analog Control – PID Check
....
4. Verify proper Control Program performance. ....
5. Verify proper Power Fail and Power Restart operation per Control Program.
....
6. Verify proper operation of CP specific alarms.
....
7. Verify proper download of program to both PLC and OIT
....
8. Verify Proper Communication Loss Annunciation
....

Notes:
Tests Completed on:____________________ Signatures: ____________________

Time Synchronization

The clock in the PLCs shall be synchronized via telemetry at least once a day to the real-time clock in the primary SCADA System Server. …….………__________
The clock in the PanelView shall be synchronized at least once a day to the PLC clock. …….………__________

Process Graphic Functional Tests

Process Graphic displays for the OIT and the HMI will be printed out and serve as the record documents for the FAT animation testing. The test will verify all features and functions of the graphic displays provided by the Owner have been integrated with the system database and the PLCs.

<u>Each screen will reference the test used to drive the animation. The IO test number or the Device Control test number or the Automatic Control test number will be referenced near the animated item and the screen will be signed off and dated.</u>

6.5.2 FAT Check List Example

PWD staff will run though the FAT Check List looking for compliance of the panel related items to the SCADA Standards.

Panel____________________ Date of FAT___________________

Wires:

- ☐ Proper wire colors
- ☐ Ferrules used
- ☐ Neat and orderly arrangement and proper installation
- ☐ Data cable properly routed
- ☐ No wire nuts
- ☐ Conduits covered
- ☐ Correct insulation type
- ☐ Terminal block correct type and color

Wire Labels:

- ☐ Proper format used
- ☐ Labels facing out
- ☐ Labels on both ends of wires
- ☐ Heat shrunk, not loose

Fans and Blowers:

- ☐ Properly installed
- ☐ Unobstructed airflow

Hardware Labeling:

- ☐ Labeling matches interconnect drawings
- ☐ Terminal blocks labeled
- ☐ Power supplies labeled
- ☐ Control relays labeled
- ☐ Fuses labeled
- ☐ Automatic Transfer Relay (ATR) labeled
- ☐ Circuit breakers labeled
- ☐ Electrical receptacles labeled (one for UPS and one (GFI) for programming)

Enclosure:

- ☐ Door open/close/latch properly
- ☐ Paint condition good
- ☐ Engraved labels for controls and bar graph displays
- ☐ Large engraved PLC/Site name label
- ☐ Laptop shelf opens/closes smoothly
- ☐ Panel information sheet on inside of door (includes fabricator information, project name, electrical information, and fuse sizes as a minimum)

Asset Information:

- ☐ PLC CPU serial #
- ☐ PanelView serial #
- ☐ Radio serial #
- ☐ Confirm BOM matches panel components
- ☐ Confirm panel layout matches drawings

6.5.3 SAT Check List Example

PWD staff will run though the SAT Check List looking for compliance of the field related items to the SCADA Standards.

PLC Panel Inspection Checklist for Site Acceptance Test (SAT)

Panel____________________ Date of SAT____________________

Wires:

- ☐ Separate conduit for analog, discrete, and power
- ☐ Power cable properly routed
- ☐ Proper field wire colors used

Field Wire Labels:

- ☐ Proper format used
- ☐ Labels facing out
- ☐ Labels on both ends of wires
- ☐ Heat shrunk, not loose

Hardware Labeling:

- ☐ Communication cables labeled

Enclosure:

- ☐ Door open/close/latch properly
- ☐ Paint condition good
- ☐ Arc flash label with rating in place
- ☐ No damage to panel due to transport or Installation

Misc:

- ☐ O&M manuals provided at site

6.6 APPENDIX F – PLC CODE STANDARDS

6.6.1 General Guidelines

The following guidelines shall be applied to any new PLC installed at a PWD facility. Additional guidelines are found in Section 5.3.4.

The standards from previous revisions were based on the SLC 500 series of PLCs. Future projects at PWD will be using the CompactLogix PLCs. The standards have not fully been established yet, but some basic elements are in place.

What is in place, and is continued from the SLC 500 PLCs, are the basic structure elements PWD is looking for in the PLC Code:

- Program Structure
- Routine and ladder Rung Comments
- Standard Code – This is now supported by PWD add-on Instructions in the CompactLogix. Please contact PWD for the latest library.

PWD uses an integer point to represent related discrete events centered a round an asset. For example, a motor status relater to a pump asset would have a status integer point value translation table:

Motor LOR Status Point

Value	Meaning
0	Off
1	Local or Not in Remote
2	Remote

Other typical Status Points are:

Device Control Mode

Value	Meaning
0	Remote Manual
1	Remote Automatic

Valve Status

Value	Meaning
0	Stopped
1	Opening
2	Closing
3	Faulted
4	Opened
5	Closed

If there is a new status point required that are not shown above, the translation table must be submitted to PWD.

6.6.2 PLC Program Structure Overview

A PLC Ladder logic program consists of:

- Tasks
- Programs
- Routines

A “Main Task”, which will primarily be a continuous task, will be a standard task for PWD projects. There may be a need to use an additional periodic task, but only with approval from PWD.

A “Main Program”, will be a standard program for PWD projects.

A number of standard routines and a number of application specific routines will make up the standard configuration for PWD projects. The following is a brief description of how the standard routines are defined.

MCP Routine

The Master Control Program (MCP) and is responsible for the calling of other routines for execution. Specifically, this routine will call the routines below:

Initialization Routine

This routine is responsible for initializing any functions required for the application and for clearing all latched tags within the program and any other values that need to be reset on power up. Also, any predefined settings that need to be loaded upon power up will be programmed here.

Communication Routine

This routine is responsible for all messaging done between processors as well as communication watchdog code. Also any other communication related functions with other devices such as power monitors, VFDs, Ethernet ports, etc.

Input Routine

This routine is responsible for scaling (from raw to engineering units) and filtering Analog Inputs that will be passed to SCADA. Filtering shall not be done in the IO Card.

Alarm Routine

This routine is responsible for generating process alarms. All of the standard PWD alarm functions and other alarm related add-on instruction blocks will be placed in this routine. Also all alarm related logic will be placed in this routine.

Statistics Routine

Two different types of “Totalization” statistics will be generated within this routine, the first being a totalization of an analog signal, and the second being a “Runtime” totalization (or similar) based upon a discrete input. PWD has standard add-on instructions for totalization functions.

Output Routine

This routine simply takes each Analog Output is scaled from its engineering units (floating point) to its raw output value using the standard PWD SCP add-on instruction block.

OIT/HMI Interface routine

This routine will contain the logic needed to interface with the OIT and HMI through data tables. Both the OIT and the HMI will use the same data structure/animation format. This routine will contain code necessary to implement any animation and interface that the PLC Control Programs (below) can’t deal with directly. The most common code within this routine is the creation of status codes for both Local/Off/Remote animation as well as pump running/faulted/stopped (or valve open/closed/moving/faulted) animation.

Control Program Routine

This routine is similar in nature to MCP and takes care of calling various other routines necessary to execute the Control Program Subroutines (see the Control Narrative Structure described in Section 6.1) for this PLC. Each PLC has an associated Control Program Description which details the control to be executed in this PLC. This functionality will be broken down into logical pieces and distributed amongst following Program Files.

Control Program Subroutines

The Control Program Subroutines, as described in Section 6.1, are structured to contained logic for the elementary operation of process equipment (i.e. valves, pumps, polymer blend units, etc.). Most routines are at this level.

Control Strategy Subroutines

The Control Strategy Subroutines take care of the implementation of the various Control Strategies, as described in Section 6.1, which contain logic controlling several Control Program Subroutines. These are more advanced control strategies which are not part of the basic control of the system.

6.6.3 Routine and ladder Rung Comments

The liberal use of routine and ladder rung comments is required for all PWD projects. This will provide a critical tool for future code work and troubleshooting.

A great source of routine and rung comments is the text from the Control Programs and Control Strategies see Section 6.1. Since the ladder logic is based on the Control Narratives, it makes good practice to insert the comments before assembling the ladder rungs.

There shall always be a "routine comment" on the first rung of all routines that describes the purpose of the routine.

Each section of a routine shall have a rung comment describing the purpose of the ladder rungs that follow.

Every rung containing a calculation, or a complicated series of logic, shall have a rung comment describing the purpose of the rung.

The requirement for inserting comments in the PLC ladder Logic has been PLC's standard for many years and it is a key element of PWD's SCADA Standards.

6.6.4 Standard Code – Add-On Instructions

PWD will provide AESS a set of standard PWD Add-On Instructions upon request. The Alarm Add-On Instruction is documented below:

6.6.4.1 Alarms - General Notes

Alarms are assigned one of four different priorities which define how the alarms are generated and handled and what level of alarm horn and light is used to annunciate them (See Section 5.2.5). Priority one and two alarms are very similar and are both “Latched” alarms meaning that once the alarm occurs, it is held in until such time as the operator presses a reset. Priority three and four alarms are not latched in.

The Priority 1, 2, and 3 alarms all generate a different alarm horn sound. When an alarm is initially generated, the appropriate alarm horn tagname is latched in with a one-shot. An acknowledgement of the alarm from either the HMI or the OIT will then unlatch that tagname. At the SLWTF, the DS1 PLC must read all other PLC’s to retrieve these three bits, or tagnames, from each processor. It then turns on one of three outputs to generate the corresponding sound.

The alarm annunciator sound is controlled by specific PLCs at a plant:

- At SLWTF out of the Chem Feed PLC (DS1) to the Gaitronics unit.
- At EEWWTP out of the HVAC PLC (HV1) to the Valcom tone generator.
- At WWWTP out of the Main PLC (WE1) to the Valcom tone generator.

If a PLC at SLWTF or at Peaks Island Treatment Plant is calling for one of the three alarm sounds, the PLC will also turn on its alarm light on the local PLC Panel as well. When the alarm horn is acknowledged and the bit turned off, the light will go out as well.

Each alarm in the system also has an override tagname point which may or may not be available to the operator. This override point will turn off the alarm bit and hold it off so that the alarm will not occur. In most cases in this system this point is not used, but there are some alarms which the operator can set this bit through an HMI alarm setup pop-up.

For PLCs in the plants, each analog input in the system has associated with it an analog status tags. These status tags contain the various alarms associated with that analog input. Following these status tags, there is an alarm word for each discrete input and discrete output card.

6.6.4.1.1 Alarm Horn, Acknowledge & Resets

The first portion of this program file takes care of some administrative tasks for alarm handling. The turning on of the alarm light, the acknowledging of the alarm horn and light all take place here. Additionally, global alarm resets logic is at the beginning of the file.

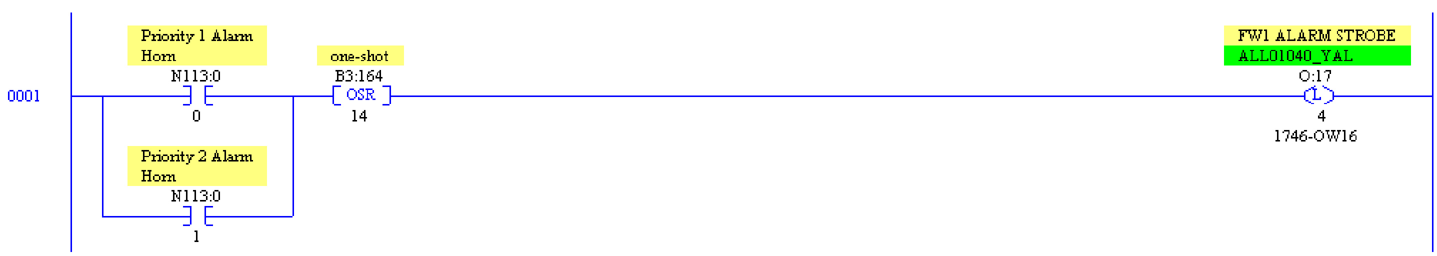
Each alarm has an individual alarm reset which may be set by the operator. A global reset is also allowed though which takes care of setting all the various individual resets.

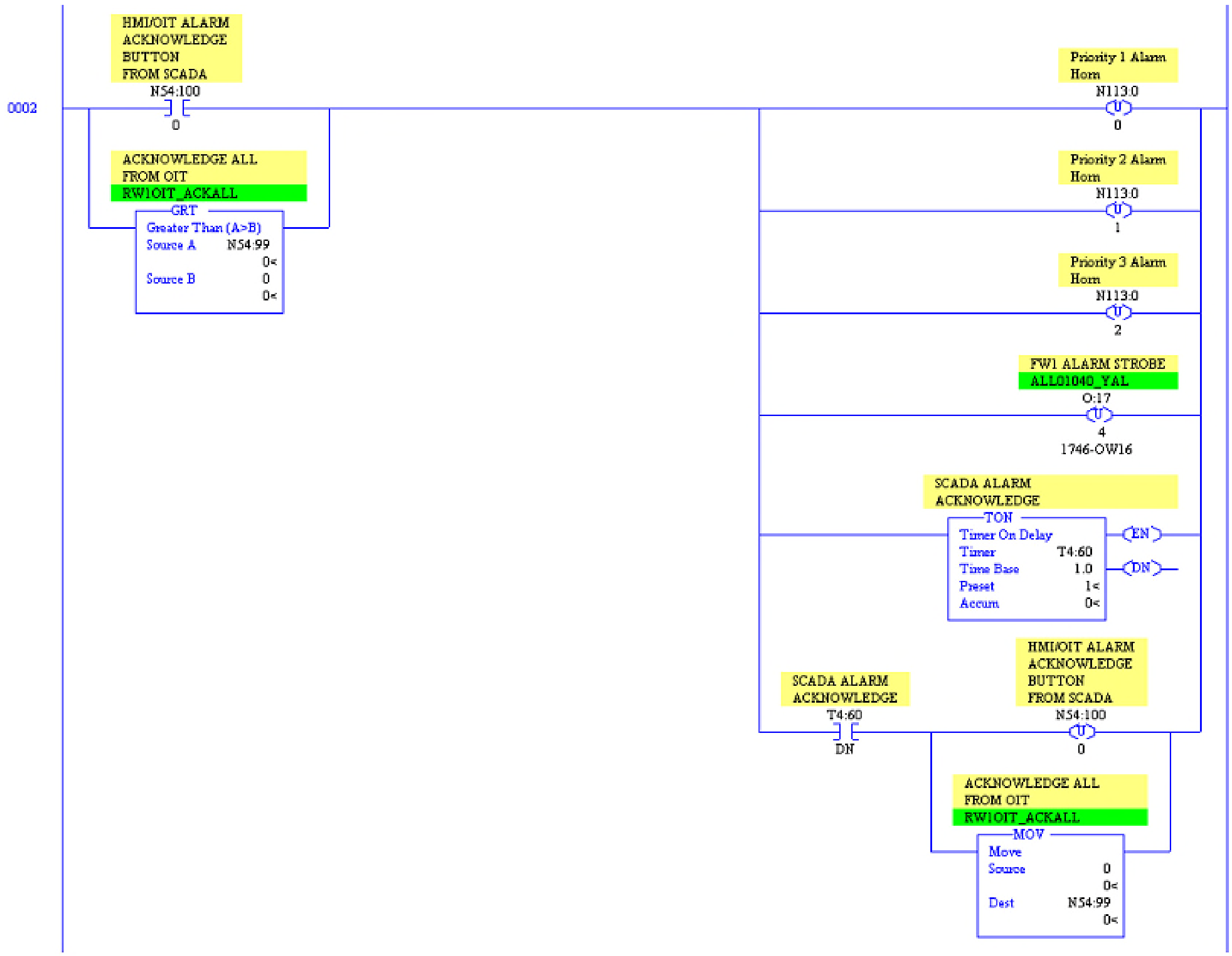
Each alarm has the ability to have a disable function. Whether this disable feature is implemented is based upon SCADA and OIT providing an enable/disable button. The IO list defines which alarms have this feature.

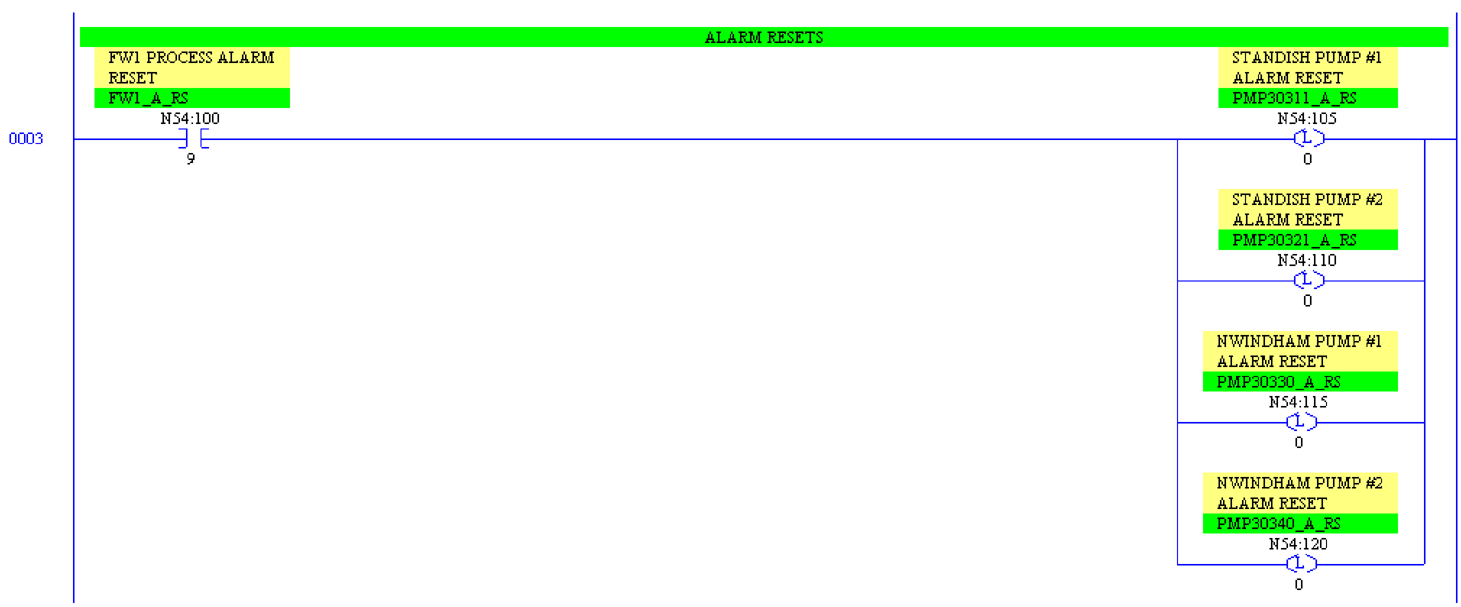
Each alarm is also assigned a Priority in the IO List for the project:

- Alarms with Priority 1 are latched on and must have a reset tag to unlatch them. Also, they will turn on alarm horn output #1 and the alarm strobe.
- Alarms with Priority 2 are latched on and must have a reset tag to unlatch them. Also, they will turn on alarm horn output #2 and the alarm strobe.
- Alarms with Priority 3 are not latched, and turn on Alarm horn output #3.
- Alarms with Priority 4 are not latched and do not turn on the horn.

Each alarm rung will latch on the appropriate horn output (using the appropriate PWD alarm add-on instruction block) when the alarm is activated. The acknowledge button from either the OIT or SCADA will unlatch the horn (this provides the acknowledge (or silence) function).




0002
HMI/OIT ALARM ACKNOWLEDGE BUTTON FROM SCADA
N54:100
0
ACKNOWLEDGE ALL FROM OIT
RW1OIT_ACKALL
GRT
Greater Than (A>B)
Source A N54:99
0<
Source B 0
0<
Priority 1 Alarm Horn
N113:0
U
0
Priority 2 Alarm Horn
N113:0
U
1
Priority 3 Alarm Horn
N113:0
U
2
FW1 ALARM STROBE
ALL01040_YAL
O:17
U
4
1746-OW16
SCADA ALARM ACKNOWLEDGE
TON
Timer On Delay
Timer T4:60
Time Base 1.0
Preset 1<
Accum 0<
EN
DN
SCADA ALARM ACKNOWLEDGE
T4:60
DN
HMI/OIT ALARM ACKNOWLEDGE BUTTON FROM SCADA
N54:100
U
0
ACKNOWLEDGE ALL FROM OIT
RW1OIT_ACKALL
MOV
Move
Source 0
0<
Dest N54:99
0<


0003
ALARM RESETS
FW1 PROCESS ALARM RESET
FW1_A_RS
N54:100
9
STANDISH PUMP #1 ALARM RESET
PMP30311_A_RS
N54:105
L
0
STANDISH PUMP #2 ALARM RESET
PMP30321_A_RS
N54:110
L
0
NWINDHAM PUMP #1 ALARM RESET
PMP30330_A_RS
N54:115
L
0
NWINDHAM PUMP #2 ALARM RESET
PMP30340_A_RS
N54:120
L
0

6.6.4.1.2 Analog Input Alarming (Treatment Plants Only)

Each AI point has the following alarm code:

Bit 0 Signal Broken
Bit 1 Signal Out of Range Low
Bit 2 Signal Out of Range High
Bit 3 Low Low Alarm
Bit 4 Low Alarm
Bit 5 High Alarm
Bit 6 High High Alarm
Bit 7 (Rate of Change Alarm) does not exist for most AI's
BIt 8 Signal Bad (Bits 0,1,2 combined)
Bit 9 Signal Faulted (All alarm bits combined)

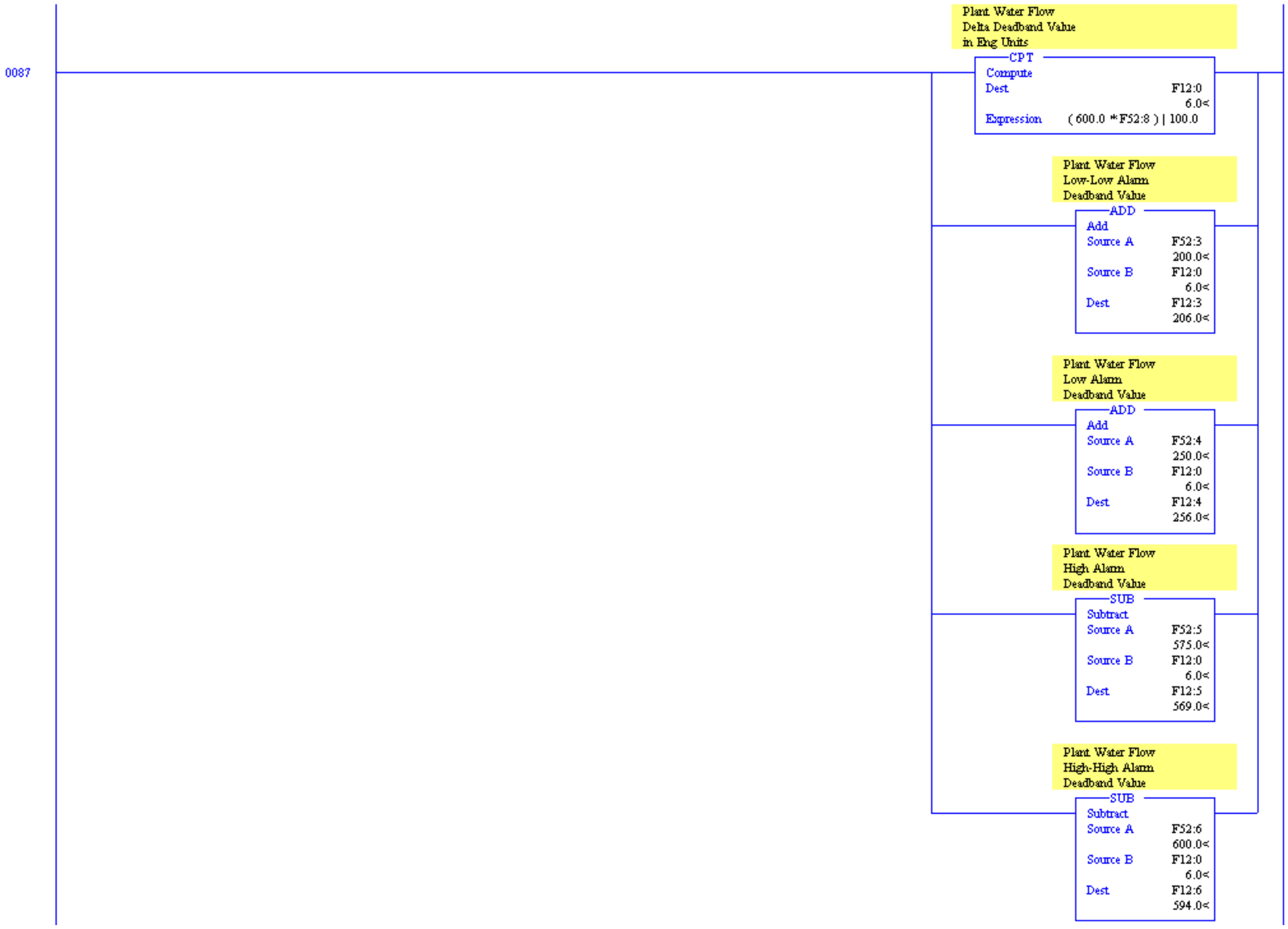
Typically only bits 3 through 6 are used. For critical analog points, all of the bits are used.

6.6.4.1.3 Analog Alarm Deadbands (Treatment Plants Only)

The next section of this file sets up the analog input alarm deadbands. As part of doing High High, High, Low, and Low Low alarms, a deadband is used. This is designed to keep the alarm from triggering in and out when right at the level of the alarm. This section of the file takes a deadband value from the operator and adds it to the current Low Low and Low alarm limits and subtracts it from the High High and High alarm limits. These four values are saved and used in the generation of these alarms.

Each analog input shall be assigned an alarm deadband that will apply to each of the 5 alarm limits. The alarm deadband may be expressed in % of full scale. The alarm deadband shall be modifiable from the OIT and SCADA HMI.

In order to implement this, the percentage value for deadband must be converted to engineering units. Then, it is added to each of the LL and L alarm limits and subtracted from the H and HH alarm limits. These values are then used in the alarm rungs later on.



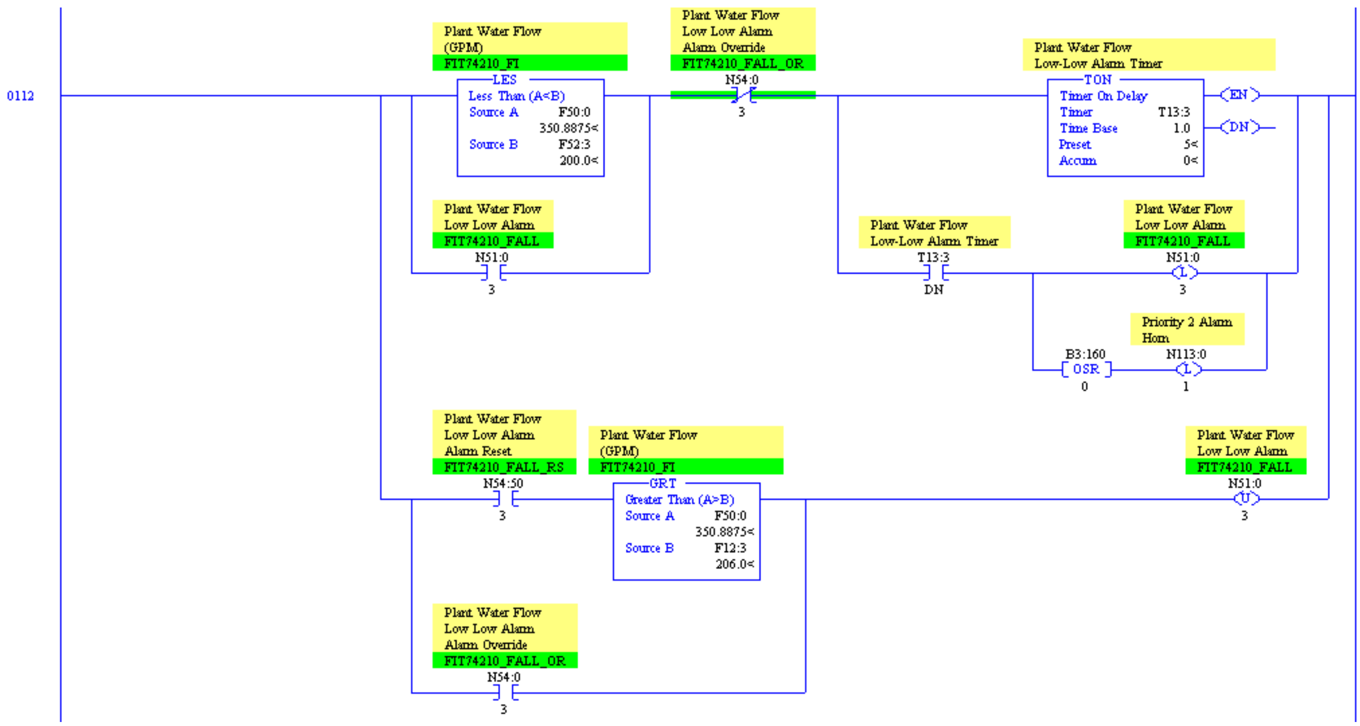
6.6.4.1.4 LL, L, H, HH Alarms

The next section generates the main body of alarms for analog inputs. Each rung generates a LL, L, H, or HH alarm for one of the analog inputs. Each alarm has a timer associated with it, as well as a deadband. If no time delay is desired for the particular alarm, the timer preset is set to zero. When the analog input crosses the alarm limit it will generate an alarm. It must then cross back over the alarm deadband limit (generated in the previous section) before it is allowed to reset. For Level 1 & 2 Priority alarms, a reset from the operator must occur in order to unlatch the alarm, otherwise they will self-reset based simply on dropping back below the deadband value. As with all alarms, there is an override tag which if available to the operator may be used to disable the alarm.

Additionally, these rungs will also contain other alarm suppression logic which is used to disable the alarm automatically based upon process conditions.

Within the status word for the analog input, bits 3,4,5 and 6 are set aside for the LL, L, H, and HH alarms accordingly.

Example: Analog Input Low Low Alarm Generation
Each analog input must have a Low Low Alarm generated. Based upon the analog input dropping below the LL limit for a specific time, an alarm is generated. Then, if it rises above the LL deadband value, it may be cleared. An alarm of priority 1 & 2 are latched in and must be reset. Also, in some cases, equipment must be in a certain state for the alarm to be generated, e.g. a pump must be running before a LL alarm can be generated. Additionally, alarm rungs have an override feature built into them which can allow if implemented in SCADA an operator to disable an alarm.

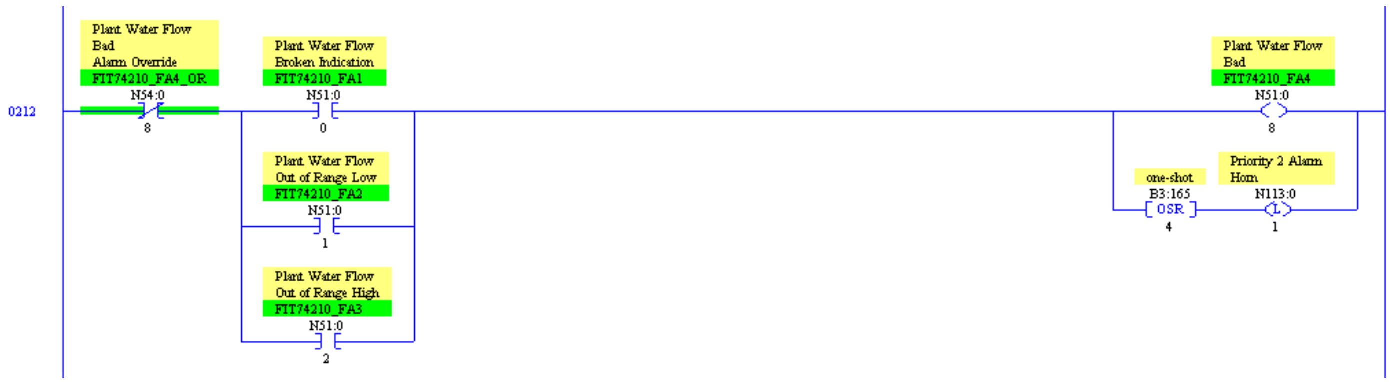


6.6.4.1.5 Signal Bad Alarms (Treatment Plants Only)

The analog input cards are setup so that they will return (in an extended part of its input image table) the signal status of each analog input. Specifically it will return a tag indicating a broken current loop, a tag indicating an out of range high signal, and a tag indicating an out of range low signal. Each of these tags will energize an alarm tag. Additionally, further down in the program, these three tags are combined into a single alarm that is simply labeled “Signal Bad”. The Broken, Out of Range High and Out of Range Low bits are bits 0, 1, and 2 within the analog signal status word. Bit 8 of the status word is the “Signal Bad” bit.

Signal Faulted Code - Bit 9 of the analog input status word is used strictly for animation purposes, mainly within the OIT. If any of the alarm bits for that status word are set, this bit is set. The OIT uses this bit to know whether or not to display the analog input as faulted (yellow) or not.

Analog Input Signal Bad code
This next section simply combines the broken, out of range high, and out of range low alarms into a single "Bad Signal" alarm

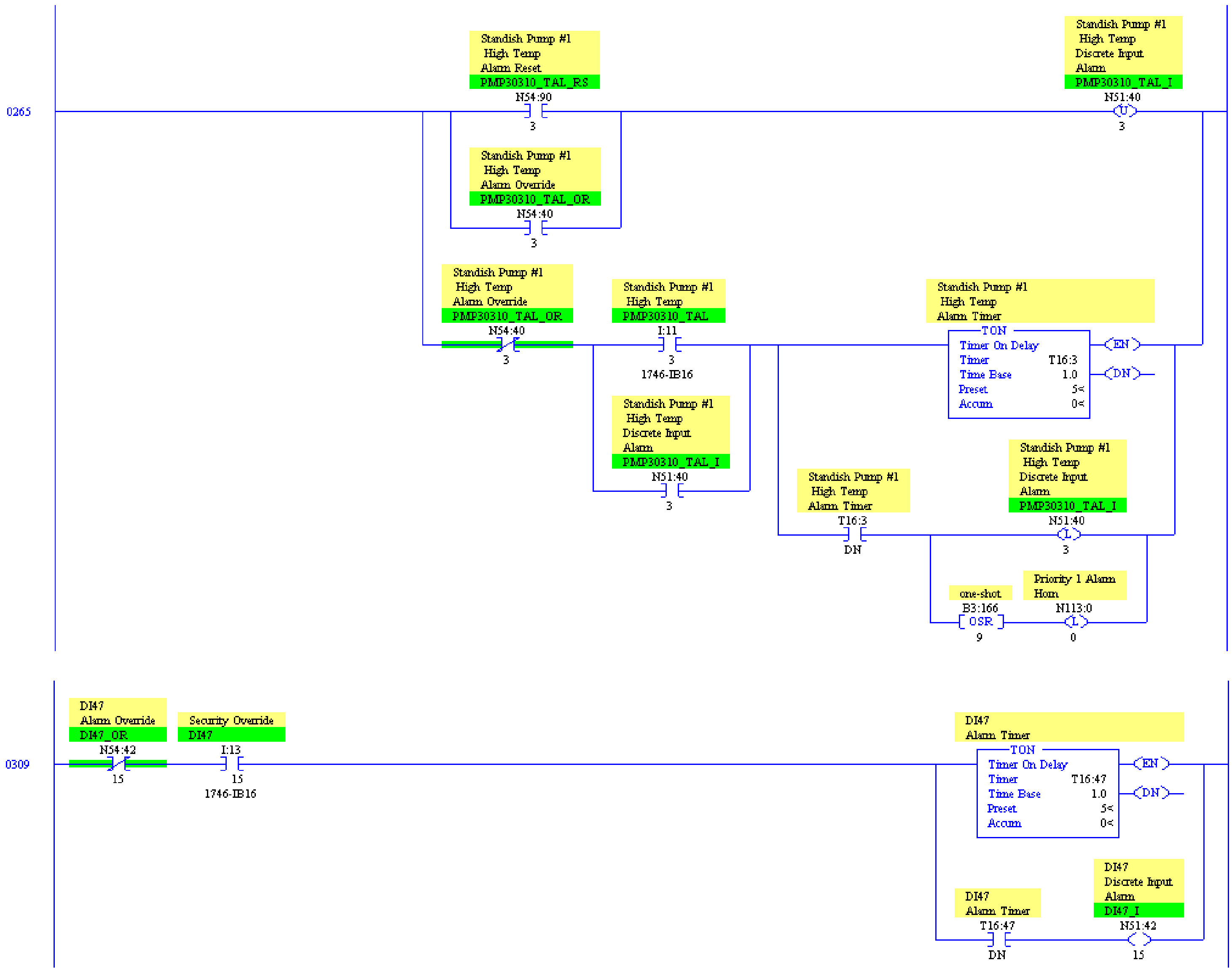


Analog Input Signal Faulted
This section simply combines the LL, L, H, HH, and Bad signal alarms together into a single bit which SCADA/OIT can utilize to animate the color of an analog display.

6.6.4.1.6 Discrete Input Alarms

Each discrete input in the system has an associated alarm with it. These may not all be used within the system (i.e. there may not be any actual alarm message or tag in the HMI/OIT). Each alarm may be overridden, and is assigned one of four priorities just as the analog alarms are.

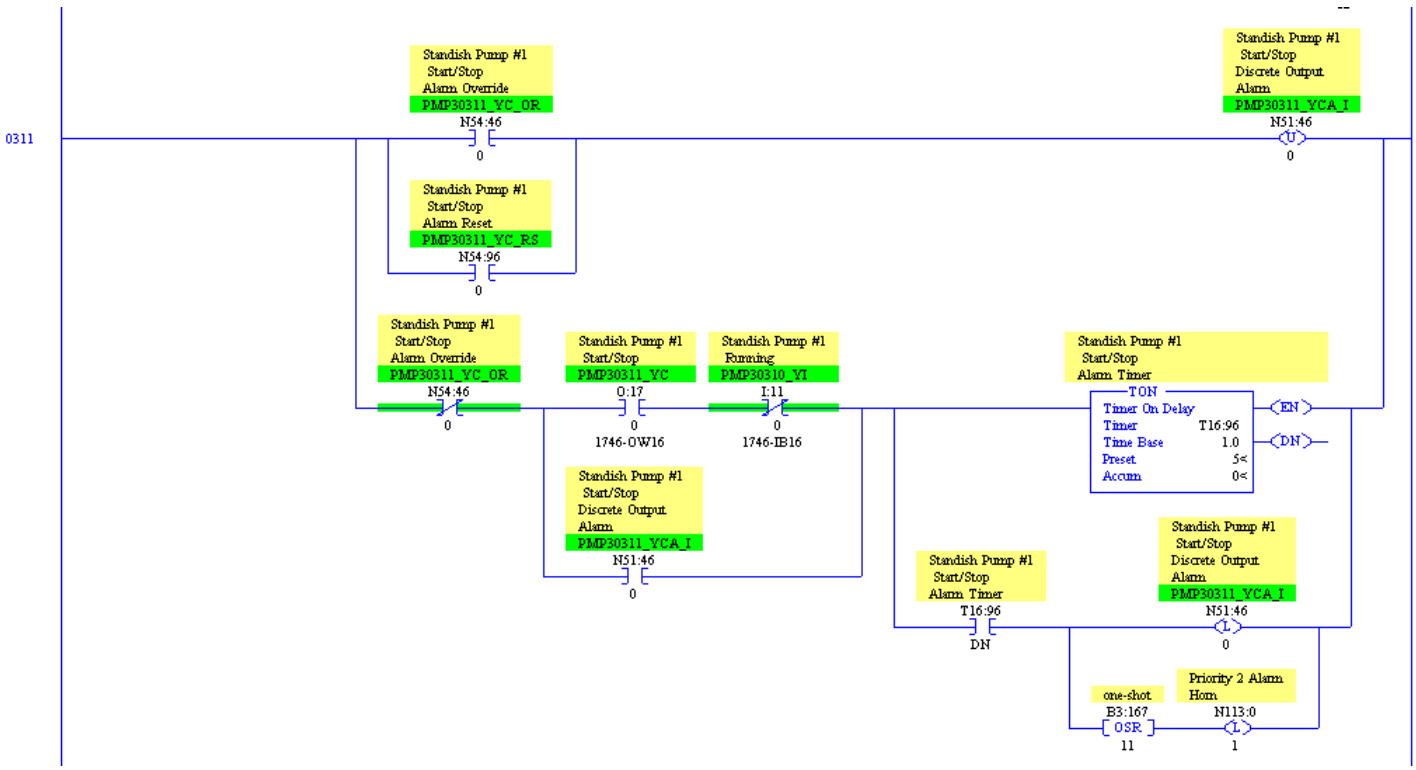
Each discrete input may have a time delayed alarm generated. Based upon the state of the input and a time delay, an alarm is generated. Alarms of priority 1 & 2 are latched in and must be reset. Priority 1, 2, and 3 alarms also will latch on the appropriate alarm horn output. Additionally, alarm rungs have an override feature built into them which can allow if implemented in SCADA an operator to disable an alarm.



6.6.4.1.7 Discrete Output Alarms

Each discrete output in the system has an associated “Failed to Operate” alarm with it. These may not all be used within the system (i.e. there may not be any actual alarm message or tag in the HMI/OIT). Each alarm may be overridden, and is assigned one of four priorities just as the analog alarms are.

Each discrete output may have a time delayed "Failed to Operator" alarm generated (this may be a failed to start/stop, or a failed to make position, etc.). Based upon the state of the output, the corresponding feedback from the device, and a time delay, an alarm is generated. Alarms of priority 1 & 2 are latched in and must be reset. Priority 1, 2, and 3 alarms also will latch on the appropriate alarm horn output. Additionally, alarm rungs have an override feature built into them which can allow if implemented in SCADA an operator to disable an alarm.



6.7 APPENDIX G – HMI/OIT DISPLAY STANDARDS

6.7.1 Color Conventions

General Color Requirements

Note that to meet Federal ADA (Americans with Disabilities Act) requirements, **color cannot be used solely** for monitoring purposes. Equipment shown as “Running”, “On”, or “Open” shall be shown with “Running”, “On”, or “Open” in the controller mode or state indictor text field (see Figure 6.7.8-1). Likewise “Stopped”, “Off”, or “Closed” shall be shown with “Stopped”, “Off”, or “Closed” in the controller mode or state indictor text field. Alarmed states shall be shown as flashing and normal states are static.

With ADA requirements in mind, color will be used in operator displays to denote processes and equipment conditions on the operator displays. The System Default color set provided by Intellution (the HMI vendor) shall be used. The color names of this set are:

The color standards are as follows:

<u>General Color Schemes</u>

• Screen Backgrounds	Gray88
• Hyperlink Text	BrightBlue
• Informational Text	Black
• Discrete State Text	White

Analog Feedback Boxes

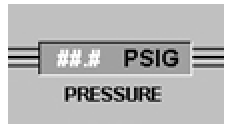


Figure 6.7.1-1 Analog Feedback Display Box Example

• Recessed Box	Grey75
• Functional Text	Black
• Analog Text	White
• Engineering Units	Black
• Background	Gray63

Analog Setpoint Boxes

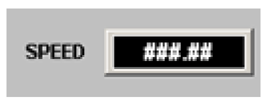


Figure 6.7.1-2 Analog Setpoint Entry Box Example

• Raised Button	Gray75
• Functional Text	Black
• Feedback Text	White
• Engineering Units	White
• Background	Black
• Background for RTU Points Only	Orange

Equipment Device Color Schemes

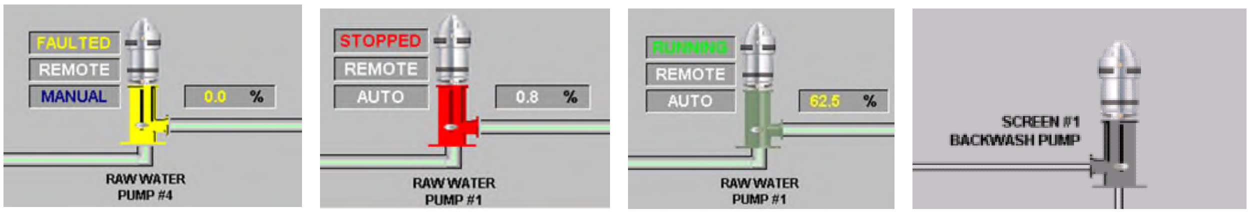


Figure 6.7.1-3 Equipment Device Color Examples: Alarm, Stopped, Running, and No Feedback

• Running/On / Open	BrightGreen
• Stopped/Off / Closed	BrightRed
• Alarm	BrightYellow
• No Feedback (or no alarm)	Gray60
• Traveling (for valves)	Color57 (medium blue)
• Traveling Close	Flashing BrightRed
• Traveling Open	Flashing Green

Water Treatment Process Colors (Sebago Lake)

• Air	Black
• Off Gas or Air Relief Vents	Yellow
• Aqua Ammonia	White
• Sodium Hypochlorite	BrightYellow
• Hydrofluosilicic Acid	Color112
• Non-potable Water	Color116
• Potable Water	Color57
• Sodium Hydroxide	Magenta
• Zinc Orthophosphate	Orange

Wastewater Treatment Process Colors (East End)

• Condensate Return	White
• Filtrate Drain	Black
• Odor Control	Yellow
• Polymer	Orange
• Plant Water	Color116
• Chlorinated Effluent	BrightCyan
• Sludge	Red (looks like Brown)
• Sodium Hydroxide	Magenta
• Sodium Hypochlorite	BrightYellow
• Steam	White
• Bisulfite	Color112

Alarm Summary Display Colors

The following definitions are from the iFIX alarm display object. The color scheme below is provided to document the configuration of this display object.

Foreground Color – Unacknowleged:	Magenta
Foreground Color – Acknowleged:	BrightBlue
Background Color – Critical:	BrightRed
Background Color – HiHi:	BrightRed
Background Color – High:	BrightCyan
Background Color – Medium:	BrightGreen
Background Color – Low:	Gray63
Background Color – LoLo:	Gray63
Background Color – Info:	Grey75

Operator Selector Buttons

The operator selector buttons (a.k.a. push buttons) are selectable by the operator to perform actions to the process via the SCADA System (i.e. start/stop pumps, etc.). The buttons are animated on the HMI/OIT displays. The buttons change their background color from grey to green when the function they perform is selected by the operator. Some buttons will go “invisible” when their operation is not needed or not selectable by the operator based on the process conditions.

Below (Figure 6.7.1-4) is an example of a popup display of a hypo pump that is stopped (note the green background color of the “Stop” button and the Control Mode Area indicator showing it is in the stopped state.

There is typically an Auto and Manual selection push buttons, but since the pump is in fault, these two buttons are invisible. Normally they would appear above the start button.

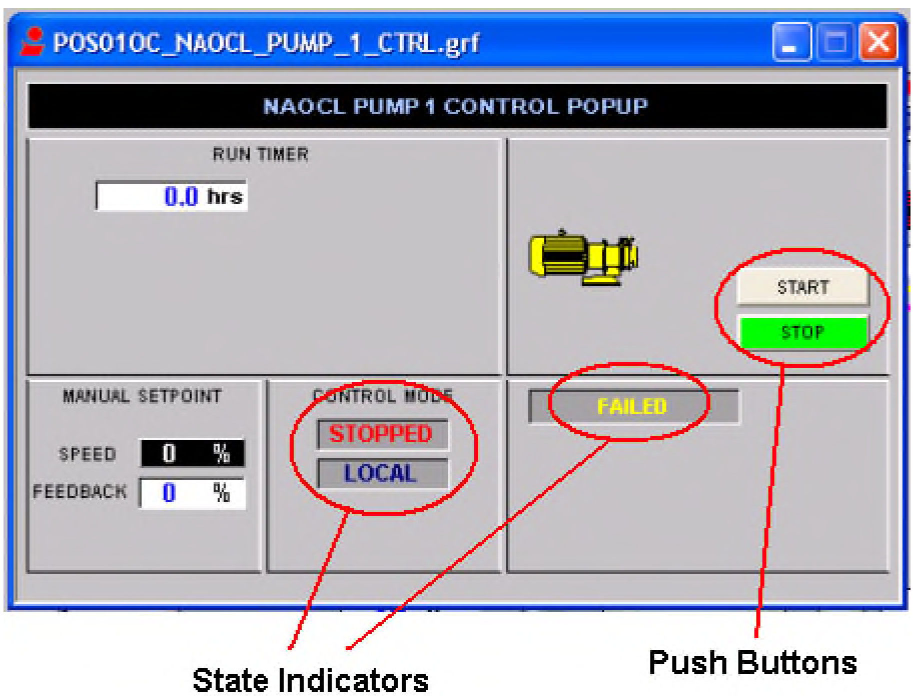
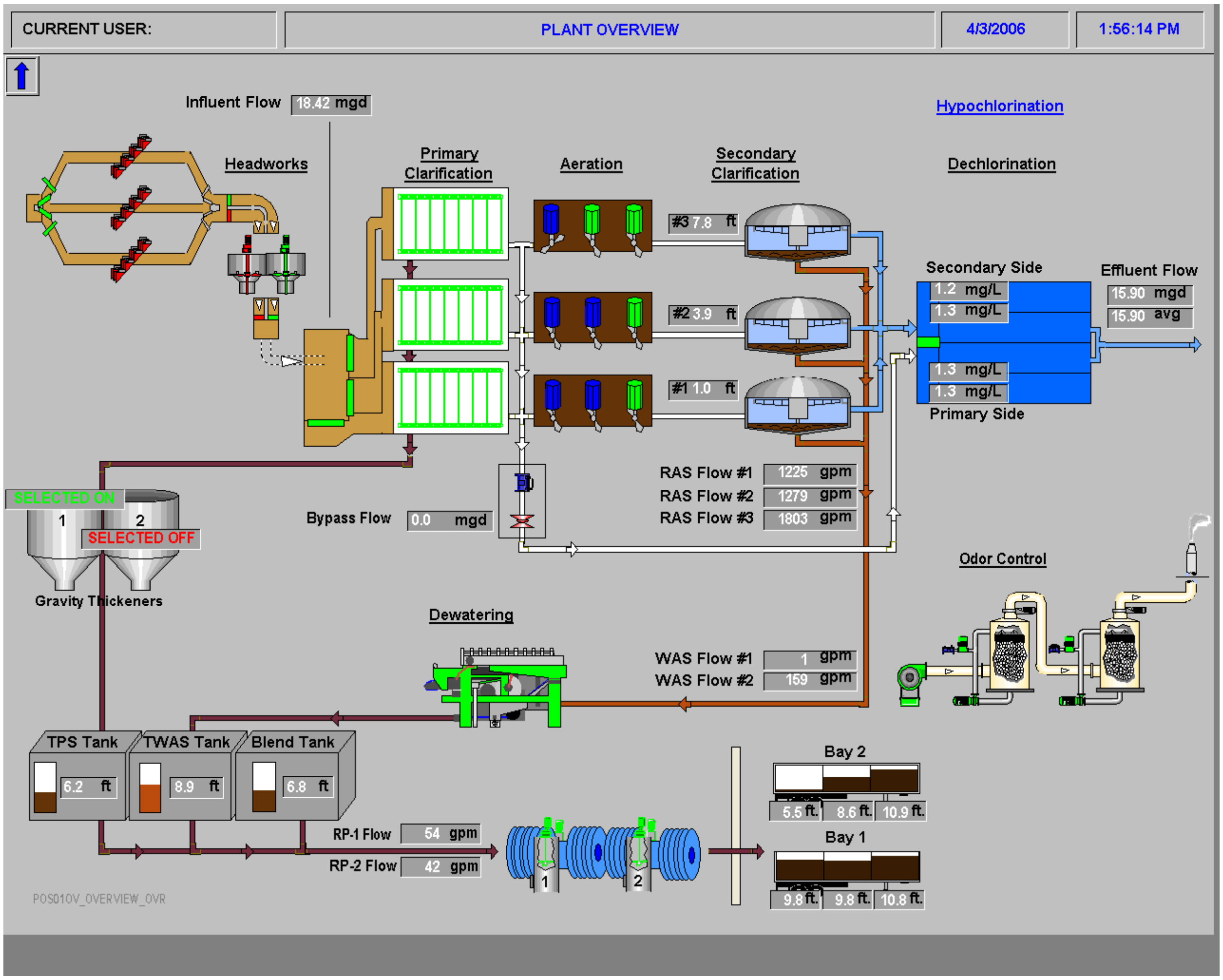
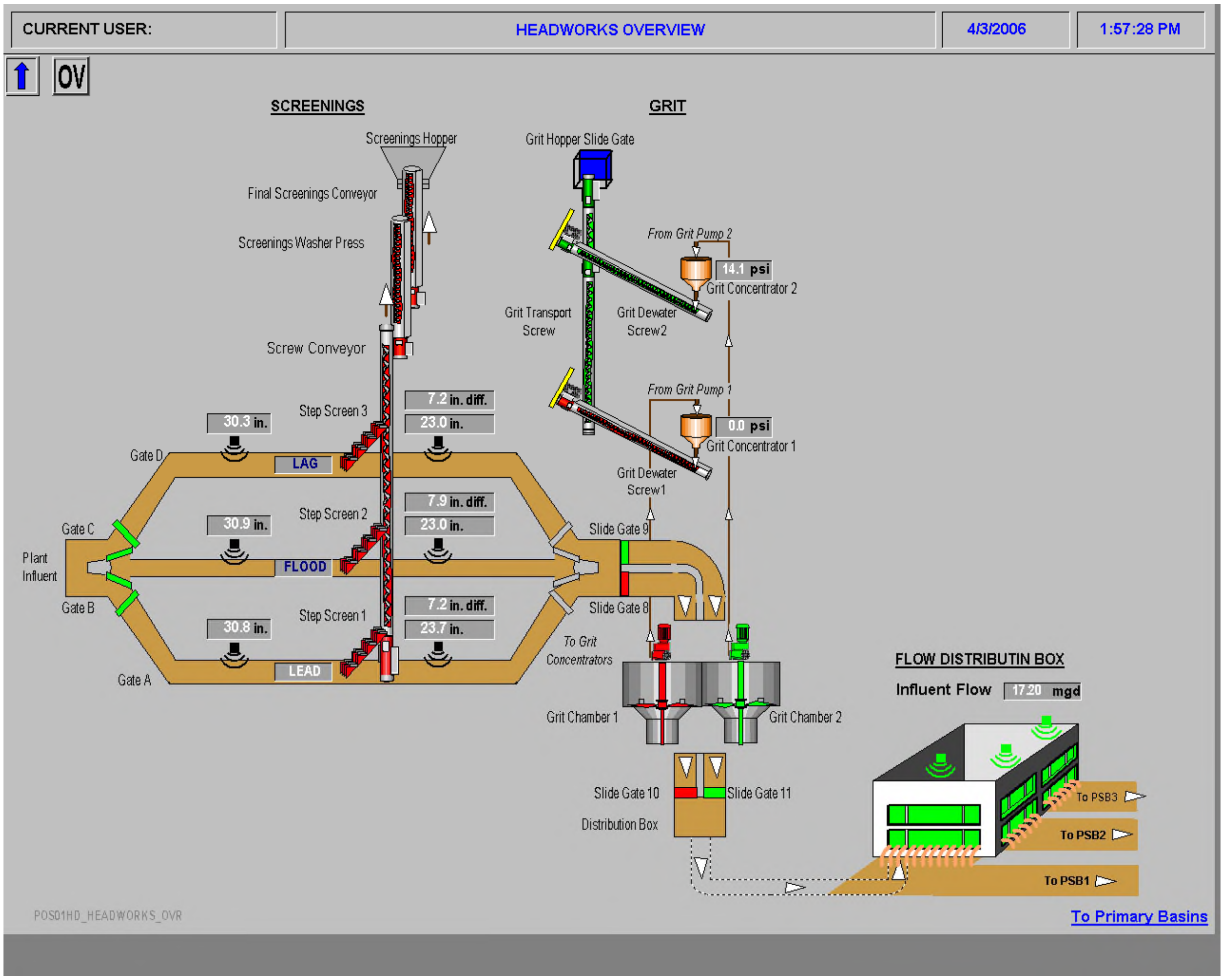


Figure 6.7.1-4 Example of Equipment Indicators and Operator Control/Selector Buttons

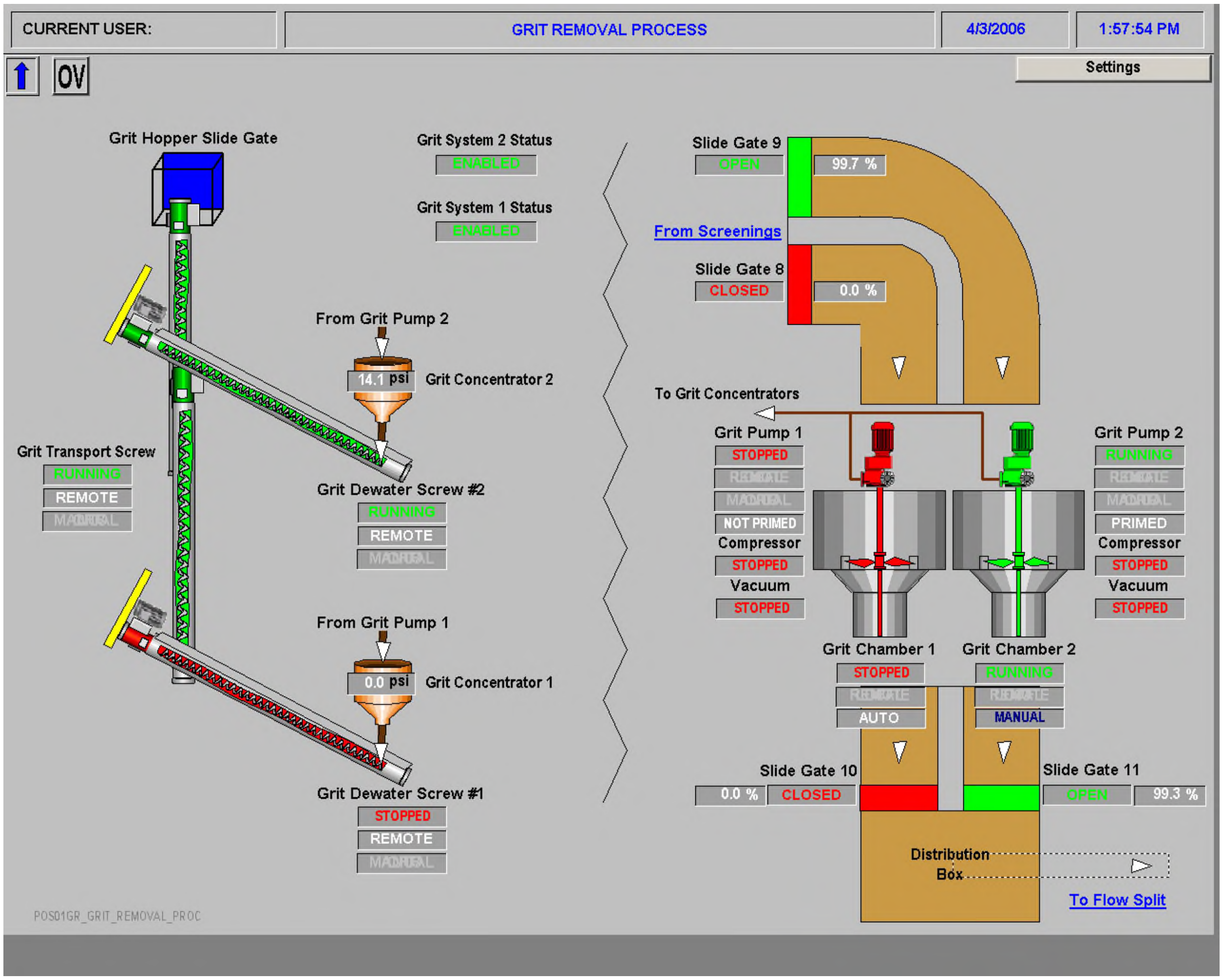
6.7.2 Overview Display Example



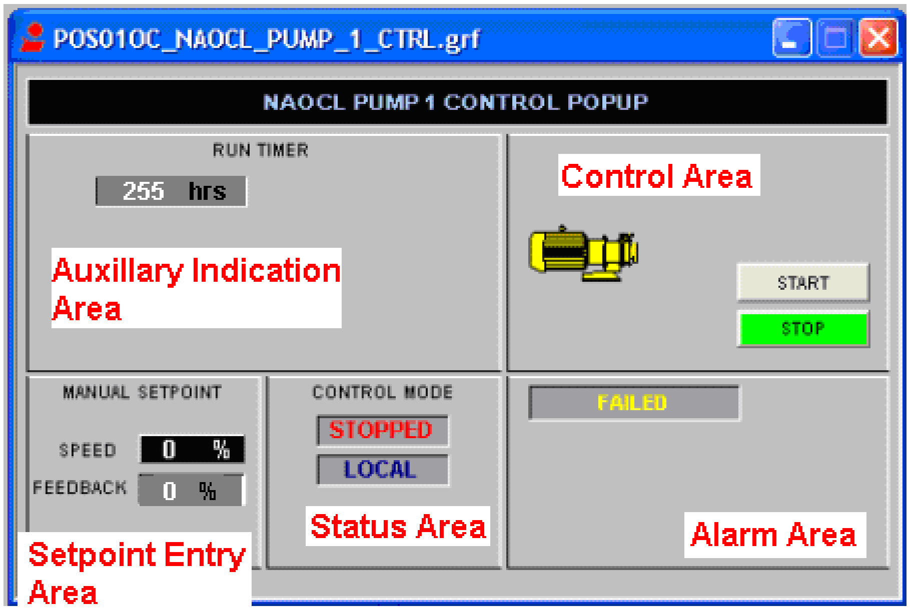
6.7.3 Sub Process Overview Display Example



6.7.4 Sub Process Detail Display Example



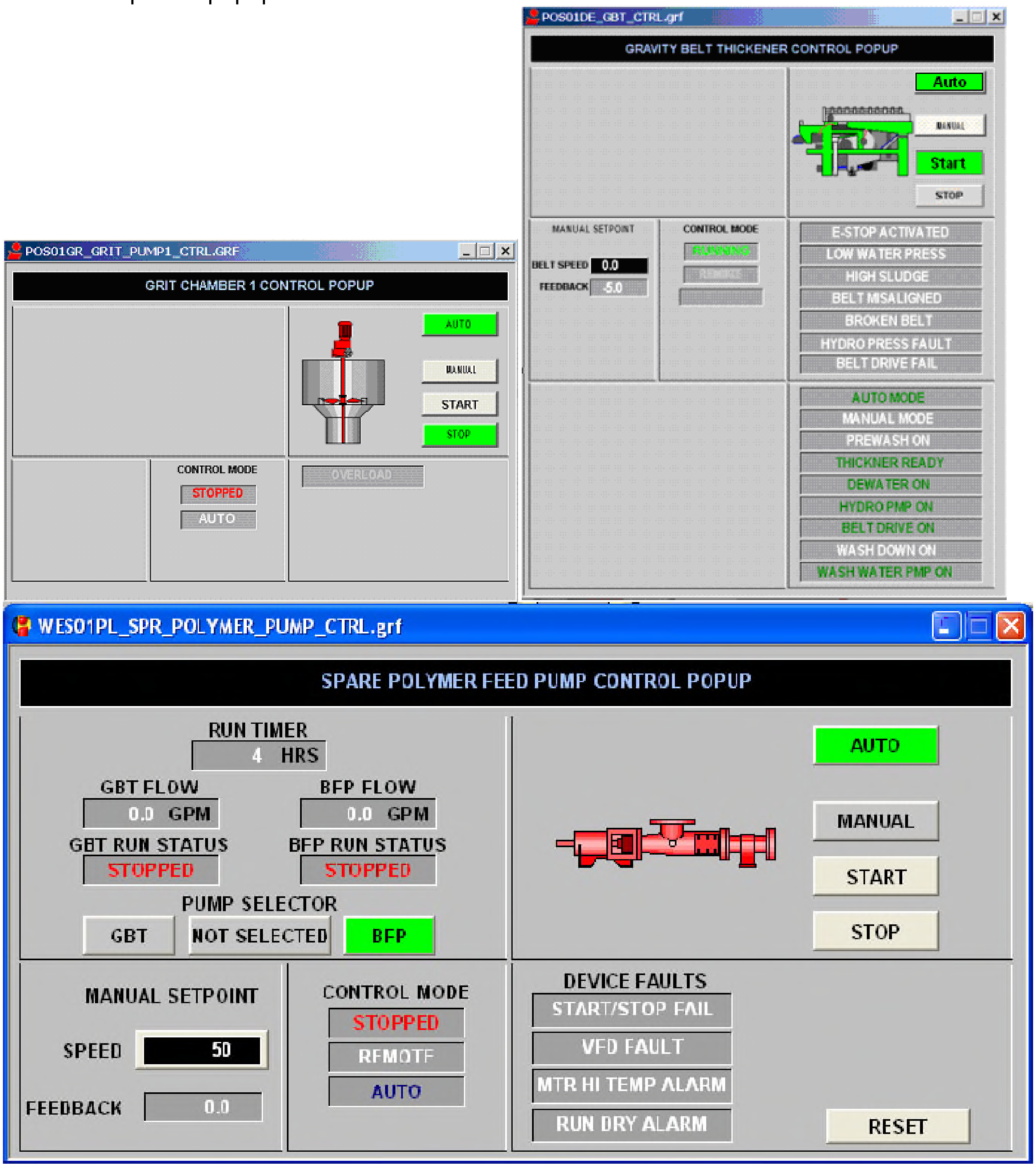
6.7.5 Control Pop-up Display Examples

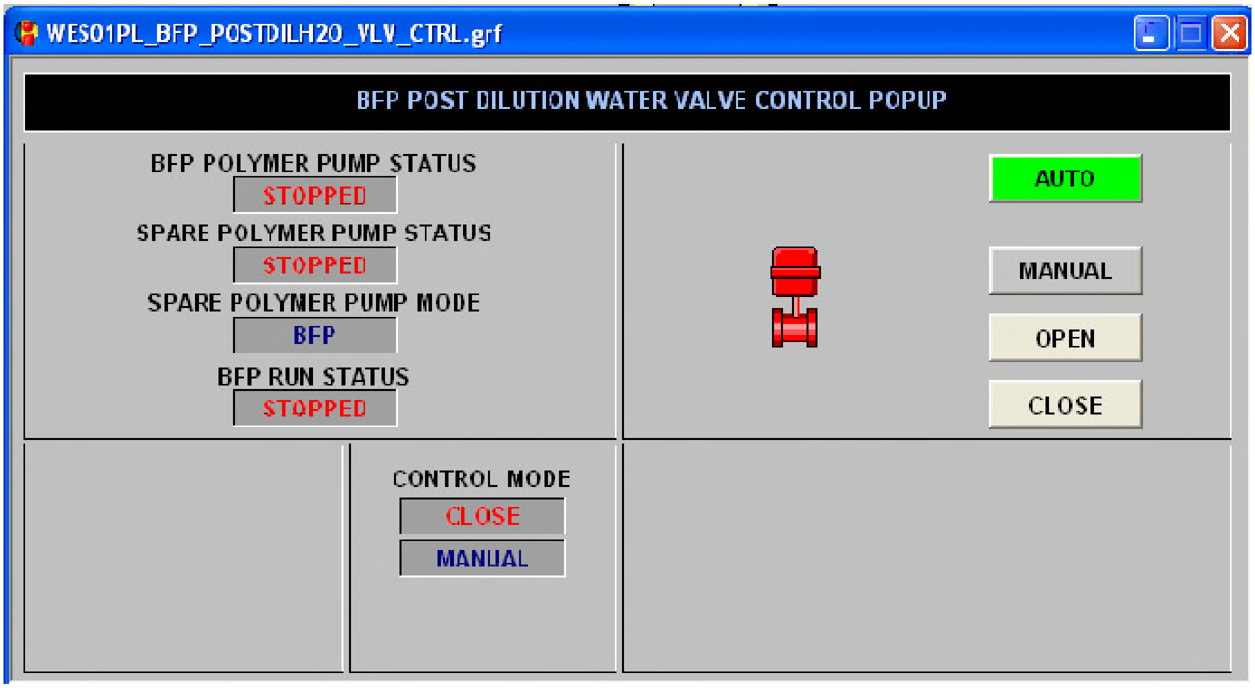


The areas within a popup display are:

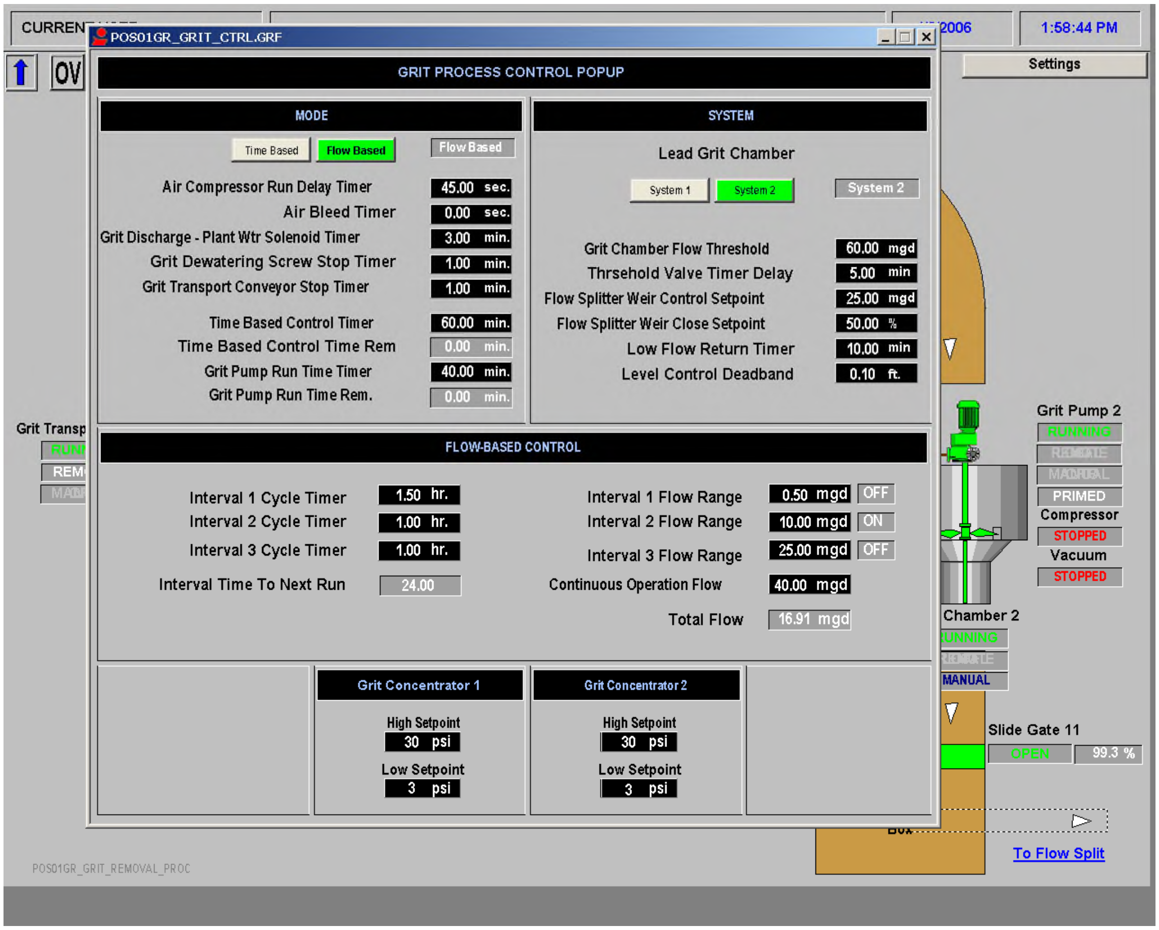
- **Control Area** - Push buttons for Auto, Manual, Stop, and Start are located here along with an animated graphic of the equipment.
- **Auxillary Indication Area** – Sometimes information is put into this area that can aid an operator with the operation of the equipment controlled by the popup. Examples of this include: runtime indicators, associated (or interlocked) equipment run status, associated flow rates for a pump, and service selector switch (see Westbrook Polymer Feed Pump).
- **Setpoint Entry Area** – Here is where an operator can see the equipment speed if there is a VFD and enter in a manual speed setpoint. This area is used for valve position control and any other analog variable associated with a piece of equipment.
- **Status Area** – This area displays the control mode and the statuses of the equipment. Color and text is used to display the status (White = Normal State, Yellow = Alarm, Blue = Abnormal State but not in alarm, Red = Stopped, Green = Running). Statuses shown in this area include, but are not limited to:
    - Running/Stopped
    - Auto/Manual
    - Lead/Lag/Standby
    - Local/Remote
    - Open/Close
- **Alarm Area** – This area lists all of the alarms associated with the equipment. On the HMI all of the alarms are displayed. If they are not in alarm, the text is white. If they are in alarm and not acknowledged, the text is yellow and blinking. If they are in alarm but acknowledged, the text is yellow. This area will have a “Reset” button if there is an alarm that requires resetting. The reset button will only reset the alarms that are in the popup.

Other examples of popups:

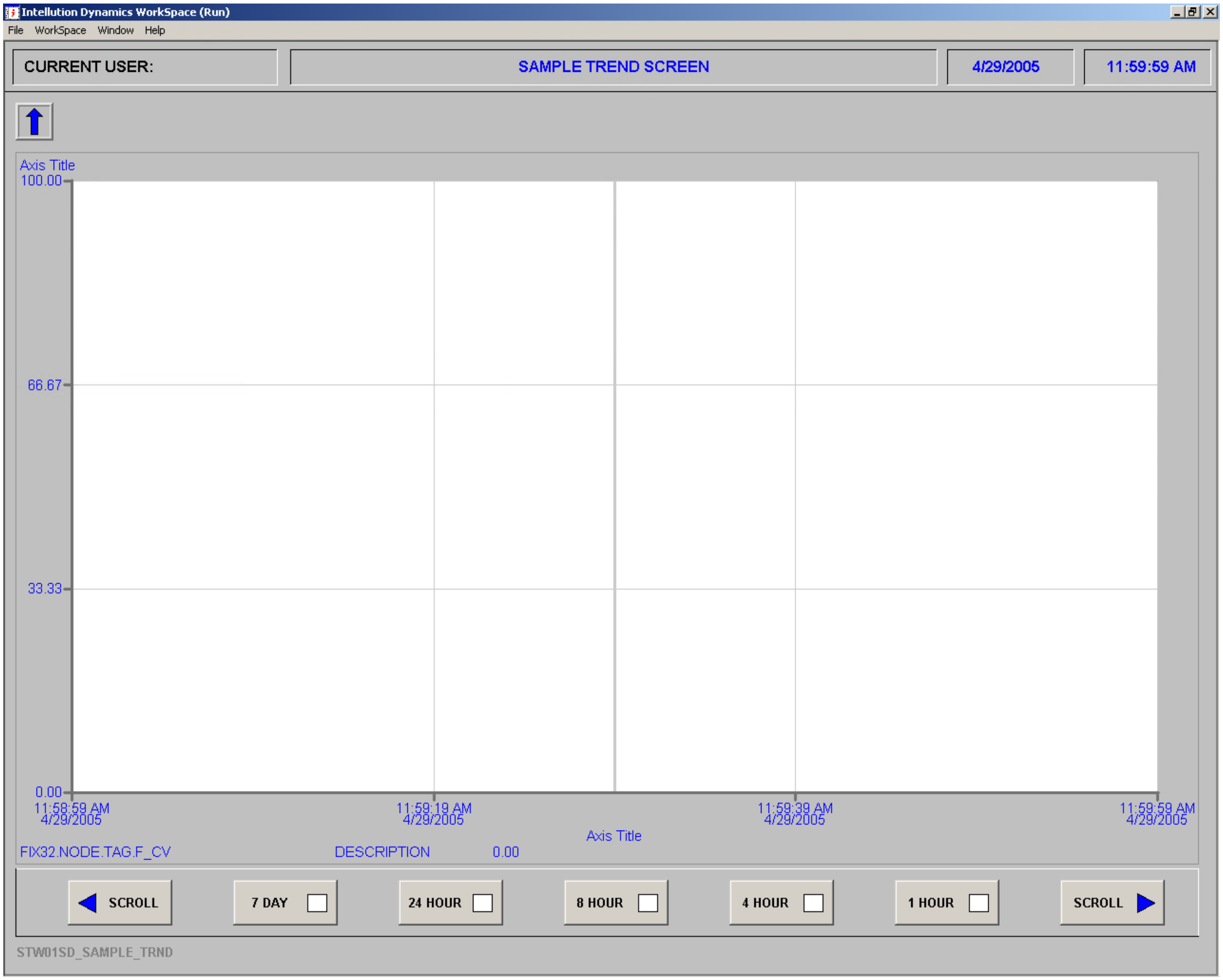



WES01PL_BFP_POSTDILH2O_VLV_CTRL.grf
BFP POST DILUTION WATER VALVE CONTROL POPUP
BFP POLYMER PUMP STATUS
STOPPED
SPARE POLYMER PUMP STATUS
STOPPED
SPARE POLYMER PUMP MODE
BFP
BFP RUN STATUS
STOPPED
AUTO
MANUAL
OPEN
CLOSE
CONTROL MODE
CLOSE
MANUAL

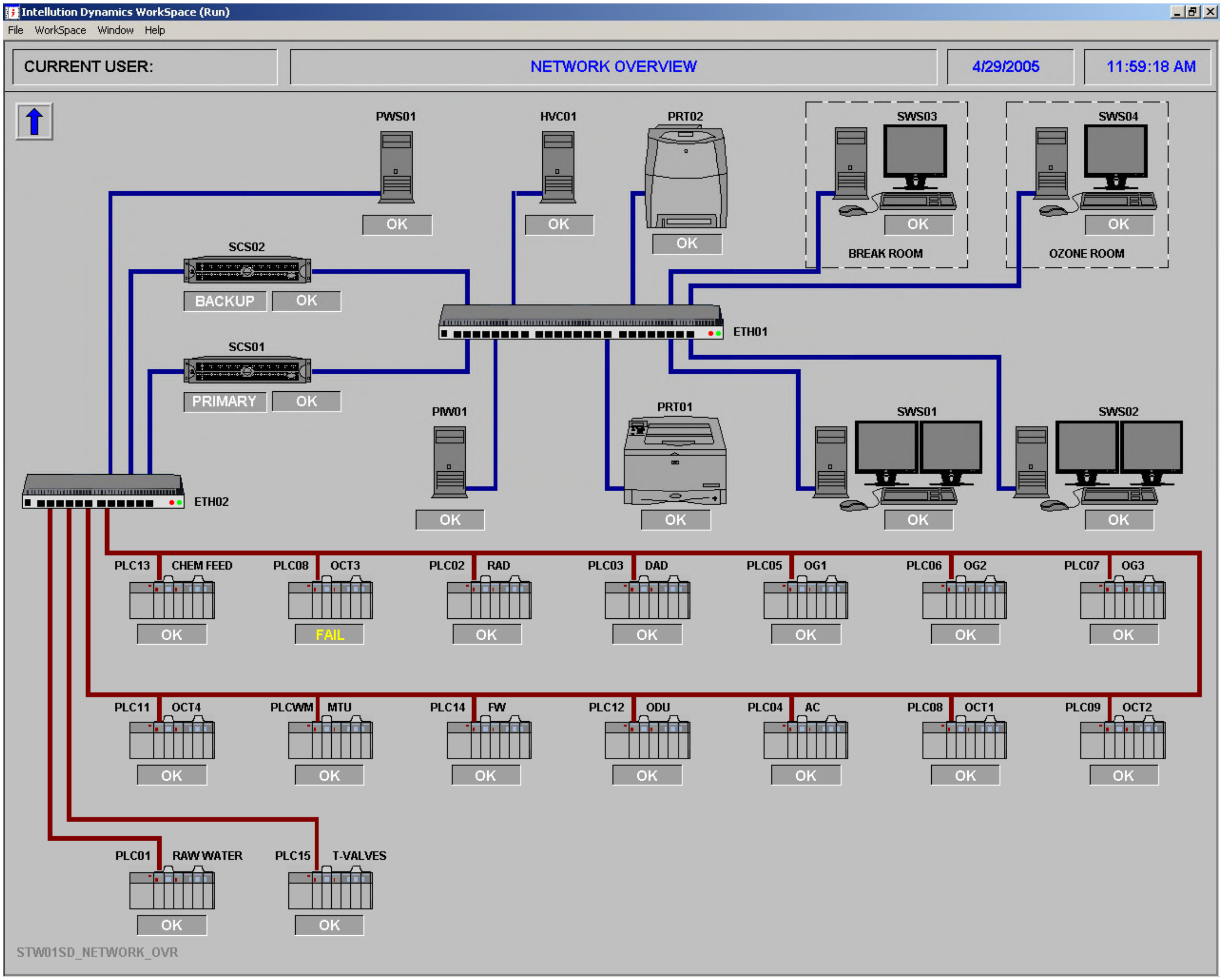
6.7.6 Settings Display Example



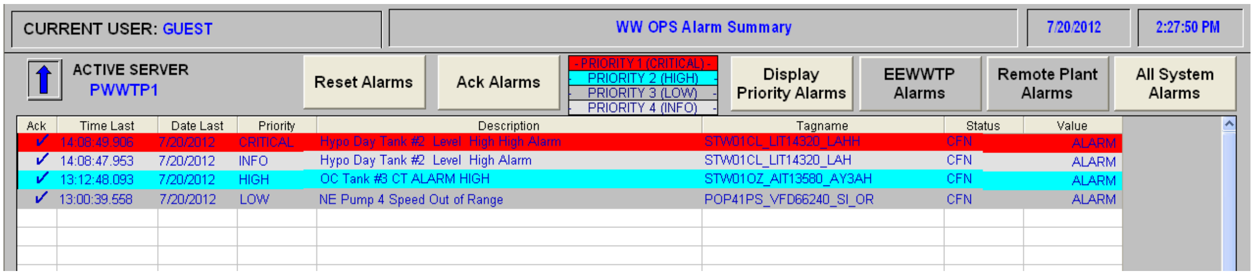
6.7.7 Trend Display Example



6.7.8 SCADA System Display Example



6.7.9 Alarm Display Example



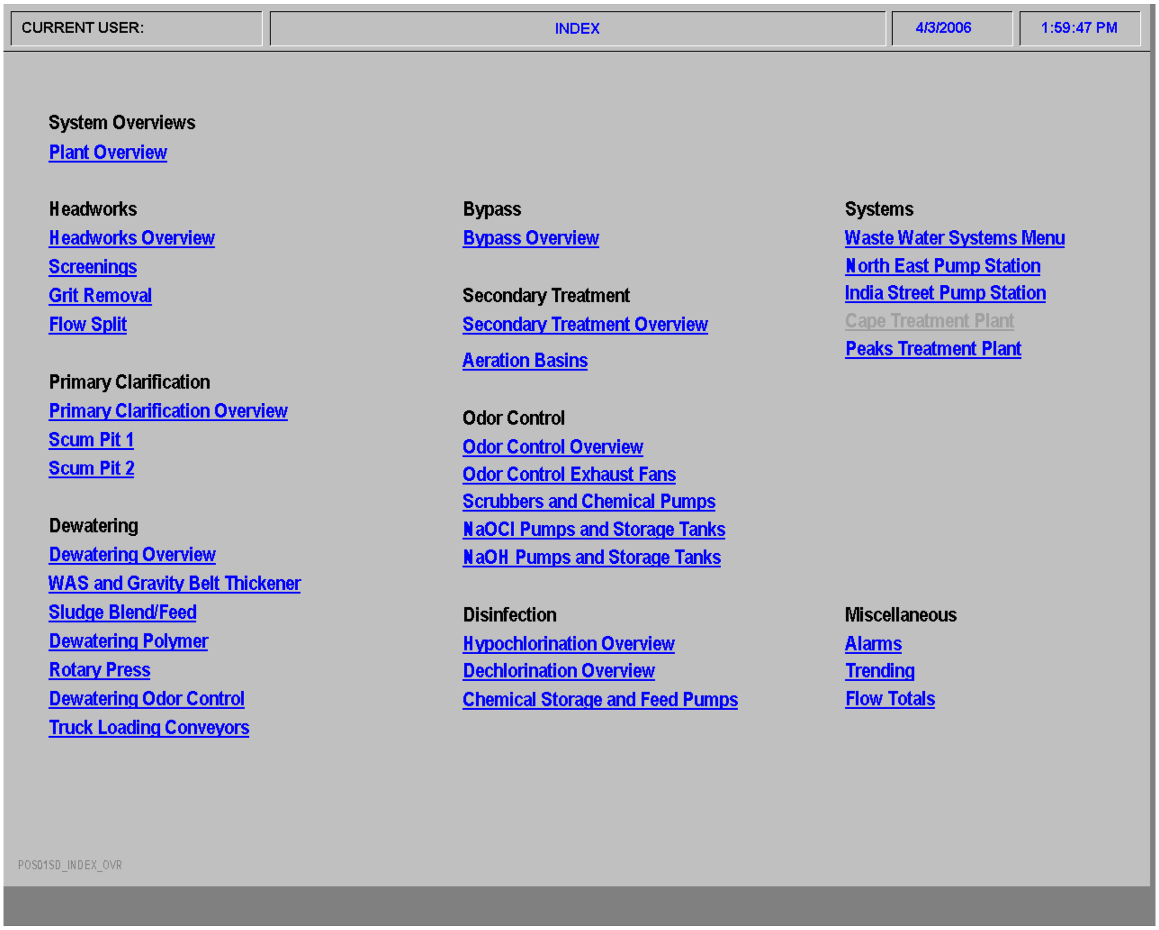
Ack	Time Last	Date Last	Priority	Description	Tagname	Status	Value
✓	14:08:49.906	7/20/2012	CRITICAL	Hypo Day Tank #2 Level High High Alarm	STW01CL_LIT14320_LAHH	CFN	ALARM
✓	14:08:47.953	7/20/2012	INFO	Hypo Day Tank #2 Level High Alarm	STW01CL_LIT14320_LAH	CFN	ALARM
✓	13:12:48.093	7/20/2012	HIGH	OC Tank #3 CT ALARM HIGH	STW01OZ_AIT13580_AY3AH	CFN	ALARM
✓	13:00:39.558	7/20/2012	LOW	NE Pump 4 Speed Out of Range	POP41PS_VFD66240_SI_OR	CFN	ALARM

Screen Capture of the Alarm Summary Display

a) The Alarm Summary Display will have the following columns:
   a. Ack.
   b. Time Last.
   c. Date Last.
   d. Priority.
   e. Description.
   f. Tagname.
   g. Status.
   h. Value.

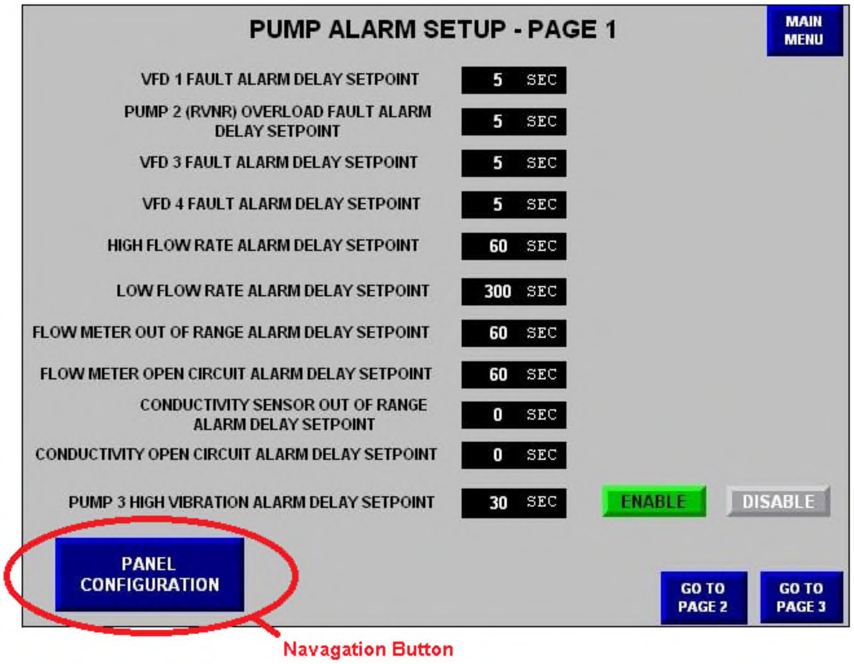
See Section 2.2.5 for additional details.

6.7.10 Menu Display Example

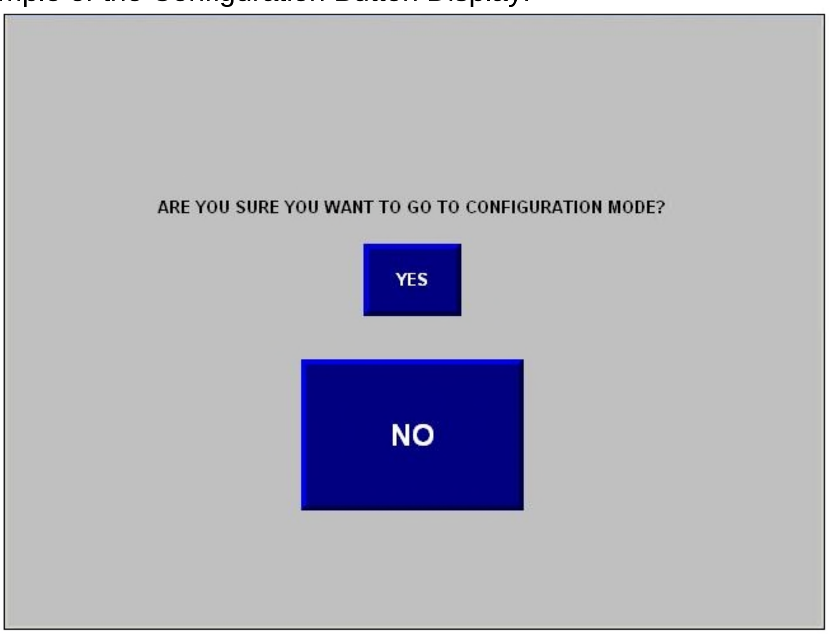


1.7.11 OIT Configuration Button Display Example

The figure below is an example of a navigation button taking the user to the OIT Configuration Button Display:



The Navigation Button is typically placed on a settings display and it takes the user to the display below. Only programmers should be accessing the programming mode of the OIT. Below is an example of the Configuration Button Display:



Revision Memo

Rev. 0	May 1, 2004	Draft Version for comments
Rev. 1	June 18, 2004	Final Version for comments
Rev. 2	July 30, 2004	Final Version
Rev. 3	April 14, 2006	PWD's Version
Rev. 4	February 27, 2009	Almost a complete re-write of this section Too many changes to note them all
Rev. 4.1	August 1, 2012	Major Revisions to Sections 1, 4 & 5 Many minor changes to all sections
Rev. 5.0	September 20, 2016	Major Revisions to All Sections For the New CompactLogix Standard