DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY
(DC Water)

"SERVING THE PUBLIC - PROTECTING THE ENVIRONMENT"

PROJECT
DESIGN MANUAL
VOLUME 2 - FACILITIES DESIGN

MASTER TABLE OF CONTENTS

August 2018

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AUTHORIZATION FORM

Revision Number	Date	Content
March 2016	March 22, 2016	Volume 2, Facilities Design Master Table of Contents
August 2018	August 15, 2018	Volume 2, Facilities Design Master Table of Contents

This 2018 version was authorized by:

L R Benson 12-20-18

Leonard R. Benson, Chief Engineer Date

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MASTER TABLE OF CONTENTS

MASTER TABLE OF CONTENTS (continued)

MASTER TABLE OF CONTENTS (continued)

MASTER TABLE OF CONTENTS (continued)

MASTER TABLE OF CONTENTS (continued)

MASTER TABLE OF CONTENTS (continued)

LIST OF APPENDICES

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF TABLES

LIST OF TABLES (continued)

Section 6

Section 7

Section 8A/Appendix C

Section 8A/Appendix E

Section 8B

Section 8B/Appendix B

LIST OF TABLES (continued)

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DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY
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"SERVING THE PUBLIC - PROTECTING THE ENVIRONMENT"

PROJECT
DESIGN MANUAL
VOLUME 2 - FACILITIES DESIGN

SECTION 1 – GENERAL

August 2018

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AUTHORIZATION FORM

Revision Number	Date	Content
September 2014	09/17/2014	Project Design Manual Volume 2 – Facilities Design Section 1 – General
December 2015	12/31/2015	Project Design Manual Volume 2 – Facilities Design Section 1 – General
August 2018	07/24/2018	Project Design Manual Volume 2 – Facilities Design Section 1 – General

This 2018 version was authorized by:

11/30/2018

David Parker PE, Senior Technical Advisor, Department of Wastewater Engineering Date

SECTION 1, GENERAL LOG OF REVISIONS (Revisions from 2010 version)		
Paragraph	**Brief Description of Revision**	**Date**
Global	- Changed 'DC WASA' to "DC Water". - Changed 'EPMC' to "PM". - Changed 'Long Term Control Plan' to "Clean Rivers Project". - Changed Section version date to August 2018	7/24/18
Abbreviations	Added DWE and PDM	7/24/18
1.1	Added overview of Volumes 1, 2, 3, and 4. (Deleted Vol. 4) Added email contact for design manual suggestions. Deleted email address; add reference to DETS Specs & Stds SharePoint. Moved 'Professional Requirements' to Volume 1. Added reference to Design Manual Change Request form. 1.1.1 - Condensed 'Deviations' and referred to PDM Vol. 1 1.1.2 – Condensed paragraph and referred to PDM Vol. 1	7/24/18 7/24/18 7/24/18 7/24/18
1.2	Moved DETS Quality Manual reference to paragraph 1.5. Condensed Submittal Rqmts para.; referred to PDM Vol. 1	7/24/18
1.3	Calculations – expanded approval and signature requirements. Deleted Calculations, as is now addressed in PDM Vol. 1	7/24/18
1.4	Added Construction cost estimating requirements. Deleted Construction Cost Estimating; see PDM Vol. 1	7/24/18
1.5	Referred to Volume 1 for requirements regarding Demolition; Value Engineering; specifications; document management; and QC/QA/DETS Quality manual. Added references for Calculations and Construction Cost Estimating	7/24/18
Appendix A	Added Appendix A – Design Manual Change Request Form. Deleted email address; add reference to DETS Specs and Stds.	7/24/18
Appendix B, All Tables	Changed 'Project Manager' to 'Pre-Final Design' and former 'Project Manager' to 'Back Check Submittal'	7/24/18
Table B-1, All Disciplines	Intermediate - Changed 'Specification outlines' to "Draft Specifications including Div 00, 01, and all technical spec sections".	
Table B-2, Civil	Concept Finalization: - Added dust and noise control, and air permitting. - Moved Hydraulic Profile from Structural to Civil. - Added Storm water management requirements. - Added Erosion and sediment control.	
Tables B-3, B-5, B-7, B-8, B-9	Intermediate – Changed 'Outline' to "Draft specifications".	
Table B-4, Structural	Concept Finalization – Added coordination with Civil for finish grades.	

SECTION 1 – GENERAL
TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

AWTP	Advanced Wastewater Treatment Plant
CDR	Concept Design Report
CIP	Capital Improvement Program
CM	Construction Management
CPM	critical path method
CSI	Construction Specification Institute
DC Water	District of Columbia Water and Sewer Authority
DETS	Department of Engineering and Technical Services
DWE	Department of Wastewater Engineering
EPA	Environmental Protection Agency
OMAP	Operations & Maintenance Assistance Program
PDE	Project Design Engineer
PDM	DC Water Project Design Manual
PM	Program Management

PROJECT DESIGN MANUAL
VOLUME 2 – FACILITIES DESIGN

1. GENERAL

1.1 PROJECT DESIGN MANUAL OVERVIEW

This Project Design Manual (PDM) is the primary guidance document for the design of the projects that comprise the Capital Improvement Program (CIP) of the District of Columbia Water and Sewer Authority (DC Water). It presents design criteria, standards, procedures, and management methods to be used for the design of all facilities encompassed in the program. The goal is to ensure that designs of all projects will not only meet DC Water standards, but that various projects designed by different designers will consistently conform to the same design standards, and thus facilitate integration of different projects for coordinated systems. To be effective, the manual must be followed by all Project Design Engineers (PDEs), and the in-house design staff participating in the design.

This manual is organized into three (3) volumes, as follows:

- **Volume 1 - Project Management -** describes the overall design goals, organization, and technical approach established for the program. It also identifies reference documents that are relevant to the management and execution of design projects, and addresses requirements common to facilities projects and infrastructure projects such as value engineering, demolition, preparation of specifications, web-based document management, quality control/quality assurance, and others as applicable.

- **Volume 2 - Facilities Design -** provides guidance to be used by engineers responsible for design of *facilities* at the Blue Plains Advanced Wastewater Treatment Plant (AWTP) and offsite water and sewer pump stations and facilities.

- **Volume 3 - Infrastructure Design -** provides design guidelines to be used by engineers responsible for design of water and sewer *infrastructure* projects.

The Project Design Manual is intended to be a working document, as it will be subject to periodic modifications as deemed appropriate. All PDEs and DC Water staff are encouraged to recommend amendments to the manual that will improve its usefulness to all designers. Comments and suggestions for improvement can be submitted online through the DC Water website, to the DC Water Specifications and Standards SharePoint, or may be forwarded to:

Supervisor, Specifications and Standards
Department of Engineering & Technical Services
DC Water and Sewer Authority
5000 Overlook Avenue, S.W.
Washington, DC 20032

Appendix A contains a Design Manual Change Request form which may be used to facilitate communication and consideration of any proposed changes to the design manual.

Technical guidance updates and Project Design Manual revisions shall be distributed to PDEs who are under contract at the date of issue. The technical guidance may originate through comments resulting from the Department of Engineering and Technical Services (DETS), the Department of Wastewater Engineering (DWE), or Program Management (PM) reviews or may be the result of suggestions from users of the manual. If the PDE takes exception to design contract specific approaches, standards, or comments, the PDE should submit a written notice and explanation, and the PM will coordinate resolution of such exceptions with the PDE, Construction Management (CM), Operations & Maintenance Assistance Program (OMAP), DETS, and other DC Water Departments.

Volume 2, Facilities Design, is developed to provide uniform technical guidance for DC Water's in-house design staff and all participating PDE firms and to establish design criteria and standards for producing consistent and cost effective designs. The objectives are to obtain competitive construction bids, minimize construction issues and provide safe, reliable, flexible and functional facilities that can be operated efficiently and maintained cost effectively.

Projects for DC Water will include new facilities and rehabilitation and retrofit of existing facilities, and will require innovative approaches to maximize the use of the existing facilities. Many projects are expected to be ongoing simultaneously at various stages of design and construction. The requirement to keep the plant in operation and provide an acceptable level of treatment during construction needs to be met. Therefore, knowledge of existing conditions and constraints will be critical to produce a coordinated and cost effective design.

Projects at Blue Plains AWTP and at other DC Water facilities may be managed by DWE, the Department of the Clean Rivers Project, or by a PM consultant. When a project is assigned to a PM, the PM team acts as an extension of the DC Water staff and manages the PDE firms engaged in facilities design.

1.1.1 Deviations

If the designer wishes to propose any design deviations from the requirements and guidelines outlined in the PDM, the designer shall follow the protocol for proposed deviations as presented in PDM Volume 1.

1.1.2 Existing Drawings, Reports and Data

DC Water will provide copies of available technical reference documents on the existing facilities commensurate with the design scope of work. See PDM Vol. 1 for more information, including the types of existing records available.

The information provided by DC Water is for the sole purpose of helping the designer become familiar with the existing conditions and is not guaranteed. The designer shall verify existing information by performing field investigations as necessary and obtain whatever additional information is required to perform the contracted design work.

1.2 SUBMITTAL REQUIREMENTS

In most cases, and especially for work at the Blue Plains AWTP, the PDE will be supplied with a Concept Design Report (CDR) prepared either by or for DC Water, or the PM. It is intended that this report will be the starting point for the PDE's design work. See PDM Volume 1 for the typical contents of a CDR.

Each design project shall require several milestone technical submittals as listed in Volume 1, and in accordance with requirements stipulated in the DC Water Standard Professional Services Agreement for each design contract. Detailed requirements are also tabulated in Appendix B of this Volume.

An appropriate response in text and/or table format to address comments from the previous submittal is required with each subsequent design submittal.

1.3 MISCELLANEOUS REQUIREMENTS

Refer to Volume 1 – Project Management for requirements and procedures for the following topics generally applicable to both facilities projects and infrastructure projects:

- Demolition
- Value engineering
- Calculation requirements
- Specifications for bidding and construction
- Construction cost estimating
- Web-based document management (Contract Manager)
- Quality control and quality assurance, and reference to DETS Quality manual

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APPENDIX A

Project Design Manual Change Request Form

DETS Project Design Manual Change Request Form

Design Manual Vol No.		Section No. / Discipline	
Initial Requestor		Date of Request	
Submitted by		Submitted to	
Referred to		Date referred	
Draft Proposed Change		Drafted by	
Reviewed by		Date Reviewed	
ACTION		DATE	

Explanation of Requested / Proposed Change
Paragraph No.; Reason; Reviewer Comments; etc.

Additional Notes

Submit Change Requests to: DETS Supv., Specifications and Standards

APPENDIX B
DESIGN SUBMITTAL REQUIREMENTS

CONTENTS

Table B-1. Design Submittal Requirements – All Disciplines

DISCIPLINE	CONCEPT FINALIZATION (Preliminary Design Documents)	INTERMEDIATE (Mid-design Documents)	PRE-FINAL DESIGN (Agency Review Documents)	BACK CHECK SUBMITTAL	FINAL DESIGN (Bidding Documents)
ALL DISCIPLINES	• Preliminary Drawings. • Outline list of proposed specification sections, showing which are DC Water Guideline Specifications and which are PDE generated specs, using CSI Numbers/Titles format. • Design analysis and report including any exceptions to the conceptual design report with supporting data for review. • Preliminary calculations. • Preliminary bill of quantities and construction cost estimates. Note: No major design changes and deviations from design standards allowed after this review without DC Water approval. The submittal shall be sufficiently complete for Value Engineering Study.	• Incorporate comments from the previous submittal and Value Engineering Report. • Updated design drawings with all dimensions, abbreviations, nomenclature, legends, general and all discipline related notes. • Updated design analysis, calculations and report. • Draft Specifications, including all Divisions 00 and 01 and all technical sections. • Updated bill of quantities and cost estimate. Note: The design submittal shall be sufficiently complete for the development of construction schedule and cost estimate.	• Incorporate comments from the previous submittal. • Complete final drawings and specifications which have been reviewed for quality assurance and revised accordingly by the designer. • Complete design calculations duly certified by the designer. • Updated Design Report. • Construction CPM schedule • Updated bill of quantities and construction cost estimate Note: This submittal shall be complete in all respects except addressing comments from Project Manager, DC Water, EPA and other regulatory agencies.	• Incorporate comments from Pre-Final review • Incorporate comments from DC Water, EPA and regulatory agencies • Updated Design Calculations. Note: This submittal shall be complete in all respects ready for bidding except final information from DC Water.	• Incorporate comments from DC Water • Update Davis Bacon wages • Sign and seal contract documents. Note: This submittal shall be complete in all respects ready for bidding.

* The submittal requirements for Back Check and Final stages of the design for individual disciplines are the same as stated herein.

Table B-2. Design Submittal Requirements - Civil, Including Geotechnical

DISCIPLINE	CONCEPT FINALIZATION (Preliminary Design Documents)	INTERMEDIATE (Mid-design Documents)	PRE-FINAL DESIGN
CIVIL (Including Geotechnical)	• A detailed list of criteria furnished, permits, codes, documents and design condition used, and references to any authorized waiver of criteria and codes. • Justification and backup information on types of pipes, drainage structures, curbing and pavements. • Detailed calculations for sizing site utilities including drainage, water and wastewater. • Roadway design calculations. • Catalog cuts for all major construction materials. • Location plan, site plan, roadway layout plans, building layout plans, utility plans, landscaping plans and standard details. • A geotechnical report including calculations as applicable, for: o Bearing capacity o Lateral pressure diagram Filter design criteria Pile, caisson or deep foundation capacity, settlement o Seismic design criteria o Potential lateral movement	• Completed roadway plans with profiles and all the geometry necessary to construct the roads, sidewalks and parking areas. • Completed location plans including all dimensions for locating the proposed structures. • A draft of civil/site specifications. • Additional details needed to complete the detail sheets and general notes attached to the plans.	• Final layout plans with dimensions to locate each structure and grid coordinates for structures. • Final grading plan with spot elevations. • Final utility plans showing all utilities. • Final roadway plan and profile sheets with all required geometry to lay out roads, sidewalks and other structures. • Final civil and site specifications. • If applicable, citations for all textbooks, handbooks and other references used in the design analysis with page numbers from which the data is obtained. • Roadway geometry calculations for all horizontal and vertical curves, as applicable. • Calculation for sizing all utility system including both hand calculations and computer printouts. • Final geotechnical report.

Note: Requirements for Back Check and Final Submittals are the same as those listed in Table B-1, All Disciplines on page 2-1-B-2.

Table B-2. Design Submittal Requirements - Civil, Including Geotechnical (continued)

DISCIPLINE	CONCEPT FINALIZATION (Preliminary Design Documents)	INTERMEDIATE (Mid-design Documents)	PRE-FINAL DESIGN
CIVIL (Continued)	• Include the following data and recommendations in the geotechnical report: o Final boring logs, in-situ and laboratory test data, and interpretive subsurface cross-sections. Type of foundation and allowable foundation pressures (including discussions of alternatives considered). o Settlement predictions for shallow foundations and friction piles. o Selection of installation method (including discussions of alternatives considered). o Selection of type, size, and capacity of deep foundation. o Observed and design groundwater levels; and the 100 year flood level. o Methods for controlling artesian pressure including relief wells and rock grouting. o Relief valve type and spacing. o Subdrainage system details if drainage is used to relieve hydrostatic pressure. o Unit weight of soil, both total and submerged weights. o Methods of dewatering excavations during construction. o Type of earth-retaining structure (piles, pier, tie-back walls, slurry walls). o Equivalent fluid pressure for active, at rest, & passive conditions for below grade structural elements. o Dynamic lateral earth pressures exerted on permanent structures. o Earth-pressure diagrams using the total weight concept for ground support structures required temporarily to protect existing facilities. ▪ Coefficient of friction versus sliding. ▪ Structural backfill. ▪ Protection of underground structures from corrosion or attack by chemicals in the soil and groundwater. ▪ Frost protection and foundation preparation. ▪ Use of excavated soil and rock and disposal of the surplus. ▪ Considerations during construction. ▪ Geotechnical instrumentation and monitoring program including number and type of instruments and monitoring schedule. • Environmental protections including dust control, noise control, & air permitting • Outline list of specifications and preliminary design details. • Provide a hydraulic profile, showing the maximum liquid levels through the entire facility. • Stormwater management requirements. • Erosion and sediment control requirements.		

Note: Requirements for Back Check and Final Submittals are the same as those listed in Table B-1, All Disciplines on page 2-1-B-2.

Table B-3. Design Submittal Requirements – Architectural

DISCIPLINE	CONCEPT FINALIZATION (Preliminary Design Documents)	INTERMEDIATE (Mid-design Documents)	PRE-FINAL DESIGN
ARCHITECURAL	• Plans of all floors, mezzanines, roofs and reflected ceilings showing: o Room and function designations. o All floor, wall and roof openings. o Location of major equipment. • Building sections in adequate number to allow all disciplines to visualize the structures in the three dimensions and to facilitate construction. Building sections shall indicate: o Most vertical and horizontal dimensions. o Horizontal and vertical clearances. • Show all elevations including hidden ones. These drawings shall incorporate: o Vertical dimensions. o All fenestration. o Relation to the ground. • Partial (enlarged) plans where smaller-scale plans are inadequate, plans of areas such as laboratories and sanitary facilities shall include detailed dimensions and descriptions.	• Drawings with full complement of fenestrations located by dimensions and : o Corrected to the latest configuration. o Coordinated with structural grid. o Fully dimensioned horizontally. o Fully dimensioned vertically with relation to adjacent existing or new grade. • Partial plans: o Fully dimensioned, cross-referenced and scribed. Coordinate partial plans for laboratories with laboratory specialists and with laboratory furniture and equipment schedules. Indicate all furniture on enlarged plans of offices and check plans against the office furniture schedule for consistency. • Check interior elevations against refined and supplemental plans.	• Stair Details o Cross-reference details with "stairs" drawings by location on stair plans and sections. o Tread and riser configuration. o Stringers, stiffeners, and curbs. Stair railings, both stringer and wall-mounted. o Description of materials. o Other - railings, guard rails, posts, toe-plate, and rung. o Details • Fenestration Details will cover all details related to doors, transoms, windows, louvers, vision panels, glazed curtain wall and related insulated panels: o Fenestration types and elevations. o Vertical and horizontal dimensions. o Masonry dimensions and clearances. o Mounting types. o Related miscellaneous metals and flashings. o Materials. o Cross-references to appropriate schedules or fenestration type.

Note: Requirements for Back Check and Final Submittals are the same as those listed in Table B-1, All Disciplines on page 2-1-B-2.

Table B-3. Design Submittal Requirements – Architectural (continued)

DISCIPLINE	CONCEPT FINALIZATION (Preliminary Design Documents)	INTERMEDIATE (Mid-design Documents)	PRE-FINAL DESIGN
ARCHITECTURAL (Continued)	• Wall sections. Design typical and basic wall sections to include: o Location on plans. o Grid or references lines. o Building systems. o Relation to floor and roofs. o Relation to wall openings. o Vertical dimensions. o Thicknesses. o Major materials and construction elements with a description of each title or number designation. • Outline list of applicable specification sections based on DC Water Guideline Specs and CSI Numbers/Titles format. Note: PDE is responsible for coordinating with the DC Fire Marshal's office and providing life safety/fire safety information and data on items such as building occupancy, class of materials, gross and net square feet tabulations, and egress/fire lanes during the progress of the design work as required.	• Stairs o Plans at all levels two full height sections (all fully dimensioned, vertically and horizontally and cross-referenced with related building sections). • Wall sections o Include supplemental wall sections as necessary. o Cross-reference lines. o Grid and reference lines. o Indication of building system (structural elements) and connections to it o Relation to floors, roofs, and wall openings. o All vertical dimensions. o Material description. o Wall reinforcement, nominal and for seismic condition. o Exterior and interior finishes. • Draft specifications o This stage of specifications will elaborate on the contents of the previously submitted and supplemental (as necessary) specification section list. Include all elements, materials and their application to the project and organize appropriately in each section.	• Door schedule • Hardware schedule • Finish schedule • Wall reinforcement o Nominal and for seismic condition. o Exterior and interior finishes. • Completed final plans and specifications with following actions taken: o Incorporated comments from previous submittal o Coordinated interdisciplinary reviews and incorporated reviews. o Coordinated nomenclature and cross-reference between drawing schedule and specifications on an interdisciplinary level. o All titles and title block. Final interdisciplinary checking of drawings and specifications and final revisions.

Note: Requirements for Back Check and Final Submittals are the same as those listed in Table B-1, All Disciplines on page 2-1-B-2.

Table B-4. Design Submittal Requirements - Structural

DISCIPLINE	CONCEPT FINALIZATION (Preliminary Design Documents)	INTERMEDIATE (Mid-design Documents)	PRE-FINAL DESIGN
STRUCTURAL	• Structural drawings shall show: o Major openings on plans. o -Show column coordinate system, letters, and numbers on plans. -Show roof pitch and big- and low-point elevation on plans. -Locate and show all expansion joints on plans. o -Indicate slab thickness and reinforcement -Indicate beam size & reinforcing in beam schedule. -Place slab and beam schedules on the same plans to which they apply. • Structural calculations. • Outline list of specifications. The structural engineer shall document the following information from other disciplines to perform a well integrated design. Architectural o Final overall building size. o Final column spacing based on conceptual design to be modified as required to respond to client's and project design team's comments and as agreed upon by the structural engineer. o Sizing for all major openings such as stairs, elevators, hatches and roof skylights. o Typical exterior wall sections. o Interior partition materials. o Anticipated floor depressions. o Roof pitches for relatively flat roofs, in coordination with the plumbing engineer, and ballast requirements. o Roof slopes for pitched roofs. o Location and size of knock-out panels.	• Incorporate comments from previous submittal. • Expand upon the concepts developed at concept finalization stage. • The drawings shall include structural notes. • The drawings shall indicate all expansion joints. • The drawings shall show all openings of 4" or larger. • The drawings shall graphically indicate center lines of openings smaller than 4". • The drawings shall show all design loads. • Draft specifications. • Updated design calculations.	• Final plans and specifications. • Final certified design calculations. • Final design analysis and report.

Note: Requirements for Back Check and Final Submittals are the same as those listed in Table B-1, All Disciplines on page 2-1-B-2.

Table B-4. Design Submittal Requirements – Structural (continued)

DISCIPLINE	CONCEPT FINALIZATION (Preliminary Design Documents)	INTERMEDIATE (Mid-design Documents)	PRE-FINAL DESIGN
STRUCTURAL (Continued)	<u>Mechanical</u> o Final inside dimensions of all tanks and galleries. o Lifting hook locations and lift capacity. o Monorail locations; lift capacity and manufacturer's literature. o Bridge crane locations; lift capacity and manufacturer's literature. o Discussion of pipe sizes for pipes hung from the underside of the structural frame. o Location, weight, rotational speed or speeds, and equipment manufacturer's literature for all large process equipment. o Location and size of openings in concrete walls for sluice and slide gates. o Locations and sizes of pipe penetrations through walls (> 24" pipes) and through mats and suspended slabs (>10" pipes) o Location and size of knock-out panels. o Floor pitches in channels and tanks. <u>Geotechnical</u> (in preliminary memo-design format) Lateral soil pressures above and below groundwater. o Seismic design criteria o Dynamic lateral soil pressure during an earthquake. o Coefficient of friction against sliding for both static and dynamic load. o Normal and flood groundwater elevations. o Net allowable soil-bearing capacity at the foundation level for mats, spread footings, and continuous wall footings; elevation of soil-bearing capacity. o Minimum footing widths. o Recommended type of foundations, whether shallow or deep, piles or caissons, etc. o All peculiar conditions of the soils which might influence the structure. o Pile type, size, tip elevation, and capacity in compression and tension. o Minimum caisson shaft size, belling criteria, bearing capacity, and bearing elevation. o Boring logs with notation of bearing elevation for both shallow and deep foundations and a boring location plan. o Unit weights of existing soil, backfill soil, and any borrow material.		

<u>Note:</u> Requirements for Back Check and Final Submittals are the same as those listed in Table B-1, All Disciplines on page 2-1-B-2.

Table B-4. Design Submittal Requirements – Structural (continued)

DISCIPLINE	CONCEPT FINALIZATION (Preliminary Design Documents)	INTERMEDIATE (Mid-design Documents)	PRE-FINAL DESIGN
STRUCTURAL (Continued)	• Upon completion of the structural design and prior to the PM review submittal, the geotechnical engineer shall review submittal, the structural foundation plans and sign prints. The geotechnical engineer shall issue a final geotechnical memo/design report for the record which will include all revised criteria made during the design phase of the project. • Civil o Coordinate structure elevations and openings with proposed finish grades. • Electrical o The location, weight, speed and manufacturer's criteria literature for electrical equipment such as generators, motor control centers (MCC), switchgears, and transformers. o Location and size of duct banks through walls and floors. Note: The interdisciplinary information required for the well coordinated and cost effective structural design, as described herein, is typical and is generically applicable to all disciplines.		

Note: Requirements for Back Check and Final Submittals are the same as those listed in Table B-1, All Disciplines on page 2-1-B-2.

Table B-5. Design Submittal Requirements – Mechanical Process

DISCIPLINE	CONCEPT FINALIZATION (Preliminary design documents)	INTERMEDIATE (Mid-design documents)	PRE-FINAL DESIGN
MECHANICAL PROCESS	• A list of all design conditions and codes used. • Final conceptual design criteria, including minimum, average, and maximum requirements. Operating ranges for all equipment and piping. • A **description** of each system, including location and specifics of its operation and system curves and pump selections for all major pumping systems. • An updated equipment list showing design capacities, weights, dimensions, and design basis vendors and model numbers of all equipment used for the concept design. • Catalog data for each piece of equipment. • Proper tagging, according to facility and service. • A piping schedule showing service, materials, valve types and insulation requirements. • System schematics, where applicable, for auxiliary systems such as tank dewatering, channel aeration, and chemical feed system. • Outline list of specifications.	• Catalog cuts of all major equipment • Calculations of major systems • All equipment and piping schedules. • A list of the standard details to be used and a list of other details that will be developed. • Draft specifications for all sections. • The drawings shall include all plans, sections, schematics, isometrics and all details. • Include specifically: o Equipment schedules for all equipment. The schedules may be included as part of the report or shown on the drawings. o Isometric drawing of the equipment, piping, and valves for each chemical system. • Design calculations.	• The design, plans and specifications complete in all respects except incorporating review comments from the PM and DC Water. • Final design calculations, cite all references used and include them in computations. • In the design analysis, include notes explaining the rationale for sizing and design that would not be obvious to an engineer reviewing the analysis. • Completed specification sections. • All equipment and piping schedules in their final forms. • Complete pipe support analysis and the support scheme shown on the drawings. • All review comments tabulated and answered. • Ensure that all interfaces between disciplines have been coordinated and checked. • Clearly show all contract limits on drawings. • Include finalized equipment and piping schedules on drawings.

Note: Requirements for Back Check and Final Submittals are the same as those listed in Table B-1, All Disciplines on page 2-1-B-2.

Table B-5. Design Submittal Requirements – Mechanical Process (continued)

DISCIPLINE	CONCEPT FINALIZATION (Preliminary Design Documents)	INTERMEDIATE (Mid-design Documents)	
MECHANICAL PROCESS (Continued)	• The drawings shall include: o A sufficient number of sections to properly present the systems required. o A legend sheet with all legends and symbols. o General notes for review. o All chemical systems shown as follows: a. Plan and section showing tanks, pumps and other equipment. b. Long runs of piping shown in plan and section with all other process piping. c. Any enlarged plans of congested areas required to show the equipment layout in sufficient detail. d. Location of all equipment and piping in both vertical and horizontal sections. e. Location of all major pipe support framing, base elbows, and base tees. • Design calculations.		• All drawings must be complete in all respects with locations of all equipment, piping and pipe supports. • Include all final plans, sections, enlarged plans, schematics, isometrics, schedules and all details required to obtain accurate and competitive bids and to provide a clear understanding throughout the construction phase of the project.

Note: Requirements for Back Check and Final Submittals are the same as those listed in Table B-1, All Disciplines on page 2-1-B-2.

Table B-6. Design Submittal Requirements – Plumbing

DISCIPLINE	CONCEPT FINALIZATION (Preliminary Design Documents)	INTERMEDIATE (Mid-design Documents)	PRE-FINAL DESIGN
PLUMBING	• When applicable, provide: o Detailed calculations for sizing equipment, piping, water treatment systems, and other items for each plumbing system required for the design. o Data showing the capacity of hot & chilled potable water circulating pumps. o Any information or computations required to permit verification that the design complies with the design criteria, codes, and standards and is satisfactory for the intended purposes. o Catalog cuts for all major items of equipment; catalog cuts will be a part of the design analysis. o Outline list of specifications. • The drawings shall include, as applicable: o -Enlarged partial plans and riser diagrams of typical toilet rooms including hot water, cold water, waste, and vent piping. o Locations and arrangement of all plumbing fixtures and equipment. o Layout of domestic water, sewer, roof drainage, and all other piping systems used in the building, including sections and details, especially of congested areas. o Flow diagrams of air systems for all air operated equipment, such as air compressors, accessories, pipe, tubing, & control valves.	• Include as applicable: o Complete plumbing plans & riser diagrams. o Plumbing specifications. o All diagrams, details, and schedules related to plumbing. o Any plumbing schematics related to equipment arrangement & configuration. o Updated design calculations. • Plans shall be complete in all respects showing location of all equipment, piping, and accessories including required sections and details to clearly show all aspects of the system design. • Include the following items as applicable: o -Schematic flow or riser diagrams of all systems. o Equipment room layouts and appropriate sections and details o Pipe sizes. o Equipment to be furnished and/or installed. o Equipment schedules with capacities, working temps & pressures, & other pertinent data for give clear and concise description of all equipment. o Vertical control for horizontal guns of piping, clearly delineated on the drawings.	• When applicable: o Cite all textbooks, handbooks and other references used in the design and analysis, citing page and/or paragraph numbers from which data is obtained. o Indicate the basis for determining the quantity of water. o Show domestic water pump gpm, TDH, horsepower calculations for chilled drinking water, and hot water recirculating pumps; tabulate the friction losses in the water circuits and pipe sizing. o Show the method of sizing hot water heaters. o Show equipment sizing calculations to support the selection of all equipment in the design analysis. o Include explanatory notes in the design analysis covering all rationale for design that would not be obvious to an engineer reviewing the analysis. o Submit complete catalog cuts and data sheets for all major items of equipment; catalog cuts will be a part of the design analysis.

Note: Requirements for Back Check and Final Submittals are the same as those listed in Table B-1, All Disciplines on page 2-1-B-2.

Table B-7. Design Submittal Requirements - HVAC

DISCIPLINE	CONCEPT FINALIZATION (Preliminary Design Documents)	INTERMEDIATE (Mid-design Documents)	PRE-FINAL DESIGN
HVAC	o Final design criteria used for all system sizing. o Detailed descriptions of all systems including system selection rationale and preliminary control system descriptions. o Preliminary calculations including "U" value calculations for wall and roof sections, heat loss and gain calculations, ventilation calculations including heating requirements, duct and piping pressure-loss calculations for major duct and piping runs, and preliminary equipment sizing calculations. o Updated master equipment list showing all equipment with proper tag numbers. o Outline list of specifications, indicating which sections are DC Water Guideline sections, and which are PDE generated sections. • Provide o Plans showing all equipment labeled by tag number, ductwork, piping. o Sufficient number of sections to clarify the design intent. o Flow diagrams for any complicated systems, as required for clarity or as directed by the PM. o A legend sheet with all symbols and abbreviations and general notes for review. o Enlarged plans of mechanical rooms and congested area showing the equipment layout in detail.	• Provide: o Draft specifications for all sections. o Final descriptions of all systems incorporating comments from the previous submittal, including detailed sequence-of-operation descriptions for all control systems. o Revisions of any calculations, as required by comments on the previous submittal. o Detailed pressure-loss calculations for all fan, duct, and piping systems. o Final heat-loss and heat-gain calculations for all areas; for air conditioned areas, use energy analysis software with the modified bin method to accurately account for heat gains in each zone. o Final equipment sizing calculations for all equipment. o Written responses to all comments from the previous submittal. o Drawings with all plans, sections, floor diagrams, & required details. o Control schematics with sequence - of- operation descriptions for all systems.	• Cite all references used or include them in the computation. Catalog cuts of all equipment. • Include design analysis with discussion on any rationale for sizing and design that would not be obvious to the reviewer. • Tabulate response to review comments from previous submittal • Ensure interfaces between all disciplines are properly coordinated and reflected in the submittal documents • Complete & final drawings: o All plans, sections, enlarged plans, flow diagrams, control schematics, and details required to obtain accurate and competitive bids and to afford a clear understanding of the project throughout the construction phase. o Clear delineation of all contract limits. o Final equipment schedules.

Note: Requirements for Back Check and Final Submittals are the same as those listed in Table B-1, All Disciplines on page 2-1-B-2.

Table B-8. Design Submittal Requirements - Instrumentation

DISCIPLINE	CONCEPT FINALIZATION (Preliminary Design Documents)	INTERMEDIATE (Mid-design Documents)	PRE-FINAL DESIGN
INSTRUMENTATION	• Provide in report format: o Detailed calculations and catalog data for each piece of equipment. o Detailed description of operation including interlocks, local, and remote controls. o Locations of major inline instruments. o Control panel dimensions. o Outline list of specifications, indicating which sections are DC Water Guideline sections and which are PDE-generated or custom sections. • Drawings shall include: o All equipment labeled by tag numbers. o A legend sheet with all symbols and abbreviations and general notes for review; use the standard legend. o Preliminary piping and instrumentation drawings. o Preliminary control room layouts.	• Include in report format: o Draft specifications, all sections. o Final descriptions of all systems incorporating comments from the previous submittal. o Revisions of any calculations as required by comments on the previous submittal. • Drawings shall include: o Detailed, complete P&IDs. o Detailed panel layouts. o Detailed control room layouts. o Locations of all instruments.	• Submit completed final design with updated drawings including detailed and completed P&IDs, panel layouts and control room layouts. • Include in report format: o Final design analysis with review comments incorporated. o All review comments, tabulated and answered. o Instrument data sheets. o Computer input/output schedule. o Process control algorithms. o Cite all references. o Discussion on any rationale for sizing and design that would not be obvious to the reviewing engineer. o Catalog cuts of all equipment.

Note: Requirements for Back Check and Final Submittals are the same as those listed in Table B-1, All Disciplines on page 2-1-B-2.

Table B-9. Design Submittal Requirements – Electrical

DISCIPLINE	CONCEPT FINALIZATION (Preliminary Design Documents)	INTERMEDIATE (Mid-design Documents)	PRE-FINAL DESIGN
ELECTRICAL	• Update conceptual design report clearly delineating all necessary revisions and modifications. • Review and modify all 15-kV, 5-kV, and 480-V equipment assigned to electrical distribution equipment (buses). • Identify the types of required calculations. • Update the electrical motor and load list. • Preliminary calculations on the power distribution system to size main buses, breakers feeding this equipment and main feeder cables. • Choose fixture types, perform preliminary lighting calculations to determine fixture quantities and locations. • List the final drawings required for site plan(s), single line diagrams, power, grounding, and lighting plans. • Preliminary single line diagrams. • Preliminary power and lighting plans, including the development of metering and protective relaying. • List of exceptions and major modifications. • Outline list of specifications to be used. • Typical calculations for each calculation type listed. • Updated preliminary drawing list. • Preliminary design drawings, as applicable. • Main single line diagram. • Switchgear single lines and outline elevations. • Motor control center single lines and outline elevations. • Typical power plan and typical lighting plan shown on the same sheet.	• Responses to all comments on the previous submittal • Updated electrical motor and load list • Preliminary calculations for the sizing of all switchgear buses, motor control center buses, main breakers, and cable feeding these buses including voltage drop calculations on the feeders • A list of all wiring diagrams to be provided with typical diagram • A list of all riser diagrams to be provided with typical diagram • Draft specifications of all sections. • All single line diagrams with their associated equipment elevations. • All power and lighting plans. • Typical conduit and wire schedules and typical panelboard schedules shown on one sheet. • Instrument diagrams.	• Responses to the comments on submittal. • All specifications (complete) • All calculations (complete) • All drawings (complete)

Note: Requirements for Back Check and Final Submittals are the same as those listed in Table B-1, All Disciplines on page 2-1-B-2.

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DISTRICT OF COLUMBIA

WATER AND SEWER AUTHORITY

(DC Water)

"SERVING THE PUBLIC - PROTECTING THE ENVIRONMENT"

PROJECT
DESIGN MANUAL
VOLUME 2 - FACILITIES DESIGN

SECTION 2 – CIVIL

August 2018

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AUTHORIZATION FORM

Revision Number	Date	Content
Draft 3	1999	Site work, Utilities, Geotechnical, Environmental
Draft 4	2001	Site work, Utilities, Geotechnical, Environmental
Draft 5	2/6/2012	Site work, Utilities, Geotechnical, Environmental
2013	3/1/2013	Site work, Utilities, Geotechnical, Environmental
2014	7/31/2014	Site work, Utilities, Geotechnical, Environmental
2016	3/8/2016	Site work, Utilities, Geotechnical, Environmental
August 2018	7/30/2018	Site work, Utilities, Geotechnical, Environmental

This 2018 version was authorized by:

S. Bian 12/20/18

Steve Bian PE, Supervisor, Civil, Structural Design Date

SECTION 2, CIVIL LOG OF REVISIONS (Revisions from 1999 Draft 3 version)		
Paragraph	**Brief Description of Revision**	**Comments**
Global	Changed “DC WASA”/“WASA” to “DC Water” Changed “EPMC” to “PM”	2012
2.2.1 General Rqmts for Civil Dwgs	Addressed multiple vertical datums in Washington Metro area. Clarified Blue Plains plant north and true north outside of Blue Plains site.	2013
2.3.1 Codes and Regulations	Updated names; deleted dates of standards/codes, and added reference to “latest edition.”	2013
2.3.3 Buildings and Structures	Added: 2.3.3.1 Flood Plain 2.3.3.2 Water and Sewer Structures	2013
2.3.4.6 Pavement Design	Reinstated HS20 design loading criteria.	2013
2.3.4.12 Open Storage Area	Added reference to DDOE Toxic Substances Division requirements.	2013
2.3.8.4.1 Settlement	Added caution to consider potential lateral movement.	2013
2.3.9 Environmental Considerations	Added: 2.3.9.1 Dust Control 2.3.9.2 Noise Control 2.3.9.3 Air Quality Permitting	2013
2.3.9.3	Added Figure 2-2-1. Project screening chart for air permits	03/08/2016
2.3.7	Reference to Vol. 3 for thrust restraint design	07/20/2018

SECTION 2 - CIVIL
TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMNS AND ABBREVIATIONS

AAN	American Association of Nurserymen
AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
ANSI	American National Standards
AOAC	Association of Official Agricultural Chemists
ASCE	American Society of Civil Engineers
ASNS	American Standard for Nursery Stock
ASTM	American Society for Testing and Materials
AWTP	Advanced Wastewater Treatment Plant
CAD	computer-aided design
dB	Decibel
DC	District of Columbia
DCDWP	District of Columbia Department of Public Works
DDOE	District of Columbia Department of the Environment
DDOT	District of Columba Department of Transportation
DETS	Department of Engineering and Technical Services
HAPS	hazardous air pollutants
ICC	International Code Council
lbs	pounds
LIS	Location Information System
LUST	leaking underground storage tank
mph	miles per hour
MOP	Manual of Practice
OSHA	Occupational Safety and Health Act
PC	point of curve
PDE	Project Design Engineer
PI	point of horizontal intersection
PT	point of tangent
PVC	point of vertical curves
PVI	point of vertical intersection
PVT	point of vertical tangent
SPN	Standardized Plant Names
SU	single-unit
UST	underground storage tank
VOCs	volatile organic compounds
WB	wheelbase

PROJECT DESIGN MANUAL
VOLUME 2 – FACILITIES DESIGN

2. CIVIL

2.1 INTRODUCTION

This section presents general technical guidance for civil/site and geotechnical design. Those items covered include roads, sidewalks, parking, grading, drainage, site utilities, landscaping, topography, bathymetrics, geotechnical, vertical and horizontal control, and the location coordinate system. The civil requirements outlined in this section are general in nature and apply to all design projects. Specific civil requirements for each design project will be developed during the concept or preliminary (if there is no concept design) design stage and presented in individual concept finalization reports.

The arrangement of facilities must be integrated with project sites to achieve optimum land use, good functional relationships, environmental harmony, and a pleasant appearance. Particular attention is required in the design of landforms, roadways, and layouts of facilities to minimize visual, noise, and odor impacts on the site and surrounding areas.

2.2 FORMATS

2.2.1 General Requirements for Civil Drawings

When preparing contract documents, adhere to the standards described in Section 2.3, Technical Guidelines. Prepare base plans showing pertinent information from the field survey, including benchmark(s), survey control point locations, and datum references. The designer shall be aware there are multiple vertical datums used in the Washington Metropolitan area. Verify the proper datum to be used for each project outside of Blue Plains. Blue Plains projects shall be based on the District of Columbia (DC) Datum (vertical). Ensure that all construction plans for any project are consistent with the accepted datum. Develop site grading to ensure proper drainage. Critical spot elevations must be located and indicated in relation to a survey control point, structure, or road baseline. Show the following items on the drawings:

- Interrelationships of buildings, streets, parking areas, fences, and utilities.
- Sizes of all new or existing utilities to service new facilities and the locations of connections to existing lines.
- Sizes of all new drainage facilities with controlling grades.
- Proposed locations for access and egress to all facilities.
- Horizontal layout for fencing.
- Project north arrow and key plan; true north only appears on the cover sheet of the drawings. For the Blue Plains Advanced Wastewater Treatment Plant (AWTP), project north is based on the Location Information System (LIS) grid for the site. For other projects, north shall be based on the Maryland State Plane Coordinate System.
- The location plan shall show the project area with a sheet location index and the true north arrow.
- Plans shall be oriented with true north to the top or the left of the drawings. The north arrow shall be shown at the top left corner of the plans.
- Vertical profiles of roads, paved areas, sanitary sewers and storm drains.

- Vertical profiles for water mains 16 inches in diameter or greater, and for all water mains where heavy congestion of utilities occurs.
- Details of utility crossings where required.
- Locations of all site and utility structures.

For each type of roadway, develop typical sections according to level of service. These sections shall show dimensions, pavement structure requirements, and methods of meeting existing grades for the various site conditions. Where possible, structures should be located by horizontal coordinates. Locate reinforced concrete structures in relation to the face or centerline of a wall. Locate steel structures by column centerline. Locate roads based on a centerline horizontal alignment. Establish a baseline to locate large paved areas.

For location purposes, all site structures should be properly dimensioned. Provide adequate dimensions so that nothing has to be scaled from the drawing. However, avoid repetitive dimensioning between various civil, structural and architectural drawings.

Include specific requirements for materials in the technical specifications, not on the drawings. Requirements on drawings should be carefully coordinated with technical specification requirements. Provide clear and sufficient cross-referencing of details to plan sheets.

The following items must be adequately shown, defined and coordinated with other sections of the contract documents such as demolition, paving, landscaping, etc.

- Project Limits.
- Limits of new work, existing work to be abandoned and removed, and existing work to remain.
- Demolition items that are to be disposed of, stored, or reset.
- Disposition of all existing site items including those to remain.
- Limits of all grading work.
- Rights-of-way.

2.2.1.1 Civil Legend, Abbreviations, Codes and Notes

The drawings shall include a civil legend, list of abbreviations, codes and notes. Standard abbreviations, symbols and codes are provided in DC Water Drafting Standards (CAD) Manual. Provide sufficient details to identify and clarify symbols, line work, and abbreviations used throughout the drawings. Notes shall be provided on the drawings as necessary to further define or clarify civil requirements which may not be explicitly shown or covered by the drawings and specifications.

2.2.1.2 Topographic and Bathymetric Base Plans

Topographic and bathymetric base plans must reflect all existing features of a site so that proposed structures and other improvements do not interfere with features that will be retained and incorporated into the design. The drawing scales for base plans should be 1"=20' or 1"=40'. Where additional detail is needed, base plans at a scale of 1"=10' may be used. The base plan scale should be selected such that the same scale will be used for all subsequent site, grading, geometric, yard piping and landscaping plans. The base plans should also include the following data:

- Site survey showing existing topography, elevation contours, important spot elevations and all known benchmarks.

- Location of existing roads, utilities, buildings, and other features.
- Boring locations.
- Survey control points.
- North arrow (LIS) north at Blue Plains AWTP; project north at remote facilities).

2.2.1.3 Site Plans

The site plan shall show the layout of proposed structures, paved areas, fencing, storm drainage pipes and structures, and other proposed site features. Notes shall be provided as necessary to clarify proposed site work and cross-reference with other drawings and disciplines. For projects at the Blue Plains AWTP, use the LIS grid to name and locate facilities.

2.2.1.4 Grading Plans

Contour intervals of one or two feet will be appropriate for most situations. For grading plans, the designer shall:

- Verify that existing grading and spot elevations are correct and based on the proper datum.
- Show all existing and proposed structures on the grading plans
- Show roads, sidewalks, and parking areas.
- Include critical spot elevations as required for grading around buildings and other structures.

2.2.1.5 Geometric Plan

A geometric plan shall show the layout of major structures, paved areas, fence lines, etc. according to a grid coordinate system, roadway stationing and critical dimensioning. The geometric plan shall show survey traverse and/or baseline for locating new construction. Specify that the contractor shall reestablish any permanent survey monuments disturbed during construction.

2.2.1.6 Stormwater Management Plan - Details

Stormwater management facilities must be detailed on the drawings in accordance with DC Stormwater Management Regulations. Design standards are contained in the DC Department of the Environment (DDOE) Stormwater Guidebook, latest edition.

2.2.1.7 Erosion and Sediment Control Plans

The drawings shall show erosion and sediment control plans, details and notes in accordance with DDOE requirements and standards contained in the Standards and Specifications for Soil Erosion and Sediment Control, and the Erosion and Sediment Control Handbook, latest editions.

2.2.1.8 Yard Piping

Yard piping plans shall clearly identify all line sizes, type of service and direction of flow (where applicable). Yard piping shall include all exterior process piping, chemical piping, service water, potable water and sanitary sewer. Storm drainage piping shall be shown separately on the proposed site plan. A yard piping schedule shall identify pipe codes, sizes, type of service, materials, critical elevations and other pertinent information. (Coordinate with the process piping requirements discussed in Section 5, Mechanical Process.) Provide supplemental details, profiles and notes as necessary for clarification.

2.2.1.9 Landscape Plans

On the landscape plans, show all landforms, elevations, types of cover (i.e., trees, shrubs, and grasses), finished contours, roadways, sidewalks, retaining walls and seawalls. Where applicable, provide a planting material schedule.

2.2.1.10 Road Plans and Profiles

Road plans and profiles shall show all data required to construct the travel way. This includes, but is not limited to, curve geometry, pavement widths, stationing and offsets, elevations, contours, utilities, drainage structures and centerline profiles corresponding to the plan view. Separate road plans will not be necessary if the information can be shown concurrently on the grading plans. Road plans and profiles shall clearly show the following:

- Roadway name.
- Curve data for all horizontal curves (based on arc definition):
  - Deflection angle.
  - Degree of centerline curve.
  - Radius of centerline curve.
  - Length of centerline curve.
  - Tangent length.
- Centerline stationing for roadway, including all points of horizontal intersection (PI), points of curve (PC), and points of tangent (PT).
- Vertical curves with points of curve (PVC), points of tangent (PVT), and points of vertical intersection (PVI).
- Centerline grid-coordinate locations for beginning and end of the roadway, and for all points of horizontal intersection.
- Centerline bearings, based on the Blue Plains coordinate system, along all roadway tangents.
- Grades along centerline, positive and/or negative grades.
- Centerline elevation at every 100-foot station along roadway tangents and every 50-foot station at horizontal and vertical curves.
- Existing ground surface with areas of cut and/or fill distinguished.
- Existing and proposed streets and all watercourses or water surfaces, including contour lines at suitable intervals.
- The direction of flow in all watercourses, and high and low water elevations of all water surfaces at storm sewer outlets and overflows.
- The location, size, and direction of flow of all existing and proposed sanitary and existing combined sewers.
- The location, size, and direction of flow (if applicable) of all existing and proposed site utilities.

Where the roadway surface is well defined by standard cross-sections, an exaggerated scale of 10 on the horizontal to 1 on the vertical is typically used for roadway profiles. For instance, use a horizontal scale of 1" = 40' and a vertical scale of 1" = 4'. In critical pavement areas, along roadways and in parking areas, special cross-sections and/or expanded profiles (e.g., 1" = 20' horizontal and 1" = 2' vertical) may be used to better define the surface configurations.

When the roadway plan and profile are placed on the same drawing, the horizontal scale on the plan and the profile should be the same, with the stationing on the profile falling directly below the same stationing on the plan, to the extent possible.

Roadway stationing shall increase from left to right on separate profiles and on drawings with plan and profiles on the same sheet. For site orientation, provide north arrows for plans on drawings with both plan and profile on the same sheet. Roadway sections should always be drawn looking up-station. Thus, the left and right sides of the roadway on the plan and on the sections will always remain in the same orientation.

2.2.1.11 Piping Profiles

For piping profiles, use a drawing scale of 1" = 40' horizontal and 1" = 4' vertical. Larger scales may be used in congested areas to enhance clarity. Show invert and rim elevations and horizontal stationing. Show all utilities that cross the pipe being profiled. Several profiles may be placed on a single sheet if there is sufficient space. Show hydraulic grade lines where applicable.

2.2.2 Geotechnical Information

The geotechnical information generated for the project shall be documented in the design analyses, geotechnical reports (both factual and interpretive), and design details, and included on civil and structural drawings, and in the specifications. Formats shall be as follows:

2.2.2.1 Boring Logs and Samples

Boring logs shall be shown on the contract drawings. Include the following information:

- Name and address of boring contractor.
- Name of boring inspector.
- Name of driller and helper(s).
- Dates of beginning and completion of work.
- Boring number.
- Grid coordinates and ground surface elevation at boring location.
- Type and make of drill rig.
- Method of boring (hollow stem auger, wash, rotary bit, wireline coring, use of bentonite).
- Diameter of boring.
- Depth of casing.
- Weight and drop of hammer.
- Standard penetration resistance and sample depth.
- Description and classification of soil density, consistency, color, type, and elevation of occurrence.
- Elevation of groundwater after drilling and after 24 hours if the hole remains open.
- Percent of soil sample and rock core recovery.
- Depth and type of all undisturbed samples and in situ tests.
- Method of sample recovery.
- Any other information such as artesian pressure, gas, boulders and cobbles, and foreign objects, depth of topsoil, depth of fill, thickness of pavement.

Recovered soil samples and rock cores shall be preserved and stored by the geotechnical consultant and made available to DC Water upon request.

2.2.2.2 Test Data

Produce all test data, both in-situ and laboratory, in tabular or graphical form on 8½ by 11-inch or 11 by 17-inch data sheets. Each sheet and test shall be numbered and titled with appropriate notes and legends. Data shall be neat, orderly and logically arranged. Geophysical exploration data, if required, shall show profiles of the ground surface, major strata changes, the surface of bedrock, and fault zones.

2.2.2.3 Reports of Subsurface Explorations

Reports of subsurface explorations shall be prepared for use by the design engineers and for inclusion in the contract documents for use by construction contractors. The following information shall be included in these reports, where applicable:

- Introduction - Project Background.
- Existing Conditions: Structures, Topography, Geology, Site Preparation.
- Previous Subsurface Investigations.
- Subsurface Conditions.
- Exploration Program.
  - Geophysical Surveys.
  - Test Borings.
    - Soil and Rock Sampling.
    - In Situ Testing.
  - Groundwater Observations.
  - Laboratory Testing Program (Soil and Rock Testing).
  - Test Well Pumping Program.
- Appendices
  - American Society for Testing and Materials (ASTM) Standards used in field and laboratory testing.
  - Test Boring Logs.
  - Geophysical Data.
  - In Situ Test Data.
  - Groundwater Data.
  - Laboratory Test Results.
  - Test Well Pumping Data.
  - Cross Sections.
  - Unified Soil Classification.

2.2.2.4 Geotechnical Design Analysis Report

This report shall include data and recommendations for geotechnical design of the proposed facilities. Include computations where applicable. The following are typical topics and information for wastewater facilities:

- Final boring logs, in-situ and laboratory test data, and interpretive subsurface cross-sections.
- Soil design parameters pertinent to design, such as grain size distribution, Atterberg limits and related indices, consolidation test reports, and recommended values for:
  - Unit weight of soil, both total and submerged weights.
  - Effective friction angle.

  - Shear strength.
  - Allowable bearing pressure.
- Type of foundation and allowable foundation pressures (including discussions of alternates considered).
- Settlement predictions for foundations.
- Recommendations for passive earth pressures for use in stability calculations.
- Selection of type, size and capacities of deep foundations and anticipated driving lengths.
- Selection of installation methods (including discussions of alternates considered).
- Observed and design groundwater levels.
- Methods considered for controlling artesian pressure.
- Hydrostatic relief valve type and spacing.
- Subdrainage system details if drainage is used to relieve hydrostatic pressure.
- Methods of dewatering excavations during construction.
- Type of earth retaining structures (sheet piles, piers, soldier piles and lagging, tie-back walls, slurry walls).
- Active and passive earth pressure parameters based upon Rankine or Coulomb theory.
- Dynamic lateral earth pressures exerted on permanent structures.
- Earth-pressure diagrams using the total weight concept for ground support structures required temporarily to protect existing facilities.
- Structural backfill.
- Protection of underground structures from corrosion or attack by chemicals in the soil and/or groundwater.
- Frost protection and foundation preparation.
- Use of excavated soil and rock, and disposal of the surplus.
- Recommendations for observations and testing during construction.
- Geotechnical instrumentation and monitoring program including number and type of instruments and monitoring schedule.
- Outline specifications and preliminary design details
- Description of any additional subsurface data needed for design.

2.2.2.5 Geotechnical Design Data

The geotechnical engineer shall furnish the civil and structural designers, and engineers in other disciplines, with geotechnical details, drawings, notes and specifications applicable to the specific design project. The following are listings of the types of geotechnical information that may be required for the drawings and specifications depending on the type and location of the project under design.

Geotechnical Data for Civil Drawings

- Location of all borings, seismic exploration lines, and groundwater observation wells.
- Legend to describe the size and type of boring and type of geotechnical instrument.
- Compaction Requirements and quality control testing schedules for roads, embankments, and utility trenches.
- Location of retaining structures for temporary support of existing facilities (if design engineer′s responsibility).
- Location of dewatering systems (if design engineer′s responsibility).
- Typical road section showing pavement, base and subbase thickness, and compaction requirements.

- Location of cut slopes that affect stability of existing facilities.
- Location of geotechnical instrumentation.

Geotechnical Data for Structural Drawings

- Allowable gross or net soil bearing pressure in pounds per square foot.
- Compaction requirements and quality control testing schedules for fill and backfill around and beneath structures and facilities expressed as a percent of the maximum density at optimum moisture content as determined by ASTM Designation D 1557 Method D.
- Pile type; capacity (compression, tension or lateral): minimum spacing; number, location and length of test piles; and type and number of pile load tests.
- Type of foundation treatment with reference to the appropriate standard details.
- Type and spacing of relief valves with reference to the appropriate standard detail for bottom or wall-type valves.
- Unit weight of soil, both submerged and dry, for use by contractor when designing sheeting for which pressure diagrams are not required.
- Earth-pressure diagrams for retaining structures (ground support systems) required to support temporary structures to be designed by the contractor.
- Requirements for the type, rigidity, installation (vibration reduction), depth of penetration, movement tolerances, contingency procedures, and post-construction status of earth support structure.
- Details of rock or soil anchors.
- Location, inclination, length and capacity of tiebacks.
- Data for underpinning requirements for rehabilitation projects.
- Data for street stabilization for projects involving narrow city streets lined with private properties.
- Location of geotechnical instrumentation related to both existing and proposed structures.

2.2.3 Standard Details

Use DC Water standard details as applicable for drawings, figures, and report text descriptions. Modification of the details and the creation of new details to meet a specific project requirement is acceptable provided all modifications are approved in advance by DC Water.

2.2.4 Specifications

Refer to DC Water Guideline Specifications for applicable civil, site work, and structural specifications. The design engineer shall edit these and develop additional specifications as required for the specific project, in accordance with the DC Water General Instructions for the guideline specifications. Specifications shall be provided in approved DC Water format.

2.2.5 Calculation Requirements

Refer to Section 1 of this volume for general calculation requirements and submittal requirements. The Project Design Engineer (PDE) shall prepare and submit calculations for all major civil and geotechnical project elements. Required calculations include, but are not limited to, the areas listed below, as applicable to the specific project:

- Site layout and survey
- Runoff/hydrological

- Storm drainage hydraulics
- Foundations and earth retaining structures

2.3 TECHNICAL GUIDELINES

2.3.1 Codes and Regulations

At a minimum, the latest version and edition of following codes, standards, and regulations shall be observed by the designer and referenced, as applicable, in the contract documents:

- American Association of State Highway and Transportation Officials (AASHTO), *Policy on Geometric Design of Highways and Streets.*
- AASHTO, *Materials Test Standards*, with interim commentaries.
- ASTM, Standards.
- DC Water, *Local Codes and Permitting Guidelines Manual.*
- DC Water, *Sewer Use Rules and Regulations.*
- DC Water *Guideline Specification Masters.*
- DC Department of Transportation (DDOT), *Design and Engineering Manual.*
- DDOT, *Standard Specifications for Highways and Structures*.
- *DC Stormwater Management Regulations*, DC Law 5-188, Sections 509 through 518.
- DDOE, *Stormwater Guidebook.*
- DDOE, *Standards and Specifications for Soil Erosion and Sediment Control* and *Erosion and Sediment Control Handbook*.
- *Environmental Policy Act of 1989*, DC Law 8-36.
- Department of Agriculture. Soil Conservation Service, Engineering Division, *Urban Hydrology for Small Watersheds, Technical Release 55.*
- DDOT, *Design and Engineering Manual*.
- Department of Transportation, Federal Highway Administration, Public Roads Administration, *"Drainage of Highway Pavements", Hydraulic Engineering Circular No. 12.*
- The District of Columbia, *Construction Codes and Supplements.*
- The International Code Council (ICC), *International Building Code.*
- Water Environment Federation, *Manual of Practice (MOP) FD-5, and* American Society of Civil Engineers *(ASCE) MOP 60, Gravity Sanitary Sewer Design and Construction.*

The above information is presented as a guide for the user of this manual and should not be considered a comprehensive listing of all applicable codes and regulations. Applicable codes and regulations shall be referenced in the appropriate sections of the contract documents. The most recent versions of codes and regulations shall be used unless specifically directed otherwise.

2.3.2 Horizontal and Vertical Alignment

Horizontal grid coordinates for Blue Plains projects shall be based on LIS grid. Any point may be located by a distance north (northing) and a distance east (easting) from the respective base lines of origin. All distances northing and easting are expressed in feet. For projects outside Blue Plains the horizontal datum shall be Maryland State Plane Coordinate System.

The vertical control datum shall be determined for each project during the preliminary design stage in consultation with DC Water's Department of Engineering and Technical Services.

2.3.3 Buildings and Structures

2.3.3.1 Flood Plain

Projects at Blue Plains shall be designed with all equipment and building openings set higher than the 500-year flood plain elevation. As of 2011, the 500-year flood elevation at Blue Plains based on District of Columbia Department of Public Works (DCDPW) datum is 14.2 and the 100-year flood plain elevation is 10.7. The design engineer shall confirm the latest design flood elevations.

For projects outside of Blue Plains, all equipment and first floor elevations of buildings shall be set at least 1.5 feet above the 100-year flood plain. DC Water may require a more stringent requirement depending on the level of the mission of the proposed facility. The 100-year flood plain elevation shall be determined based on available FEMA mapping and/or engineering analysis.

2.3.3.2 Water and Sewer Structures

Design of all water and sewer structures shall comply with DC Water design requirements.

2.3.3.3 Civil Coordination

Civil responsibility for all building utilities connections begins at a distance five feet from the outside face of the structure or building. Show overall outlines for buildings and other structures on all site plans and indicate the building or structure designation. Coordinate with the architectural and structural designers for the most up-to-date building layout and orientation. Coordinate with other disciplines for proper locations of all penetrations through foundation walls so that utilities shown on the site plan correspond to those on building or structure plans.

2.3.4 Roads, Sidewalks, Parking and Open Storage

Design considerations related to roads, sidewalks, parking, and open storage are discussed in the following sections. Roadways, paved areas, related structures and utilities shall be designed in accordance with DDOT *Design and Engineering Manual* (latest edition) except as may be otherwise noted herein.

2.3.4.1 Pavement Widths

Roadways shall be 26-feet wide to provide for two-way traffic. In areas where only one-way traffic will be accommodated, use a roadway width of 14 feet.

2.3.4.2 Grades

Longitudinal grades on curbed roadways shall not be less than 0.5 percent. To improve gutter drainage along curved sections of curbed roadways and along curb radii at intersections, use a minimum gutter slope of 0.7 percent. Uncurbed roadways with open ditches for drainage may have a 0.0 percent longitudinal grade if ditch drainage can be maintained. Maximum desirable roadway grade shall be 7 percent.

Vehicular and pedestrian ramps, except for ramps for handicapped persons, shall have a maximum slope of 1 vertical to 8 horizontal (12.5 percent). Ramps for handicapped persons shall have a maximum slope of 1 vertical to 12 horizontal (8.3 percent), with level landings at intervals in accordance with American Disabilities Act (ADA) requirements.

2.3.4.3 Transverse Slopes

Use crowned sections on all roads with transverse slopes up to 2 percent along paved roadways and 3 percent along unpaved roadways. Take special care in the grading of intersections to provide adequate drainage from the intersection area to the gutters and catch basins or to ditches. Sheet drainage across the entire roadway width or intersection area will not be allowed.

For drainage purposes, roadway intersections, parking areas and other vehicular traffic areas shall have a minimum slope (combined longitudinal and transverse slope) of not less than 1 percent for paved areas and 1.5 percent for unpaved areas.

Direct roadway drainage away from areas where pedestrians will walk unless raised curbs and sidewalks are provided for pedestrian traffic.

2.3.4.4 Curbs

Provide curbs along paved roadways. Curbs for new construction areas shall be built in accordance with the standard details.

2.3.4.5 Gutter Drains

Roadway gutters shall be drained by catch basins or curb inlets at intersections, pedestrian crossings, and other convenient locations. Catch basins and/or curb inlets shall be constructed in accordance with the standard details.

Where catch basin or curb inlets are not provided with a concrete approach apron designed to direct the gutter flow to the inlet, lower the top elevation of the catch basin or inlet about 3/4 inch (0.06 feet) below the calculated gutter elevation. For instance, where standard 6-inch curb heights are used, set the top of the catch basin 6-3/4 inches (0.56 feet) below the top of the curb or 3/4 inches (0.06 feet) below the gutter elevation. This will reduce surface ponding in the area of the catch basin or curb inlet. Where possible, the design gutter flow should be confined to a 2- to 3-foot flow width, with catch basins and/or curb inlets spaced accordingly. Special consideration must be given to inlet location and capacity in gutter sag areas where ponding can be expected.

2.3.4.6 Pavement Design

Pavement sections shall be designed using AASHTO Pavement design method for flexible or rigid sections.

All structures within DDOT right of way subject to vehicular traffic shall be designed for AASHTO HS20 live load. For confined areas where a slab is two feet or more above grade, a live load of 300 lbs/square foot shall be used in lieu of HS20 Live load.

2.3.4.7 Turning Movements

Heavy truck roadways and traffic areas should be designed for truck turning movements without encroaching into oncoming traffic lanes. Provide adequate space for truck backing movements where required. A truck traffic pattern with counterclockwise forward movements and clockwise backing movements is preferred.

Where possible, design pavement edges (using three centered compounded curves where necessary) for 65-foot-long truck tractor and semitrailer combinations. The 65-foot semitrailer combination will require the maximum edge of pavement curves for any truck configuration allowed on the highway without a permit. Where possible, provide truck parking areas with direct pull-through movements that do not require backing.

Limited truck roadways and traffic areas should be designed to allow encroachment into oncoming traffic lanes to make full use of the entire pavement area for truck turning and backing movements. The design should allow space for truck movements that are necessary for heavy equipment maintenance; the design should allow space for the largest truck that might be required for hauling the heavy equipment. Often these restricted areas will require access for smaller trucks, i.e., AASHTO design vehicles single-unit (SU) or wheelbase (WB)-40. Infrequent use of these areas will not justify designing for extra truck turning and backing movements, whereas daily or weekly truck use of an area will justify designing for more favorable truck turning and backing movements.

Automobile and light truck parking areas should be designed to allow free traffic movement for smaller vehicles, giving consideration to emergency access to buildings for fire trucks, and daily access for maintenance vehicles.

2.3.4.8 Parking Areas

Passenger car parking lot dimensions for various parking angles shall be in accordance with the *DDOT Design and Engineering Manual, latest edition*. Electric cart parking lot dimensions shall be 5 feet by 10 feet, with the number of spaces determined in each design project.

2.3.4.9 Guiderails and Guideposts

Provide guiderails and guideposts as required for safety and guidance of traffic, and conforming to AASHTO design criteria.

2.3.4.10 Intersection Curves

The minimum radius for edge-of-pavement design on street intersections is 30 feet, which is required for passenger cars on 90-degree turns. A larger radius should be used if any truck traffic is expected or turning speeds greater than 10 mph are anticipated. The minimum radius on road intersections is 50 feet.

The curb design should fit the minimum turning path of the critical design vehicle expected in the traffic. Curb radii of 25 feet are adequate for passenger cars. Curb radii of 30 feet or more should be provided at all major highway intersections to accommodate an occasional truck in the traffic.

Signage and markings should conform to DDOT requirements and Federal Highway Administration standards as given in the *Manual of Uniform Traffic Control Devices.*

2.3.4.11 Sidewalks

Provide smooth, hard-surface walks to accommodate pedestrian traffic. Design walkways in accordance with the standard details. When directed, provide walks, in accordance with American National Standards Institute (ANSI) Standard A117.1, that are accessible to the physically handicapped.

The minimum width for walks shall be 4 feet. Walks shall normally be increased in width in increments of 2 feet as required to accommodate the anticipated volume of pedestrian traffic. Extra width should be added to walks adjacent to curbs or where obstacles encroach on the walk.

The grade of walks should follow the natural grade of the ground as nearly as possible. The transverse grade shall not be less than one-quarter inch/foot. The longitudinal grade should not be greater than about 15 percent. Use steps where the maximum longitudinal slope would otherwise be too great. Steps should be grouped together, rather than spaced as individual steps, and located so that they will be lighted by adjacent street or night lights. The sum of the depth of tread and height of riser shall not be less than 18 inches, and risers shall not be less than 5 inches or greater than 7 inches on any steps.

Use handrails or parapet walls in areas where the adjacent grade slopes away from the sidewalk at a slope greater than 2 horizontal to 1 vertical and in land areas where the sidewalk is placed along the crown of a retaining wall with a vertical separation above finished grade exceeding 3 feet.

Provide walkways on the building or structure side of all 26-foot-wide paved roadways.

2.3.4.12 Open Storage Areas

Vehicle maintenance areas include all areas provided for storage, service, and repair of organizational and functional equipment assigned to the facility. The functional uses of these areas require that they be divided into areas for servicing and repair and areas for storage or parking of vehicles. The former include all grease, wash, and inspection racks; fuel dispensing units; similar miscellaneous facilities; and access drives to the various service facilities and the necessary outside wash areas. The storage area is used for parking or storing individual units of equipment. The size of the service area depends on the type and number of service facilities required. Use rigid pavement for vehicle wash areas and areas where vehicles receive fuel, oil, or lubricants.

Provide material storage areas in accordance with the requirements of the facility. The areas requiring rigid pavement, flexible pavement, or all-weather aggregate surface will depend on the material being stored.

Open storage areas shall be designed with protection from contamination by stored materials in accordance with requirements of DDOE Toxic Substances Division, including the Hazardous Materials Branch, the Underground Storage Tank (UST)/Leaking Underground Storage Tank (LUST) Branch, and the Land Development and Remediation Branch.

2.3.5 Grading and Drainage

Designs for finished grades, slopes, and storm drainage must conform to the following guidelines.

2.3.5.1 Finished Grades

The finished grade establishes the relation between the finished floor elevations, steps at doors, the finished ground line along the outside walls of buildings and structures, truck dock and loading areas, and vehicular access into buildings or structures.

Finished grading should provide drainage away from buildings, structures, concrete-support slabs-on-grade, and other critical areas where the accumulation of stormwater is not desirable. Graded areas should drain to streets, ditches, swales, or catch basins connected to the storm drainage systems. Planting areas and gravel-surfaced areas require minimum slopes of about 3 to 4 percent to provide adequate drainage. Minimum slopes of 2 percent will usually provide adequate drainage for hard-surfaced areas.

Where possible, avoid isolated low areas. Develop overflow drainage patterns that direct excess storm water away from critical areas where flooding will affect the operation of critical processes or damage equipment.

Sites subject to flooding are often protected by dikes. Dikes provide flow protection but also cause some special grading and drainage problems. Draining the interior diked area may require pumping storm water during flood periods.

The elevation of + 14.0 (DC Datum) is the design elevation to protect the Blue Plains AWTP from flooding.

In grading and drainage systems, incorporate the most up-to-date technology available for erosion control against wave run-up, groundwater, storm and surface waters, and roof and surface runoff.

2.3.5.2 Slopes

In designing the grading of the site, provide the flattest slopes possible to ensure drainage. Over a given elevation difference, a uniform slope will be easier to construct and maintain than terracing steeper and flatter slopes. Terraced slopes may be desired for special planting effects, to reduce needs to import fill material, or to increase excavation material. Grassed or other areas where mowing is required should be graded at slopes of 4 horizontal to 1 vertical or less.

Cut-and-fill slopes must be stable. Therefore, care and consideration must be given to site soil and rock conditions before selecting maximum cut-and-fill slopes. Except for rock-cut areas, cut-and-fill slopes should not exceed 2 horizontal to 1 vertical.

2.3.5.3 Storm Drainage

Design storm drainage conveyance in accordance with DC Water and DDOT requirements. For criteria within DDOT right of way refer to DDOT Design and Engineering Manual Chapter 33. For DC Stormwater Management Regulations comply with DDOE requirements as outlined in the "*Stormwater Guidebook.*"

For DC Water facilities, the design of combined and storm sewers shall generally be based on the 15-year frequency storm using the Rational Method, TR-55 or other approved method. The duration-intensity relationship for the 15-year frequency storm is defined in Table 2-2-1 (next page).

The design engineer shall provide design computations for runoff and storm sewer design, including design storm criteria and reasons for selection, rainfall and infiltration rates, method of computing runoff, times of concentration, pipe capacities and velocities, and all other information affecting design discharges. Consider minimum and maximum pipe velocities required to flush debris and avoid scour. Design velocities should not exceed 10 feet per second.

Drainage patterns must be established to protect the structural integrity of existing and proposed building components from erosion caused by additional storm runoff from new and future site development. Unless otherwise approved, the drainage system must keep any groundwater, storm and surface waters, and roof and surface runoff separate from sanitary sewage.

Table 2-2-1. Rainfall Intensities for 15-Year Frequency Storm Durations

Duration (minutes)	Rate (inches per hour)	Duration (minutes)	Rate (inches per hour)
5	7.56	60	2.66
10	6.30	80	2.22
15	5.44	100	1.92
20	4.81	120	1.70
30	3.95	150	1.46
45	3.16	180	1.29

When storm sewers discharge to watercourses, the influence of high water levels must be considered from a hydraulic point of view. Design the drainage facilities to perform adequately in the event that an intense storm and very high river stage occur simultaneously.

Provide backwater flap valves at the outlets of all drainage pipes subject to high water levels at the discharge point. Backwater flap valves shall be iron body construction with angle seat valves and a lifting chair for manual opening. Use endwalls and riprap at all drain outlets along watercourses.

Materials of construction for storm drain piping, manholes, catch basins and appurtenances shall conform to DDOE and DDOT requirements.

2.3.6 Landscaping

The broadest and most important consideration of landscape planting is to create an attractive and cohesive environment that will promote the physical and psychological well-being of people who work at the facility. In addition, landscaping should be used to achieve the following objectives: shade; reduction of noise, glare, and dust; erosion control; and modifying temperature, humidity, and wind. The environment can be enhanced with planting by establishing and defining areas of different uses, by framing important buildings as well as outdoor spaces and vistas, and by screening undesirable views.

The following sources establish the standards and definitions applicable to the work of this section:

- American Association of Nurserymen (AAN), *American Standard for Nursery Stock* (ASNS), ANSI Z60.1, latest edition.
- American Joint Committee on Horticultural Nomenclature, *Standardized Plant Names* (SPN), latest edition.
- Association of Official Agricultural Chemists (AOAC).
- National Arborist Association, *Standards for Pruning Shade Trees.*
- ASTM, *Standards*.

2.3.6.1 Simplicity of Planting Layouts

Layouts for planting trees and shrubs should take broad, simple forms so that excessive maintenance will not be required. Shrub beds should be simple in shape when they are bordered by turf requiring mowing.

2.3.6.2 Related Planting Design Factors

Good drainage of both surface and subsoil is necessary not only for the successful growth of nearly all plants but also as an erosion-control measure. If necessary to correct conditions of soil saturation, subsurface drains should be installed during site work. In grassed areas, flush concrete, straight stone, or metal edgings will allow use of mowers to produce a neat appearance at minimum maintenance cost.

Avoid excessively steep banks. Where turf banks are unavoidable, their gradients should not exceed a 3 horizontal to 1 vertical slope with top and bottom rounded to obtain a gradual profile, thereby preventing erosion and facilitating mowing. Steeper banks may be riprapped or planted with ground-cover plants for erosion control.

The landscape architect shall develop a plant material inspection program including inspection, approval, and contractor liability issues. The planting specifications shall define planting seasons for deciduous and evergreen materials in accordance with local requirements.

Follow the standard landscaping details for planting of trees and shrubs. All deciduous trees shall be planted a minimum of 15 feet from all edges of evergreen tree masses. The contract documents shall provide direction to the contractor for staking, anchoring, wrapping of deciduous tree trunks, pruning, application of mulch material and fertilizer, excavation of plant pits, and treatment of plant roots.

2.3.6.3 Selection of Plants

Confine the selection of plant materials to as few varieties as possible to satisfy the requirements and objectives of the design. Choose only those plants capable of thriving with low maintenance under actual site conditions and able to produce the desired effect. Abide by the standard details for designated planting.

2.3.6.4 Fine Grading and Loaming

Loam shall be placed and spread over all areas to be permanently seeded or planted. A testing program should be specified by the landscape architect to confirm the quality and consistency of the loam. Testing should include chemical analyses, percent of organics, and mechanical gradation of the loam. All tests shall be performed in accordance with the current standards of the AOAC.

2.3.6.5 Hydroseeding

Hydroseeding shall be done as soon as possible after spreading of loam is completed and approved. Include erosion control measures in the design for all drainage swales and all slopes of one foot vertical to two feet horizontal, or steeper, immediately after such areas have been hydroseeded.

A maintenance and protection program shall be specified by the landscape architect to include re-hydroseeding, watering, weeding, fertilizing, resetting and straightening of protective barriers, chemical treatments as required for fungus and/or pest control, and contractor liability issues.

2.3.7 Site Utilities

Requirements for water, sewer, and fire protection facilities are discussed below. Other site utilities, consisting of natural gas, electrical, and telephone lines, shall be designed in accordance with local and federal guidelines. Process piping outside of buildings and structures shall be shown on the yard piping plan included in the civil drawings. Piping systems must be designed for all static and dynamic loads (i.e., water hammer, thrust design, test pressures, earth loads, live loads, thermal expansion/contraction, effects of valve position, etc.). Refer to Volume 3, Linear Infrastructure Design, for technical guidance on thrust restraint design. Refer also to Volume 3 for guidance regarding water distribution and wastewater collection systems outside the limits of Blue Plains AWTP and pumping stations, as well as yard piping installation requirements. Refer to Section 5, Mechanical Process, for process piping design requirements.

2.3.7.1 Potable Water Distribution System

The water main connecting the site to the potable water supply system and the site potable water distribution system shall be designed based on DC Water standard specifications.

Size the potable water distribution system to meet the peak-day demand plus fire-flow demand. Base the peak-day demand on all site water requirements from the potable water source. These requirements include, but are not limited to, potable water, service water, seal water, and other service demands. Where practical, the distribution system shall be a closed-loop system designed to provide service to any branch line from two directions.

Design all valves, valve spacing and location, valve casings, meters, and other appurtenances in accordance with DC Water standards.

2.3.7.2 Outside Fire Protection

Design outside fire protection systems in accordance with the National Fire Code, as promulgated by the National Fire Protection Association. Hydrant type, spacing, and location shall be in accordance with DC regulations.

2.3.7.3 Sanitary Sewers

Design sanitary sewer system in accordance with Design Manual Volume 3, Linear Infrastructure Design.

2.3.8 Geotechnical Requirements

The geotechnical requirements consist of four principal functions:

- Geotechnical investigations to obtain data required for the detailed design and construction of the facilities.
- Preparation of a design analysis for each construction project to provide geotechnical data, parameters, and recommendations to be used by designers and engineers in conceptual and detailed designs.
- As warranted by the nature of the work contemplated, preparation of a geotechnical report for the construction project, such report to be included with the contract documents.
- Preparation of design details and specifications.

2.3.8.1 Geotechnical Investigations

The initial phase of geotechnical investigations shall be coordinated with DC Water′s Department of Engineering and Technical Services (DETS), and will involve researching and evaluating pertinent pre-existing data from geologic publications and previous site investigations and testing. Attention should be directed to the seismic history of the site, the type of geologic surface and bedrock formations, maximum water elevation, and any existing site explorations. A site reconnaissance to observe general site geology, topography, and drainage will also be a part of the initial site investigations.

The second phase of the site investigations will be site-specific geophysical explorations, including soil borings, test pits, rock coring, in situ testing, laboratory testing of soil and rock samples, and/or test well pumping, as determined by the geotechnical engineer based on the nature of the project. The geotechnical engineer shall provide specifications for boring and sampling methods per ASTM specifications including sealing and storage of samples. Borings and test pits shall be located and spaced in a manner that will reliably define the subsurface stratigraphy and provide representative samples of the soil strata for laboratory testing. Borings shall be referenced to a permanent system of coordinates and benchmarks. Borings depths shall be sufficient to define a bearing stratum capable of supporting proposed structures. The minimum inner boring diameter shall be 3 inches whenever undisturbed samples or rock cores are required. All underground utilities shall be located in the field prior to commencing borings or other subsurface field work.

2.3.8.2 Design Requirements

The geotechnical engineer shall evaluate and develop design recommendations for earthwork in the following areas, as applicable:

- Excavation support system and side slopes.
- Excavation and replacement of unsuitable materials.
- Backfill and compaction requirements.
- Structural fill requirements.
- Lateral earth pressure.
- Surcharge loadings.
- Construction settlement.

The geotechnical engineer shall recommend appropriate types of foundations to support the various structures. Recommendations shall be justified on the basis of cost-effectiveness, performance considerations and previous experience at existing DC Water project sites. In general terms, the geotechnical engineer shall consult the structural engineer and select between shallow foundations (i.e., spread or continuous footings and mats) and deep foundations (i.e., piles, drilled piers, caissons).

Shallow Foundations

Shallow foundations should be used wherever feasible because they are typically less costly than deep foundations. The geotechnical and structural engineers shall evaluate the feasibility and cost-effectiveness of shallow versus deep foundations based on site-specific subsurface conditions and structural design requirements. In addition, the following evaluations shall be conducted, where applicable:

- For soil conditions such as inadequate bearing capacity or non-cohesive soils subject to liquefaction, evaluate methods of in-situ corrective measures (e.g., over excavation and replacement, in-situ densification) and compare the cost and scheduling impacts with those of an alternative deep foundation.
- For tanks and structures with foundations below the groundwater table, conduct an analysis to determine the most appropriate method of protecting against hydrostatic uplift (e.g., relief valves, extending/thickening base slabs, rock anchors, tension piles).
- Where relief valves are proposed, conduct an analysis to evaluate performance and proper placement. (Note: In existing construction at the Blue Plains AWTP, relief valves have been mounted in tank base slabs rather than in walls.)

Contract specifications for relief valves shall require submittal of catalog cuts showing design data. Drainage blanket systems for relief valves shall be protected against infiltration of fine soil particles by means of filter fabric or a 6-inch thick appropriately graded sand filter.

Rock anchors must be prestressed with a stressing length at least two times the bonded length. Anchors must be suitably protected against corrosion. Anchor testing must conform to code requirements.

Exterior footing and mat foundations must be protected from frost heave by extending them to a minimum depth of 2'-6" below the finish grade elevation or placing them on an equivalent thickness of non-frost-susceptible soil.

Deep Foundations

For deep foundations, evaluate the various types of driven piles, drilled-in piles, piers, augercast piles or caissons. Selection shall be justified based on geotechnical testing methods, pile formulas and consideration of required foundation capacity, driving conditions, potential obstructions, bearing strata, cost, etc. Timber piles, shell piles or Franki piles shall not be used unless specifically approved by DC Water.

(a) Test Pile Program

Where deep foundations are recommended, specify that a detailed test pile program be implemented by the construction contractor and evaluated by the geotechnical engineer before production pile driving or installation occurs. This program must be described on the structural drawings and in the foundation specifications. The program must include test piles whose length and locations are specified by the geotechnical engineer.

Select test pile locations to allow the contractor to adequately predict all production pile lengths across the site. Test borings shall be performed at each test-pile location. After the test piles are driven, select the test piles that shall be load-tested by an independent testing firm. Specifications must detail the procedures and instrumentation necessary (e.g., dynamic pile analyzer) for all aspects of this program. With the load test information, confirm the design capacities of the piles.

The pile contractor is then responsible for ordering the remainder of the production piles necessary to complete the foundation. Indicate in the contract documents whether test piles may be incorporated into the work or must be removed. Show locations of anchor (tension) piles relative to test piles.

The testing requirements and allowable capacity of deep foundations must conform to the building code. Down drag caused by soil consolidation shall be considered in the design, in accordance with code requirements.

(b) Foundations Subject to Long-Term Consolidation

Pre-consolidation by means of a preload should be considered to overcome consolidation of soils surrounding deep foundations. It is vital that a detailed settlement monitoring procedure be defined for all preloading. Use wick drains and a drainage blanket to expedite the consolidation and minimize the amount of the pre-consolidation load. The preload procedure must be monitored by piezometers to measure the reduction in pore water pressure and by settlement gages to measure the amount of consolidation. Use the standard piezometer and settlement plate details provided in Volume 5. Post-construction consolidation must be reduced to less than the structural tolerances and angular distortion permitted for the structure.

2.3.8.3 Construction Considerations

Groundwater Control

Groundwater must be maintained a minimum of two feet below the bottom of all excavation levels. The dewatering system may consist of sumps in soil with low permeability or in cases where the water table is near the elevation of the bottom of the excavation. Higher water table levels in more permeable soil will require the use of the well points or deep wells. When possible, the specific dewatering methods should be chosen by the construction contractor.

The effect of groundwater lowering on existing structures must be considered. Install and monitor observation wells at critical locations. A groundwater recharge system may be necessary to maintain the groundwater level under existing structures.

When groundwater control is critical, specify that a dewatering plan, prepared and sealed by a professional engineer registered in the District of Columbia, be submitted by the construction contractor for review 30 days before the start of construction.

Effect of Vibrations

Additional procedures are required to monitor the effects of vibrations during construction.

(a) Vibration from Pile Driving

Driving piles or sheet piling in the vicinity of structures supported by cohesionless soil may cause structures to settle. When this condition is encountered, vibration monitoring is required by means of a seismograph with maximum ground acceleration specified. Drilled-in piles or piers or drilled-in-soldier piles and lagging should be considered under these conditions.

(b) Vibration from Blasting

Ground acceleration caused by blasting also must be kept within specified limits to prevent damage to existing structures. Vibration monitoring with seismographs and controlled blasting techniques must be specified.

Noise Abatement

The contract documents must address noise abatement requirements, particularly for construction activities such as pile driving and blasting. Measures to limit construction schedules and/or daily hours of operation shall be considered.

Retaining Structures

Retaining structures (i.e., sheeting and shoring, retaining walls, etc.) are classified in three categories. First are those that perform no permanent function, whose installation will not adversely affect existing structures or do not protect any existing adjacent structure or facility, and which are primarily used at the construction contractor's option. Portable trench boxes are included in this category. Design of these retaining structures is solely the responsibility of the construction contractor.

The second category are those temporary installations that may affect existing adjacent structures through vibration or soil displacement, or that actually support and protect existing structures and/or utilities. In those cases, the geotechnical engineer must provide specialty contractor qualification requirements, a design lateral earth pressure diagram, a minimum depth-of-penetration elevation, and requirements as to whether the system must remain in place or be partially extracted on the contract drawings. The construction contractor remains responsible for designing the system.

For both the above categories, the contract documents shall require all ground support systems provided by the contractor to be designed by a professional engineer registered in the District of Columbia. The construction contractor must submit to the engineer, for documentation purposes only, shop drawings containing construction details, layout, and a certificate of design stamped by a registered professional engineer.

The third category includes support structures that are designed as a permanent part of the finished construction project. In those cases, the geotechnical and structural engineers are responsible for designing the permanent support structure in accordance with all applicable codes and standards.

When walls require an especially high degree of rigidity, a slurry wall or a drilled pier wall may be specified. In instances where driven sheeting may cause harmful vibrations or soil remolding, soldier piles and lagging or ground freeze walls should be considered. Slurry walls should also be considered where they may be incorporated as a permanent part of the structure.

All retaining structures shall be designed and constructed in accordance with local and federal Occupational Safety and Health Act (OSHA) requirements and all applicable codes and standards.

Geotechnical Instrumentation

For projects where geotechnical monitoring is required, the geotechnical engineer shall design the installation and monitoring of geotechnical instruments. The installation and monitoring of instrumentation will be provided under a separate contract.

Materials Testing

A commercial laboratory conforming to the latest version of ASTM E548, Generic Criteria for Use in the Evaluation of Testing and Inspection Agencies should be employed and directly reimbursed by DC Water or a program management consultant to perform compaction and other construction quality control tests on materials.

Pre-Construction Condition Survey

Specifications should require the Contractor to perform a thorough condition survey prior to the start of construction to document the conditions of existing structures which may be affected by new construction. A photographic record of selected structural locations may be documented as part of the pre-construction condition survey.

2.3.8.4 Post-Construction Considerations

Settlement

A settlement monitoring program should be considered for structures subject to long-term settlement. This applies to structures founded on shallow foundations overlying compressible strata of cohesive soil and those founded on friction piles in cohesive soil. Short-term settlement monitoring should also be considered for shallow foundations on non-cohesive soil when the foundation soil is subjected to vibration from equipment operating in the structure and from adjacent construction. Additionally, consider the potential for lateral movement and provisions for protection from structural damage due to lateral movement.

Groundwater Monitoring

Groundwater monitoring wells established during construction or added after construction should be monitored in conjunction with the settlement monitoring. This is an especially important consideration for the protection of structures that are completed while temporary dewatering is in progress.

2.3.9 Environmental Considerations

2.3.9.1 Dust Control

Where areas and projects are subject to dust blowing and movement due to construction activities, specify that the contractor shall implement dust control methods in accordance with the requirements of the DDOE Standard and Specification for Dust Control.

2.3.9.2 Noise Pollution

Any noise above 80 decibel (dB) is considered noise pollution per DDOE. If such a noise is anticipated the designer shall consider preparing a plan for sound attenuation or mitigation to control noise levels, or make it a condition of the construction contract for the contractor to prepare and implement such a document.

2.3.9.3 Air Quality Permitting

Any project involving the production of, or change in air emissions including, but not limited to, installation of new equipment or processes, modification of such processes, or replacement in-kind of equipment or processes, may be subject to requirements for air permits. Air quality shall comply with DC Regulations and Federal Clean Air Act and Clean Air Act Amendments, which are enforced by DDOE Air Permitting & Enforcement Branch. There are two types of air permits to be considered for each project: an air permit to construct, and a Title V operating permit. For all DC Water projects, the designer shall consult the DC Water air permit contact to review project components and determine which if any permits or types of analyses are required. See Figure 2-2-1, Screening Chart for Air Quality Permit Determination.

Pertinent project components may include any of the following:

- Fuel Burning Equipment
- Storage Tanks / Silos with Use of volatile organic compounds (VOCs), hazardous air pollutants (HAPs), or 112(r) Substances
- Exposed Liquid Surfaces with VOCs /HAPs
- Odorous Materials or Processes
- Particulate Sources or Control Devices
- Particulate Emissions from Demolition or Construction Activities

DDOE reviews all designs that may have air emissions and issues permits if the estimated level of air emissions is within regulations or an existing permit. Depending on the project-specific components, equipment, materials, and emissions sources, the designer shall perform associated air quality and health risk assessments and analyses as required to support permit applications. Note that DDOE and District Regulations require significant lead time for an application review prior to issuance of a permit to authorize construction. Construction contract documents should also require pre-construction coordination with the DC Water air permit contact.

Permits to operate are required prior to full operation of new or modified equipment. Blue Plains AWTP holds a plantwide Title V air permit which must incorporate all projects that produce air emissions. Post-construction coordination must occur with the air permit contact to ensure proper inclusion of permit conditions required to operate specific items.

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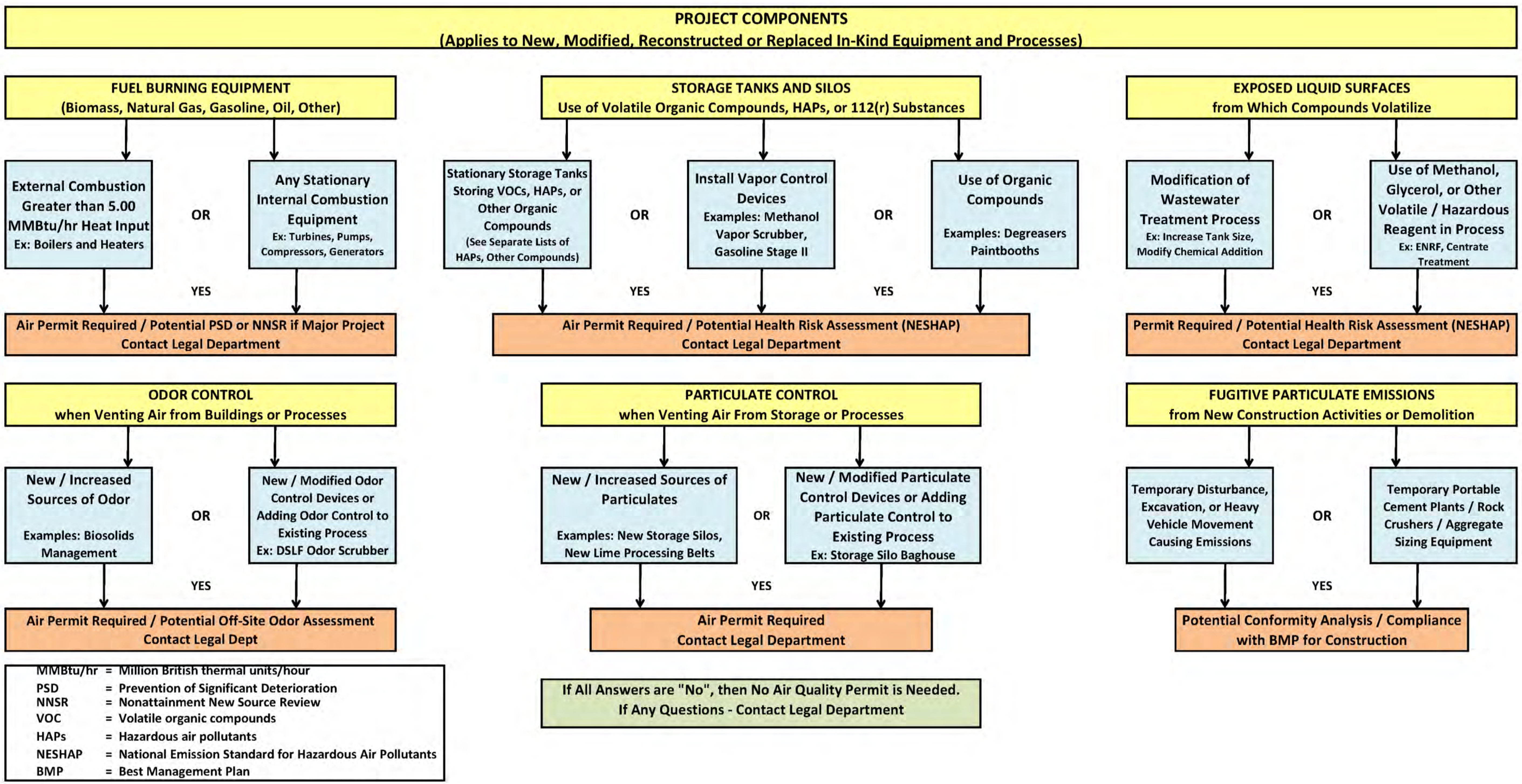

Figure 2-2- 1. Screening Chart for Air Quality Permit Determination

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DISTRICT OF COLUMBIA

WATER AND SEWER AUTHORITY

(DC Water)

"SERVING THE PUBLIC - PROTECTING THE ENVIRONMENT"

PROJECT
DESIGN MANUAL
VOLUME 2 - FACILITIES DESIGN

SECTION 3 – ARCHITECTURAL

August 2018

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AUTHORIZATION FORM

Revision Number	Date	Content
Draft 3	7/30/2000	Project Design Manual Volume 2 - Facilities Design Section 3 - Architectural
March, 2013	03/01/2013	Section 3 – Architectural
September 2014	09/08/2014	
August 2018	07/25/2018	Section 3 - Architectural

This 2018 version was authorized by:

S. Bian 12/20/18

Steve Bian PE, Supervisor, Civil, Structural Design Date

SECTION 3, ARCHITECTURAL LOG OF REVISIONS (Revisions from 1999 Draft 3 version)		
Paragraph	**Brief Description of Revision**	**Date**
Global	Changed "DC WASA"/"WASA" to "DC Water"	
3.2.2.3 Window Schedule	Deleted 'location, number, and materials,' as windows are identified by types, and not numbered like doors.	
3.2.2.3 Louver Schedule	Deleted 'location, number, and screen type,' as louvers are not numbered like doors.	
3.3.1 Standards	1. Deleted dates of standards/codes; added reference to "latest version". 2. Added LEED standard.	
3.3.1.1 Codes and Regulations	-Added NFPA -Created separate line for ACI 530/ASCE 5/TMS 402	
3.3.1.2 Life Safety Considerations	Changed firestop requirements from drawings to specs, since not all penetrations are shown on drawings.	
3.3.1.3 Building Systems and Materials	1. Clarified flat roof type and added provision for additional Green roof type. 2. Added LEED info for COOL Roof types. 3. Added optional finish for aluminum windows.	
3.3.1.3 Building Systems and Materials	-Added roofing maintainability item -Floors, added one maintainability item -Fenestration – translucent panel & skylight **frames** -Hardware will be corrosion resistant **metals** -Walls – avoid using plaster, too labor intensive and costly; resistant drywall is more cost effective**.** -Stairs – add corrosion protected steel -Glazing – caution against wired glass, can be dangerous when broken. Other types of fire resistant glazing are available. -Added – "Other design items for coordination & maintainability." -Added stated preference for guardrails in lieu of safety nets-Added new OSHA requirements for ladder safety systems	7/25/18 7/31/18
3.3.1.5 Special Considerations	-Address safety hazards based on the Safety Hierarchy of Controls	7/25/18
3.3.2.1 Exterior Doors	Add "corrosion protected steel" & several maintainability items	
3.3.2.2 Sustain - ability & Branding	Added Sustainability and Branding guidance for DC Water facilities	

3.3.2.3 DC Green Building Act	Added requirements of DC Green Building Act	
Table 2-3-2 Finish Schedule	Minor revisions	
3.3.2.4 DC Green Building Act	Applicability is subject to project-specific clarification and confirmation at the time of design.	
Table 2-3-1	May be subject to modification per confirmation of project-specific GBA requirements.	

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SECTION 3 – ARCHITECTURAL
TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

ACRONYMNS AND ABBREVIATIONS

ACI	American Concrete Institute
ADA	Americans with Disabilities Act
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
BP	Blue Plains
CAD	computer-aided design
CFA	U.S. Commission of Fine Arts
CMF	Central Maintenance Facility
COF	Central Office Facility
COO	certificate of occupancy
CP	construction package
DC Water	District of Columbia Water and Sewer Authority
DCRA	Department of Consumer and Regulatory Affairs
DDOE	District Department of the Environment
DP	design package
EA	Energy and Atmosphere
EPA	U.S. Environmental Protection Agency
GBA	Green Building Act
GFA	gross floor area
HAZOP	Hazard and Operability
HVAC	heating, ventilation, and air conditioning
HQ	Headquarters
IBC	International Building Code
ICC	International Code Council
IRMA	Inverted Roof Membrane Assembly
LEED	Leadership in Energy and Environmental Design
MPR	minimum program requirements
NCPC	National Capital Planning Commission
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Act
PCS	Process Control System
PDE	Project Design Engineer
PMR	Protected Membrane Roof
PPE	Personal Protective Equipment
SHPO	State Historic Preservation Office
SRI	Solar Reflective Index
SS	Sustainable Sites
TMS	The Masonry Society
USGBC	U.S. Green Building Council
WE	Water Efficiency

PROJECT DESIGN MANUAL
VOLUME 2 – FACILITIES DESIGN

3. ARCHITECTURAL

3.1 GENERAL REQUIREMENTS

The requirements outlined in this section apply to all design packages (DP). Specific architectural requirements for each design package are contained within the individual DP conceptual design reports and will supplement the requirements and guidelines outlined in this section. The major intent is to provide a highly functional facility.

Structures shall generally be unobtrusive, subdued, with natural color and appearance compatible with its environs. Structures at Blue Plains shall respect the architectural style, proportions, color, and detail, and work in harmony with the existing character of other DC Water facilities. Generally, the architectural design objectives shall be geared toward the permanence of the facility, aesthetics, comfort of occupants, maximizing efficiency of the functions and minimizing maintenance. The buildability and the economy of the structure should be considered at all stages of the design process. Designers should strive to be environmentally responsible and provide high performing and energy efficient facilities.

3.2 FORMATS

3.2.1 Standard Details

Use Volume 5, Standard Details, throughout the design in all drawings, figures, and report text descriptions, when applicable. If a Standard Detail needs to be modified to suit the design, modification may be done with prior authorization by the Authority. Provide new details as required to support the design.

3.2.2 Schedules and Symbols

Schedules included herein are examples only. The format shown is not mandatory as long as the required design information is provided on the schedule. Prepare additional schedules such as lintel schedule, signage schedule, etc. as required by the design. Include schedules in the drawings unless approved otherwise by the Authority.

3.2.3 Door Schedule

A tabular type of schedule, an example of which is shown in Appendix A, Table A-1, will include door location, number, opening size, type, door swing, materials, reference to details, and other required information. All schedule items will be cross-referenced with common nomenclature for door details and specifications and indicated on the drawings. Use the abbreviations provided in Appendix B, Table B-1 to the maximum extent possible.

3.2.4 Finish Schedule

An architectural finish schedule will indicate, in tabular form, all interior materials as well as finishes and colors of floors, walls, ceilings, and other related items. The finish schedule will be supplemented by legends, symbols, and references to a product, all cross-referenced with plans of areas to which the schedule applies. An example of a finish schedule is presented in Appendix A, Table A-2, and abbreviations are presented in Appendix B, Table B-1.

3.2.4.1 Window Schedule

A window schedule will include type, opening size, and reference to details and other information. See example in Appendix A, Table A-3.

3.2.4.2 Louver Schedule

A louver schedule will include, type, opening size, materials, reference to details and other required information. See example in Appendix A, Table A-4.

3.2.4.3 Architectural Abbreviations

Architectural abbreviations are shown in Appendix B, Table B-1.

3.3 TECHNICAL GUIDELINES

All designs will adhere to the guidelines described in this section, unless otherwise directed by the reviewing authority.

3.3.1 Standards

3.3.1.1 Codes and Regulations

The Project Design Engineer (PDE) shall verify and use the latest current editions of the following codes and regulations applicable to the project at the time of the design:

- The Americans with Disabilities Act (ADA)
- Building Code Requirements for Masonry Structures [American Concrete Institute (ACI) 530/American Society of Civil Engineers (ASCE) 5/The Masonry Society (TMS) 402
- DC Green Building Act (GBA)
- District of Columbia Construction Codes latest Supplement
- International Code Council (ICC), American National Standards Institute (ANSI) A117.1, *Accessible and Usable Buildings and Facilities*
- International Code Council (ICC), International Building Code (IBC)
- International Code Council (ICC), International Energy Conservation Code
- National Fire Protection Association (NFPA) 101 and other codes as referenced in the ICC
- Occupational Safety and Health Act (OSHA) regulations
- U.S. Green Building Council (USGBC), *Leadership in Energy and Environmental Design (LEED) for New Construction*
- All other latest applicable city or local building and safety regulations.

3.3.1.2 Life Safety Considerations

The following information shall be provided as part of the architectural code review.

- ADA Title II Analysis to determine all spaces that will require access by those with disabilities
- Description of proposed work

- Use Group and Construction Type
- Building Data (Gross Area)
- Occupant Load
- Exits per occupant load
- General Height and Area Limitations
- Fire Suppression Requirement
- Fire Separation Requirements
- Length of access travel
- Stairways
- Guards and Handrails

Construction documents for all buildings shall designate the type of construction and the fire resistance rating of all structural elements and fire separation assemblies as required by the building code. The construction documents shall include documentation or supporting data substantiating all fire resistance ratings.

Specifications shall include a schedule detailing how penetrations for electrical, mechanical, plumbing and communications conduits, pipes and other systems shall be fire stopped and indicate the materials and methods for maintaining the required structural integrity, fire resistance rating and fire stopping.

Guards and handrails may be shown and detailed on the architectural construction drawings, or if clearer and more convenient, on the structural drawings. Determine location within the construction documents that most clearly shows the appropriate details.

3.3.1.3 Building Systems and Materials

All materials used on the project will be:

- Noncombustible (unless approved by Authority)
- Corrosion resistant
- Moisture resistant
- Easy to maintain
- Readily available

Conceptual design reports in the individual DP will indicate the structural systems to be used for the respective projects. The preferred structural system in most mechanical process buildings will be a reinforced concrete frame composed of columns, beams, floor slabs, and roof slabs, with masonry infill for the enclosure.

Some buildings may have steel skeletal structures (columns and beams) with reinforced concrete floor and roof slabs with a masonry skin. Precast-concrete elements, backed with insulation may be used for lintels, arches, and architectural trim elements.

Interior walls will be constructed (subject to location) of:

- Masonry units or structural facing tile units, both with joint reinforcing.
- Gypsum board on metal studs, of a type appropriate for required finish.

Roofing material will vary depending on the structure's use and will meet the following guidelines:

- For flat roofs – Preference is to use an Inverted Roof Membrane Assembly (IRMA), also known as Protected Membrane Roof (PMR) Assembly, with closed cell rigid insulation placed on top of the membrane, and ballast and/or pavers on top of the insulation. Unless approved otherwise by DC Water, the roof structure shall be designed with adequate additional dead load capacity and the roofing materials shall be suitable to be 'buried' or covered to accommodate potential addition of a 'green roof' design. Low sloped roof systems (but in no case less than 1/4-inch per foot) such as hot or cold built-up or modified bitumen may be used when appropriate and approved by DC Water. Cool roofing can qualify for 1 point within LEED-NC 2009, Sustainable Sites (SS) Credit 7.2, Heat Island Effect: Roofing by using roofing materials that have a Solar Reflectance Index (SRI) minimum of 78 for low sloped roofs (≤ 2:12). Consider selecting a roofing material that meets the solar SRI. Another option for a flat roof is a green or vegetated roof system. These roof systems can qualify for SS Credit 6 by reducing storm water, SS Credit 7.2 by reducing temperature, Water Efficiency (WE) Credit 3.1-3.3 for water efficient landscaping, Energy and Atmosphere (EA) Credit 1 for heat absorption properties and Optimizing Energy Performance and a potential for an Innovation and Design Process point.

- For sloping roofs - use corrosion-resistant, prefinished, standing-seam-type metal roofing on closed-cell rigid insulation and furring, slate or fiberglass shingles. Cool metal roofing can qualify for 1 point within LEED-NC 2009, Sustainable Sites Credit 7.2, Heat Island Effect: Roofing by using roofing materials that have a SRI minimum of a minimum of 29 for steep sloped roofs (> 2:12). Consider selecting a finish color that meets the solar SRI.

- In specific areas - use elastomeric roofing applied directly to the concrete.

- Over galleries, tanks, and areas subject to vehicular traffic - use special traffic-bearing roofing.

- All roofing shall be required to have a twenty (20) years warranty

- All roofs shall have adequate slope to roof drains to prevent any accumulation of standing water on roof.

- Walkways to protect the roof are to be provided between a roof access point and any equipment located on the roof.

- Any penetrations of existing roofing must be approved by a certified manufacturer's representative to maintain existing warranty.

Fenestration and door materials will conform to the following guidelines:

- Exterior doors, windows, louvers, translucent panel and skylight frames will be of aluminum, stainless steel, or other corrosion-resistant metals.
- Interior doors, glass partitions, vision panels, louvers, etc., will be hollow metal and press metal; in areas with corrosive atmosphere or high moisture content, all these elements will be of aluminum, stainless steel or fiberglass.
- All door hardware is to be corrosion-resistant appropriate for the location and all keys must be keyed to match existing locking system.

- Roll up doors are to be power operated with local pushbutton control, and shall be provided with a manual chain operator to allow operation of the door if the power opener fails.
- Recommended finishes for aluminum is a high performance Kynar® polyvinylidene fluoride type coating.

All metal stairs, platforms, gratings, plate covers and their supports will be made of aluminum or corrosion-protected steel, subject to conditions.

- Grating stairs to be used when appropriate to provide maximum slip resistant surface.
- Fiberglass to be used at chemical areas.

Subject to location and specific conditions, all interior finishes will be as follows:

- Floors:
  - Hardened concrete in rough work areas or areas exposed to vehicular traffic.
  - Dustproof-sealed concrete, in color, in other work areas and storage rooms.
  - Seamless flooring in moist (equipment) areas and labs.
  - Polyterrazzo or vinyl tile in corridors, offices, etc.
  - Ceramic mosaic tile in sanitary facilities.
  - Uneven floor surfaces shall be clearly labeled or painted yellow to warn of tripping hazard.
  - Walkways subject to being wet from normal or occasional operations shall be designed to reduce risk of slipping hazards.

- Walls: (subject to location and choice):
  - Structural facing tile, in color.
  - Epoxy-painted concrete or concrete masonry units. (Use DC Water approved paints.)
  - Ceramic tile on masonry or gypsum board (in sanitary areas).
  - Painted gypsum board in light use areas.
  - Glazed Masonry Units in process areas where requested or directed by DC Water.

- Ceilings:
  - Painted concrete slabs, soffits and beams, except avoid painting high ceilings and industrial and process area ceilings due to maintenance issues.
  - Prefinished suspended acoustical tile ceilings, (moisture resistant type in bathrooms, locker rooms, showers and janitor’s closets).
- Stairs:
  - Materials to be concrete, aluminum, corrosion protected steel, stainless steel, or fiberglass.
  - Use non-skid nosings.
  - Use welded, seamless guardrails and railings.
  - Metalwork (pipe supports, ladders, stairs, catwalks, etc.) subject to contact with wastewater, shall be stainless steel, not aluminum.

Subject to location and specific site conditions the following types of glazing will be used:

- Bronze-tinted thermal exterior glazing
- Clear glass, plain, or tempered for internal use
- Translucent wall panels
- Tempered glass for fire resistance. Typically do not use wire mesh glass in lieu of other alternatives for fire resistance, unless approved by DC Water.

Other design guidelines for inter-discipline coordination and maintenance considerations:

- All multiple story buildings are to have hatchways or large exterior doors to allow removal of any large equipment contained in the building. Provisions for lifting equipment shall be included.
- Each major process area is to have a maintenance area for specialized equipment storage.
- The minimum clear space around equipment shall be as required by applicable codes, recognized industry standards of good practice, or 3 feet, whichever is greater. Maintenance access requirements shall take into account the need to completely remove each piece of equipment, especially large equipment, at some future time.
- Space for rescue equipment installation is to be provided at any confined space entranceway.
- The creation of confined spaces is to be minimized in plant layout. All confined spaces shall be labeled.
- All high noise areas shall have appropriate signage to require hearing protection.
- No pipes carrying liquid can be located within an electrical control room. The exception is fire protection piping, and only if fire protection sprinklers are required by the agency with jurisdiction.
- Locate floor drains in upper rooms so that drainage piping passing through lower rooms shall not be above chemical tanks, or electrical equipment.
- All monorails, jib cranes, or permanent lifting points shall have its load rating displayed in a permanent manner that cannot be obscured by painting.
- Provide signage at the entrance of any high noise area (centrifuge room) requiring ear protection to be worn when entering the room.
- Provide secure area(s) for the storage and protection of spares/hoist components not in use.
- Provide four tether points for floor-mounted hatch openings.
- Specify that touch up shall be provided as needed to repair any protective coatings damaged during installation or construction.
- Minimum clear space around equipment shall be as required by applicable codes, recognized industry standards of good practice, or 3 feet, whichever is greater. Maintenance access shall take into account the need to completely remove each piece of equipment, especially on large equipment, at some future time.
- Where budget and design criteria allow, provide stairs, catwalks, platforms, hatches, freight elevators and lift platforms for accessing and removing equipment. Where appropriate, such provisions for personnel access shall be bolted in place to allow convenient removal if needed for major equipment repairs or replacement.
- For edges of elevated slabs, or where floor openings are designed, such as for personnel or equipment access, or equipment installation or removal, include safety provisions to avoid falling hazards. Guardrails are considered more durable and preferable to safety nets. Safety nets require periodic maintenance, testing, and occasional replacement.
- Where removable handrails are needed to allow occasional temporary clearance or access to equipment, design such handrails to be installed in conveniently sized sections, and to be removable with common hand tools.
- Where building roof access stairs are located at the edge of a roof, provide handrails on each side of the stair.
- Any elevated floors or ramps accommodating material handling trucks shall have guardrails.
- Try to avoid requiring use of ladders to access equipment for maintenance, or for carrying maintenance equipment. Ladders may be suitable for small buildings. Fixed ladders shall conform to OSHA regulations 1910.28, including the following:

  - For caged, fixed ladders erected before November 19, 2018, employers have up to 20 years to install ladder safety or personal fall arrest systems (1910.28(b)(9)(i)(A))
  - For new fixed ladders erected on or after November 19,2018, the employer must equip the ladder with a ladder safety or personal fall arrest system (1910.28(b)(9)(i)(B))
  - For ladder repairs and replacements, when an employer replaces any portion of a fixed ladder, the replacement must be equipped with a ladder safety or personal fall arrest system (1910.28(b)(9)(i)(C))
  - After November 18, 2036, all fixed ladders must be equipped with a ladder safety or personal fall arrest system (1910.28(b)(9)(i)(D))

- Any area where pipes, tanks, or other liquid-containing vessels are located shall have specific measures to prevent damage to electrical equipment in the event of an uncontrolled release of the liquid. Mounting motors above the likely flood level is one alternative.
- Proper spill containment shall be provided to prevent process liquids from causing environmental damage. Absorbent materials and ad hoc barriers are not acceptable.
- Areas designated for location of Process Control System (PCS) terminals, records storage cabinets, and desks, are to be enclosed and climate-controlled.
- Any building roof that has equipment requiring periodic maintenance such as filter changing, lubrication, belt replacement, etc. shall have an appropriate means to carry these materials to the roof.
- Building roofs with equipment located on it shall have means of egress in accordance with code requirements, which vary with roof heights above grade. Large electrical or mechanical spaces may require two means of egress, remotely located.
- Roof walkways shall be located at least 6 feet from the edge of roof as much as possible. Wherever walkways are needed to encroach within 6 feet of the edge of a roof, provide handrails for separation and safety, or alternatively make provisions for adequate tie-off in accordance with OSHA requirements. OSHA also requires a railing for any equipment located 10 feet or closer to the edge of roof.

3.3.1.4 Energy Conservation

The design objective shall be the maximization of energy savings through prudent selection of material and equipment. The design and construction of the exterior building envelope and the selection of heating, ventilation, and air conditioning (HVAC), service water heating, electrical distribution and illumination systems required for effective use of energy shall be governed by the current codes as indicated in Section 3.3.1.1.

3.3.1.5 Special Considerations

The designer shall consider appropriate fire protection and safety measures and coordinate fire protection design with the Fire Marshall Office.

For fire protection, the design may include:

- Fire separation walls of fire areas
- Sprinkler systems
- Fire hydrants, hoses, and extinguishers
- Application of fireproof materials
- Fire-rated walls, doors, and dampers
- Explosion proof electrical equipment in gaseous areas

- Accessibility for fire-fighting equipment
- Alarm systems

Safety of personnel will be achieved by:

- Provision of adequate emergency exits
- Application of appropriate egress travel distances
- Use of enclosed stairs as means of egress when required
- Non-skid surfaces in wet areas

Additionally, whether or not a Hazard and Operability (HAZOP) study is conducted for the design project (See PDM Volume 1), other safety issues, concerns, or hazards may be identified. Such safety hazards or issues shall be mitigated based on a common safety hierarchy of controls, as listed below:

- Elimination/substitution
- Engineering controls
- Administrative controls
- Personal protective equipment(PPE)

Make provisions for handicapped persons in areas that may be used by handicapped personnel or visitors. Include the following:

- Accessible route
- Handicap parking spaces when required
- Ramps
- Accessible stairs (with area of refuge when required)
- Elevators
- Wide doors
- Wheelchair-accessible sanitary facilities

Use the following to provide acoustical treatment to reduce noise by absorption, transmission, or deflection in selected and agreed-upon areas:

- Appropriate noise-attenuating walls
- Noise-absorbing materials (built in or applied to the surface)
- Noise dampers (applied to equipment)
- Noise-deflecting walls and screens
- Acoustical louvers

Consider the following items as appropriate to ensure security of the whole project or of individual components.

- Fences and gates
- Alarm systems
- Monitoring systems
- Special hardware
- Limited accessibility zoning
- Warning signs

- Keying system compatible with the Authority
- Site lighting

3.3.2 Architectural Design Considerations

To maximize efficiency and to minimize maintenance, give special consideration to the permanence of all structures. Consider the buildability and economy of construction at all stages of design.

Exterior finishes at plant should match existing brick and bond pattern to the fullest extent possible.

3.3.2.1 Exterior Doors

Exterior doors shall be protected from the environment where possible. Subject to security requirements, doors shall be recessed as part of the design, or provide wing walls and/or hold open devices as needed. Heavy duty fiberglass, aluminum, and corrosion protected steel doors shall be provided.

Roll up doors are to be power operated with local pushbutton control, and shall be provided with a manual chain operator to allow operation of the door if the power opener fails

For all equipment rooms, access by forklifts, for equipment delivery or removal, provide minimum 8-foot wide openings, with ramps and guardrails as needed.

3.3.2.2 Compatibility of Design and Construction

The designer will execute final work in a manner ensuring the compatibility of the final construction product with all DPs and Construction Packages (CPs). Coordination of the design with the work of other PDEs must be done through program management.

3.3.2.3 Sustainability and Branding for Blue Plains

Coordinate all proposed designs for Blue Plains facilities with DC Water and appropriate permitting authorities. Design facilities for long term sustainability and coordinate branding considerations consistent with DC Water guidelines. The designer shall verify the latest guidelines with DC Water for each project.

The Facilities and Security Department will review the selections of interior and exterior materials/finishes and provide guidance in standardizing facilities systems and components to reduce long-term maintenance and operational costs. This department will also ensure that all designs meet the security standards of the Authority, and should be consulted for each project beginning with the concept design stage.

Guiding Principles for new construction and significant renovations:

- Promote a safe and sustainable workplace for DC Water staff, consultants, contractors, and visitors.
- Operate in harmony with neighbors and the surrounding community.
- Comply with all Laws, Rules and Regulations, including but not limited to: ADA, the National Environmental Policy Act (NEPA), reviews by the U.S. Commission of Fine Arts (CFA) and the National Capital Planning Commission (NCPC), plus District permitting requirements such as Historic Preservation, Stormwater management, floodplain control, and building occupancy requirements as determined by Department of Consumer and Regulatory Affairs (DCRA), District Department of the Environment (DDOE) and the State Historic Preservation Office (SHPO).

- Materials and finishes used are to be standardized to the fullest extent possible, for ease in long-term maintenance and replacement.
- Exteriors: The only blue or green colors that are to be used on the exteriors of facilities are Pantone 369 (green) and 3005 (blue). There are no alterations to the colors, logo and/or tag line.
- Interiors: Complimentary shades of blue and green are to be used along with neutrals, standard sizes of cubicles and associated space to be implemented in all areas using the Central Maintenance Facility (CMF) renovation as a model. The Knoll product line for cubicles has been selected as the system furniture that is to be used – any interior work or additions of furniture, fixtures, etc., must be through Facilities and approved by them.

DC Water facilities are classified as different types based on visibility, use and level of community engagement. Table 2-3-1 (following page) presents the facility types and principles for general guidelines.

3.3.2.4 DC Green Building Act

The DC GBA of 2006 as amended in 2012 imposed certain requirements on different categories of DC Water building projects. For each individual building project, the designer shall review the latest requirements of the DC GBA, the USGBC, and coordinate with DC Water to confirm the project-specific category and applicability of GBA related requirements. For government agencies which are mandated to have new and refurbished buildings be LEED Silver Certified, certain conditions apply per the USGBC minimum program requirements (MPRs). LEED Silver Certification is not available for buildings less than 1,000 square feet, and LEED Certification is not applicable to non-occupied buildings, such as temporary trailers, utility, mechanical, storage, or process buildings. Buildings which are a combination of the above and are also occupied and have offices, restrooms, locker rooms, showers, training rooms, kitchenettes and break rooms, may possibly fall in the LEED Silver category depending on the percentage of the total building area that is occupied, versus process/utility areas. The USGBC should be consulted first before a building is programmed or mandated to meet LEED Silver requirements, otherwise USGBC may not accept the application. This does not preclude DC Water's prerogative to require that buildings meet the most stringent energy conservation requirements, but trying to get LEED Silver Certification for buildings which do not fall under the MPRs may be an unproductive endeavor.

The category known as "LEED Buildings", includes new buildings 10,000 square feet or more, and may possibly include all new or substantially improved buildings regardless of size. Unless otherwise directed or approved by DC Water, these buildings must attain at least LEED Silver certification within two years of receiving a certificate of occupancy (COO), defined by the GBA to mean "the first certificate of occupancy issued for a usable, habitable [occupied] space at grade or above grade." Although certificates of occupancy are defined more broadly in the DC Zoning Code, the more narrow definition in the GBA controls for purposes interpreting and applying GBA. Under the DC Zoning Code, a certificate of occupancy is required prior to use of "any structure, land, or part of any structure or land for any purpose. DC adopted the International Building Code (2006) which defines "structure" as "that which is built or constructed."

The category known as "Energy Star Buildings," covers new, substantially improved, and existing buildings with 10,000 square feet or more of gross floor area (GFA) if Energy Star performance tools are available for the specific building type. GFA is defined as the sum of the gross horizontal areas of the several floors of all buildings on the lot, measured from the exterior faces of exterior walls and from the center line of walls separating two (2) buildings. It includes basements, elevator shafts, and stairwells at each story; mechanical equipment spaces and attic spaces with headroom of 6 feet, 6 inches or more; penthouses; interior balconies; and mezzanines.

The GBA imposes benchmarking and reporting requirements on all Energy Star Buildings, while new and substantially improved Energy Star Buildings must also meet performance standards based on the Environmental Protection Agency (EPA) national energy performance rating system. Upon receipt of a COO, building owners must institute systems monitoring and maintenance accountability methods for the new or substantially improved Energy Star Buildings. Performance of existing buildings in this category must also be benchmarked. Owners of all Energy Star Buildings must perform annual benchmark scoring using the appropriate Energy Star Portfolio Manager tool and must submit the score report to the DDOE within sixty days of its generation.

Table 2-3-1. General Sustainability and Branding Guidelines for Facility Types

Type	*Facility Description*	*Sustainability Principles*	*Branding Principles*
A	***Highly Visible (prominent street views or riverfront)*** • *Occupied by DC Water staff/consultants* • *Significance within the community or DC Water operations* • *Historical Buildings – officially designated or eligible for designation* *Examples include:* *- Main Pump Station ?* *- Bryant Street Pump Station?* *- COF/HQ Bldg* *- Warehouse Facility?* *- Blue Plains Visitor Center*	***Green Building is Critical*** *LEED Gold or above (may not seek official USGBC cert)* *Long-term maintenance costs are likely to be highest in this category, but should not override design decisions, especially with historic building considerations and access to the public*	***Make the Facility Stand-out*** *Bright visible use of the DC Water colors and logo* ***Engage the Public*** *Education/Public outreach Exhibits and Interactive displays to be emphasized, many opportunities for public tours to demonstrate DC Water's critical role in the community*
B	***Moderate Visibility*** • *Rarely or less occupied by DC Water staff/consultants* • *Significance within the community or DC Water operations* *Examples include:* *- O Street Pump Station?* *- Poplar Point Pump Station?* *- Anacostia Pump Station?* *- Ft. Reno Pump Station?* *- Lab & Grit 2 Bldgs at BP?*	***Moderate Green Building*** *LEED Standards (will not seek official USGBC cert) are to be used but cost/benefits must be considered* *Long-term maintenance costs to be considered, and may override design options, but the cheapest alternative may not be preferred because of other concerns*	***Accent*** *Limited use of DC Water colors and logo* ***Provide information to the Public*** *Educational signage or similar outside of secured areas, limited access to the public*
C	***Minimally or Not Visible*** • *Unoccupied by DC Water staff/consultants* • *Little to no significance within the community or DC Water operations* *Examples include:* *- Other Blue Plains facilities?* *- Potomac Pump Station?* *- Potomac Interceptor?* *- Support bldgs at Main and Bryant for crews* *-Diversion Structures and Outfalls?*	***Minimal Green Building*** *Green building focus on Stormwater Management & Energy Use* *Long-term maintenance costs to take priority, cheapest alternative to be favored in design and selection of materials*	***Blend In*** *Use DC Water logo only as appropriate, DC Water brick at Blue Plains or designs complimentary to COF.* ***Restricted Public Access*** *No educational/outreach opportunities (except as part of larger Blue Plains tour, these facilities would most likely never be entered by the public)*

All of DC Water's new or substantially improved-building projects with fifteen percent or more public funding are potentially subject to GBA requirements. Additionally, all existing DC Water buildings are potentially subject to Energy Star benchmarking and reporting. The following four categories of structures are identified for purposes of applying the GBA.

1. **Occupied Buildings**: New or substantial renovations of Occupied Buildings (routinely occupied offices, maintenance shops, laboratories, etc.) must meet at least LEED Silver certification standards within two years of receipt of a COO. They are also subject to the GBA's Energy Star requirements if they contain 10,000 square feet or more of GFA and Energy Star performance tools are available for the specific building type

2. **Large Structures At or Above Grade**: These structures, typically unoccupied, but designed to accommodate workers for periodic inspections or maintenance or for other purposes (e.g., pumping stations, treatment basins, tanks, etc.) may be subject to GBA requirements based on whether they require a COO and/ or have at least 10,000 square feet of GFA. GBA requirements are triggered by receipt of a COO issued for a usable habitable space at or above grade." Accordingly, coverage determinations regarding structures in this category depend on whether the structure requires a COO (as defined in the GBA) and the amount of GFA.

3. **Small *(Less Than 10,000 sq. ft GFA)* Structures At or Above Grade**: Those structures at or above grade whether or not designed to accommodate workers (e.g., tool sheds, above grade\laterals, above grade water lines, etc.) may be subject to compliance because they are "buildings" under the GBA and may also require COOs. If so, they fall under the LEED Buildings mandate. However, with less than 10,000 square feet GFA, these structures would be exempt from the Energy Star mandate.

4. **Structures Below Grade**: Tunnels, sewer interceptors, laterals, water lines, etc., do not require a COO as defined in the GBA because they are below grade. Therefore, the LEED Building and the Energy Star mandates for new or substantially improved 'buildings' (structures) would not be triggered. However, existing structures that exceed the 10,000 square feet threshold may be subject to the Energy Star benchmarking and reporting requirements.

Designers shall coordinate with DC Water to confirm the classification or category of each building or structure involved in each project, with respect to the applicability of the GBA, and consult with the USGBC whether the specific building(s) meet the MPRs and can get LEED Silver Certification. Design responsibilities may possibly include tasks to classify or categorize existing and/or proposed structures to assess the potential applicability of GBA requirements. In some cases it may be determined that certain projects or structures may be exempt from GBA requirements, or it may possibly be determined that the structures are covered by the GBA, but a basis exists for seeking an exemption.

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APPENDIX A
SAMPLE ARCHITECTURAL SCHEDULES

The schedules included in this section are intended as samples to illustrate the arrangement and type of information required. The samples have been provided to establish a minimum level of required information.

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Table A-1. Door Schedule (Sample)

Location	Door				Material	Detail							Remarks
Bldg., Floor, Room No. and Name	**No.**	**Door Opening**	**Type**	**Swing**	**Door**	**Frame**	**Head**	**Jamb**	**Sill**	**Fire Label**	**Weather Striping**	**Hardware Set No.**	
Admin. Bldg 1st Floor													
(1) Entrance	11	PR 3' - 0" x 7' - 10"	FG	RHRA	AL	AL	H-1	J-1	S-1	-	Yes	16	w/Transom
(12) Receptionist	12	3' - 0" x 7' - 2"	G	LH	HM	PM	H-4	J-4	S-2	-	-	24	
(13) Corridor No. 1	13	PR 3' - 0" x 7' - 2"	V	RHR	HM	PM	H-4	J-4	S-3	B	Yes	24A	
Admin. Bldg. 2nd Floor													
(21) Staircase No. 2	25	3' - 0" x 7' - 2"	F	LHR	HM	PM	H-5	J-5	S-4	B	Yes	24A	
(22) Manager	26	3' - 0" x 7' - 2"	V	RH	W	PM	H-7	J-7	S-4	-	-	24	
(23) Storage Rm. No. 1	27	2' - 6" x 7' - 2"	F	RHR	HM	PM	H-5	J-5	S-4	-	-	25	W/1" Undercut

Notes
1. This schedule shall be located directly on the drawing.
2. With application of CAD, all types and symbols may be replaced by attributes.
3. Door swing is described while facing the door **from outside of room or area.**

Table A-2. Finish Schedule (Sample)

Location	Floor		Base		Wall		Ceiling		Door			Doorframe		Remarks	
Bldg., Floor, Room No. & Name	Fin.	Color	Fin.	Color	Fin.	Color	Fin.	Color	No.	Fin.	Color	Fin.	Color	Item &Fin	Color
Admin. Bldg. 1st Floor															
(11) Vestibule	a	275-C	a	275-c	h	IS-49	i	01	1	h	13	h	13	Exterior Type	IS-49
(12) Receptionist	b	B-31	e*	B-31	H	029	i	01	2	h	0103	h	0105	4'0" high wainscot	W-39
(13) Corridor	c	1391	c	75	H	037	i	01	3	h	0103	h	0105		
Admin. Bldg. 2nd Floor															
Staircase No. 2	b	B-33	b	B-33	h	037	i	021	51	h	0104	h	0104		
(22) Manager	c	1450	c	75	h	037	i	01	52	h	0104	h	n-53		
(23) Storage Rm. No. 1	d	49	d	49	h	041	j	037	53	h	0104	h	0104		

Material Symbol and (Color Reference No.):

a - Quarry Tile (American Olean Tile Co.)
b - Polyterrazzo (National Terrazzo Assn.)
c - Vinyl Tile (Kentile Floors)
d - Seamless Flooring (Quartizite by TODCO)
e - Plastic Finished Panels (Formica)
h - Paint (Tnemec)
i - Acoustical Panels

Notes:

1. This schedule shall be located directly on the drawings.
2. In case of CAD application, use agreed-upon symbols.
3. All finishes shall be suitable to the facility environment.
4. The color and finish numbers indicated in the schedule are based on a system used by the manufacturers listed above. Numbers establish the type of finish and color only. Similar products of equal quality by other manufacturers will be acceptable, as listed in the appropriate sections of the specifications.

Table A-3. Window Schedule (Sample)

Type	Size		Detail			
	Width	Height	Head	Jamb	Sill	Remarks

Table A-4. Louver Schedule (Sample)

Type	Size		Detail			
	Width	Height	Head	Jamb	Sill	Remarks

APPENDIX B
ARCHITECTURAL ABBREVIATIONS

Use the abbreviations in Table B-1 in schedules and drawings where economy of space governs. Use graphic symbols as indicated in DC Water CAD Manual Supplement. Numerical symbols may be used in schedules to indicate colors and finishes proprietary to a manufacturer's product for the purpose of defining the material by catalog number only.

Table B-1. Architectural Abbreviations

Abbreviation	Name
A	active (door)
AC	acoustic(al)
AL	aluminum
AN	anodized
B	bench
BD	board
Bldg	building
BM	beam
BR	brick
C	channel (structural shape)
CAB	cabinet
CJ	construction joint
CLG	ceiling
CMU	concrete masonry unit
COL	column
CON	concrete
CPT	compartment
CR	control
CTR	center (central)
DIA	diameter
DPF	damproof (ing)
DR	drain
DS	dustproof-seal (ed) (er)
EA	each
EL	elevation (level)
EN	enamel (ed)

Abbreviation	Name
ENT	entrance
EXIST	existing
EXPN	expansion
EXT	exterior (external)
EXTN	extension
FIN	finish
FL	floor
FPF	fireproof (ing)
FT	foot (feet)
G	glazed (door)
GA	gauge
GALV	galvanized
GL	glass
GR	ground
GRG	grating
GWT	glazed wall tile
GYP	gypsum
H	head (detail)
HC	handicapped
HM	hollow metal
HWR	hardware
IN	inch (es)
INC	including
INS	insulation (ing)
J	jamb (detail)
JST	joist

Table B.1 Architectural Abbreviations (continued)

Abbreviation	Name
JT	joint
L	angle (structural shape)
LA	lavatory
LHD	liquid hardener
LH	left hand (door swing)
LHR	left-hand reversed (door swing)
LO	locker
LT	lintel
MET	metal
MT	mortar
NAT	natural (finish, color)
NO	number
O	field painted
P	paint (ed)
PAV	paving
PC	protective coating
PF	proof
PG	paint, glazed
PL	plate
PLF	plastic faced
PLR	plaster
PM	pressed metal
PR	pain (of door)
PTER	polyterrazzo
QT	quarry tile

Abbreviation	Name
R	radius
RFG	roofing
RH	right hand (door swing)
RHR	right hand reversed (door swing)
RLG	railing
RM	room
S	sill (detail)
SCR	screen
SCT	structural clay tile
SFT	structural facing tile
SH	shower
SHT	sheet
SS	stainless steel
STD	standard
STL	steel
T	toilet
TER	terrazzo
TR	tread
TYP	typical
U	urinal
V	vinyl
WD	wood (en)
WPF	waterproof
X	cross

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY
(DC Water)

"SERVING THE PUBLIC - PROTECTING THE ENVIRONMENT"

PROJECT
DESIGN MANUAL
VOLUME 2 - FACILITIES DESIGN

SECTION 4 – STRUCTURAL

August 2018

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AUTHORIZATION FORM

Revision Number	Date	Content
Draft 2	6/19/98	Project Design Manual Volume 2 - Facilities Design Section 4 – Structural
2013 Version	03/01/2013	Section 4 - Structural
2014 Version	07/31/2014	Section 4 – Structural
August 2018	07/25/2018	Section 4 - Structural

This 2018 version was authorized by:

S. Bian 12/20/18

Steve Bian PE, Supervisor, Civil and Structural Design Date

SECTION 4, STRUCTURAL LOG OF REVISIONS (From 1999 Draft 3 version)		
Paragraph	**Brief Description of Revision**	**Date**
Global	- Changed “DC WASA”/“WASA” to “DC Water” - Changed dates of Codes/Regs to ’latest version adopted by DCRA’. - Added List of Acronyms and Abbreviations.	
4.2.1	-Design structures for 100 year design life -Added requirements for concrete quality for environmental engr. structures.	
4.3.1	Added general direction for plan drawings layout and presentation.	
4.3.1.7	Allowable Stress Design procedure for Environmental type structures.	
4.3.2	Added misc. items to show on structural plans; and to field verify CJ/EJ’s in existing concrete structures as needed.	
4.3.7	Emphasis on detailing for concrete reinforcement per ACI 315	07-25-2018
4.3.8	Added requirements for use of design calcs software.	
4.4.1.1	Latest codes / regs to be ‘as adopted by DCRA’. - Emphasis to fully comply with codes and regulations	07-25-2018
4.4.1.3	Added requirement for Green Roof dead loads.	
4.4.1.5	Added Wind Loads requirements to be per ASCE/SEI 7.	
4.4.1.6	Added Seismic Loads requirements.	
4.4.1.7	Added ASD requirement for environmental structures (versus LRFD).	
4.4.2.1	Expanded concrete specifications requirements.	
4.4.2.2	Expanded spec requirements for metals.	
4.4.3.1	Updated isolation of dissimilar metals (aluminum) and aluminum coatings for contact with concrete.	
4.4.3.2.1	Precast connections requirements.	
4.4.3.3	Concrete anchors for submerged conditions, overhead locations, and shallow embedment in existing concrete.	
4.4.3.6	PDE responsibility to dictate types of structural steel connections to be fabricated, and to verify fabricator’s design.	
4.4.3.7	Added alternate waterstop materials options.	
4.4.3.8	Waterproofing requirement for walls below grade.	

SECTION 4, STRUCTURAL LOG OF REVISIONS (continued) (From 1999 Draft 3 version)		
Paragraph	**Brief Description of Revision**	**Date**
4.4.4.1	Added impact loads requirements.	
4.4.6.1	Retaining walls – deleted 2.0 FOS for cohesive soils.	
4.4.6.2	Floatation Factors of Safety for 100 yr and 500 yr floods.	
4.4.6.3	Added requirements for hydrostatic lateral loads.	
4.4.6.4	Added requirements for lateral earth pressures.	
4.4.6.5	Added requirements for seismic lateral pressures.	
4.4.6.6	Added Walls in Open Tanks and Channels.	
4.4.6.7	Protection of structures from water up to grade or 100-year flood. Changed protection to higher of 6” abv grade or 100-year flood.	07-25-2018
List of Acronyms and Abbreviations	Corrected entry for hollow structural sections, HSS. Corrected entry for WS. Deleted ASD, DP, and LRFD. Added EOR.	06-23-2014
4.2.1	Clarify additional concerns for concrete structures.	6-23-2014
4.2.2	Added new subparagraph 4.2.2 for Engineer of record verification of compatibility of contractor-provided designs.	05-20-2014
4.3	Changed title from ‘FORMATS’ TO ‘CONSTRUCTION DRAWINGS.’	06-23-2014
4.3.1	Changed title from 'Drafting Standards' to 'General. Moved text on ACI 318 and 350 code usage to Para. 4.4.1.1. Added requirement to specify minimum caisson capacity.	06-23-2014
4.3.2	Minor edits to show allowable safe bearing pressures directly on foundation plans.	05-20-2014
4.3.2.1	Added pile capacity, and minor edits to show pile data directly on plans.	05-20-2014
4.3.2.2	Show dimensions of caissons to exterior face of walls.	05-20-2014
4.3.2.3	Added ‘Mats’ to title. Show high and low points elevations and slope arrows.	05-20-2014
4.3.2.4	Added requirements for floor slabs for washdown areas.	05-20-2014
4.3.3	Minor edits for showing floor sections.	05-20-2014
4.3.4	Listed information items for various structural schedules.	05-20-2014
4.3.5	Added requirement to include governing codes, design loading.	06-23-2014
4.3.8	Moved Para. 4.3.8, Calculation Rqmts to new Para. 4.4.7 and added requirements for design calculations software.	06-23-2014

4.4.1	Added 'ASTM' to list of standards organizations.	05-20-2014
4.4.1.1	Deleted ACI 530.	06-23-2014
4.4.1.2	Added ACI 315, ACI 318, and USACE CRD-C 572.	05-20-2014
4.4.1.3	Dead Load is moved to Para. 4.4.4.1.	06-23-2014
4.4.1.4	Live Load is moved to Para. 4.4.4.2.	06-23-2014
4.4.1.5	Wind Load is moved to Para. 4.4.4.3.	06-23-2014
4.4.1.6	Seismic Load is moved to Para. 4.4.4.4.	06-23-2014
4.4.1.7	Moved Para. 4.4.1.7 to Para. 4.4.1.1, and clarified definition and design requirements for "Environmental Engineering Concrete Structures."	06-23-2014
4.4.2.1	Added additional concrete specifications requirements, including for environmental engineering concrete structures.	05-20-2014
4.4.2.2	Added 'Steel' shapes, and added ASTM 27.6	05-20-2014
4.4.3.1	Added restriction against Aluminum and Galvanized Steel contact with wastewater.	05-20-2014
4.4.3.2	Added reference for detailing reinforcement; and options for environmental engineering concrete structures.	05-20-2014
4.4.3.3	Clarifications for concrete anchor requirements.	05-20-2014
4.4.3.5	Changed reference from ASTM A167 to ASTM A276.	05-20-2014
4.4.3.6	Added AISC Specification for Structural Steel Buildings.	05-20-2014
4.4.3.7	Deleted direction to consider different waterstop materials.	05-20-2014
4.4.3.8	Changed membrane waterproofing to bentonite material.	05-20-2014
4.4.4	Paragraph is renamed 'Loading.'	06-23-2014
4.4.4.8	Thermal expansion and contraction, and use of expansion bearings	07-25-2018
4.4.5.2	Deleted staggered joint placement used to increase spacing between expansion joints.	05-20-2014
4.4.6.3	Clarified hydrostatic loading conditions to be analyzed.	05-20-2014
4.4.6.4	Clarified the at rest coefficient for lateral earth pressure due to surcharge on foundation walls.	05-20-2014
4.4.7	Added reference to PDM Volume 1	07-25-2018
Appendix A	Structural Schedules, deleted.	05-20-2014

SECTION 4 – STRUCTURAL
TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMNS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ADA	Americans with Disabilities Act
AISC	American Institute of Steel Construction
ANSI	American National Standards
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing of Materials
AWS	American Welding Society
AWTP	Advanced Wastewater Treatment Plant
AWWA	American Water Works Association
CAD	computer-aided design
CJ	construction joints
DC Water	District of Columbia Water and Sewer Authority
DCRA	Department of Consumer and Regulatory Affairs, Washington, DC
EJ	expansion joints
El.	elevation
EOR	Engineers of Record
HSS	hollow structural sections
ICC	International Code Council
kN/m^2	kilonewtons per square meter
m	meter
mm	millimeter
MPa	megapascal
NCMA	National Concrete Masonry Association
OSHA	Occupational Safety and Health Act
PCA	Portland Cement Association
PCI	Prestressed Concrete Institute
PDE	Project Design Engineer
PDM	Project Design Manual
psf	pounds per square foot
psi	pounds per square inch
PVC	polyvinyl chloride
WS	waterstop

PROJECT DESIGN MANUAL
VOLUME 2 – FACILITIES DESIGN

4. STRUCTURAL

4.1 INTRODUCTION

The requirements outlined in this section are general and apply to all DC Water design projects. Specific structural requirements for each design project are contained within the individual project conceptual design reports and will supplement the requirements and guidelines outlined in this section.

4.2 GENERAL REQUIREMENTS

The following items convey general structural design criteria for DC Water projects.

4.2.1 Design Philosophy

The design of structures shall be for a design life of 100 years. The designer shall include additional measures in designs and specifications related to durability of structures. In new and existing structures, the structural effects of all loads shall be analyzed from the point of application down to the foundation.

While strength and stability are paramount in all structures, environmental engineering concrete structures require additional concerns with respect to serviceability. Additional considerations are limitation of deflections, vibration, cracking, durability, and low permeability. Concrete for environmental engineering concrete structures that will be in contact with groundwater and wastewater must:

- Be extremely dense and impermeable to minimize contamination of the environment
- Provide maximum resistance to wastewater and processing chemicals
- Provide smooth surfaces to minimize flow resistance

Concrete is the preferred construction material for DC Water facilities. Load bearing masonry and wood frame structures shall not be used in permanent facilities. Environmental engineering structures have stringent service requirements and shall be designed with great care.

In the preparation of the construction contract documents, the Project Design Engineer (PDE) should not merely refer the Contractor to applicable codes or requirements, but should interpret the requirements by preparing specific design details and notes for the Contractor to follow. The PDE shall provide clarification where omissions, ambiguities, or incompatibilities are found in the documents, and when clarifications are requested by the Contractor.

4.2.2 Engineer of Record

A project may have multiple Engineers of Record (EOR) but each structure within a project shall have one Engineer of Record responsible for the structural design of the complete structure. As much as possible, the EOR shall avoid delegating the responsibility for providing design of specialty structural components to a construction contractor. For example, design of roof diaphragm, braces, and moment frames, elevated walkways, etc., are critical components for lateral stability of the structure. If the EOR determines it is necessary to have the construction contractor to provide specialty designs for components which interface or connect with the EOR designed structure, the EOR shall stipulate the required criteria, loadings, and analyses, etc. in the construction contract specifications. Additionally, the specifications shall require detailed submittals for review of the contractor-provided specialty design, including supporting documentation to fully demonstrate coordination, compliance, and compatibility with the EOR's design criteria.

For contractor-provided designs of specialty structural component items, the EOR shall review the contractor's submittals to verify that the specialty design, including consistency of modeling and detailing assumptions, complies with the EOR specified loading criteria and code requirements. The EOR shall also review the complete load path for coordination and interdependency of the specialty-designed components for compatibility with the entire structure and verifying that the supporting structure can support the loads from components designed by others (such as a digester wall supporting the dome roof and walkways).

Roof Diaphragm – Design of the roof diaphragm is a critical component for lateral stability of the structure. Design of roof diaphragm, braces and moment frames (components of the lateral load system) shall NOT be delegated by the EOR to the specialty engineers by contractors/sub-contractors.

The role and responsibilities of the EOR are applicable for both Design-Bid-Build and Design-Build projects.

4.2.3 Soil Condition

High levels of soil acidity (pH range of 4.5 to 5.0) have been reported in some areas of the Blue Plains Advanced Wastewater Treatment Plant (AWTP). Design all structures in contact with the soil at the Blue Plains plant site for severe acid exposure unless lower levels of acidity can be established by a soil acidity survey. See Section 2, Civil, for geotechnical guidelines and requirements.

4.3 CONSTRUCTION DRAWINGS

4.3.1 General

Refer to DC Water Drafting Standards (CAD) Manual for format, organization of drawings, and scale requirements. Refer to DC Water Standard Details, for the applicable structural details. The following are additional drafting requirements for the structural drawings.

- Structural drawings shall be coordinated with other discipline drawings, and, where appropriate or as needed, include references to other disciplines for additional information such as locations of equipment, or penetrations of structural elements, etc.

- Structural drawings shall be placed in a logical sequence. Arrange drawings by structure. In general, use the following order for each structure: plans, sections, details, schedules. As feasible, place schedules on the plan to which they apply.

- **Organization of Contract Drawings**

  The set of drawings for a project shall be organized by discipline and then by structure within each discipline. The order of structures shall be consistent within all disciplines. The order of structures shall generally follow the process flow, liquid train then solids train, as appropriate. Administrative buildings may be presented at the beginning or the end of the set of drawings.

- **Plan Drawing Layout**

  Plan drawings shall be located to the upper leftmost corner of the sheet, allowing adequate space along the borders for dimensioning.

  Plan drawings shall be oriented such that the north arrow is pointing toward the top of the sheet or to the left of the sheet.

  All lettering and dimensioning shall be positioned such that it is readable from the bottom of the sheet or from the right margin.

- **Order of Plan Drawing Presentation**

  The plan drawings for a particular structure shall be presented from the lowest level to the highest level, based on the sequence in which they will be constructed.

  For structures where only one plan view will fit on a sheet, the lowest level shall be the first sheet.

  For structures where two plan views will fit beside each other on a sheet, the lowest level shall be on the left side of the sheet.

  For structures where two or more plan views will fit above and beside each other on a sheet, the lowest level shall be at the top left of the sheet. The next levels progressing upward shall be at the bottom left, top right and bottom right, respectively.

For structures where a plan cannot be properly presented on a single sheet, it will be necessary to divide the level into part plans using match lines. When a level is divided across multiple sheets the order of presentation shall be such that the upper left area of plan shall be the first sheet in the series. The remaining areas shall be presented left to right and then top to bottom in sequence (i.e., the second sheet shall be the area immediately to the right of the first area). This sequence shall continue with the area in the lower right of the plan presented last.

- Items to be embedded into concrete for other disciplines should be called out as the following note on the structural drawings to indicate that the coordination of trades is the contractor’s responsibility:

  > REFER TO CIVIL, ARCHITECTURAL, MECHANICAL, PLUMBING, FIRE PROTECTION AND ELECTRICAL DRAWINGS AND SPECIFICATIONS FOR LOCATIONS AND DIMENSIONS OF CHASES, SLOTS, INSERTS, CURBS, OPENINGS, SLEEVES, ANCHOR BOLTS, FLOOR PITCHES, ANGLE FRAMES, GATE FRAMES, AND OTHER PROJECT REQUIREMENTS NOT INDICATED ON STRUCTURAL DRAWINGS.

- Structural penetrations and openings for access, equipment, piping, ductwork, etc., shall be shown and dimensioned, properly detailed and referenced on the structural drawings.

- Plans, sections and details shall clearly distinguish new work from existing work.

- Design live loads shall be indicated on each plan drawing just below the plan title.

- Specify size, spacing, and location of reinforcing and bar clearances.

- Specify length of embedment and splices for all reinforcing bars.
- The framing plans shall show the walls, girders, beams, slabs, lintels, and framing plan elevations. The orientation of the columns shall be clearly defined on the drawings and in the schedule.
- The north arrow shall be shown on all plans.
- Size of all welds shall be indicated using American Welding Society (AWS) standard welding symbols.
- Size and embedment depth of anchor rods, and concrete anchors shall be indicated.
- Locations of construction, control and expansion joints shall be shown on the drawings.
- Show an aluminum nosing for all interior and exterior concrete stairs.
- All shallow foundations shall be shown bearing on six (6) inches minimum of uniformly graded gravel or crushed stone, Size #57, American Society for Testing and Materials (ASTM) C33.
- Show elevation or depths of the bottom of footings.
- Show pile cutoff elevations and the minimum pile penetration depths.
- Show locations and length of test piles.
- Specify the minimum pile capacity. Show the top and bottom elevations for caissons, and specify the diameter of the shaft and bell.
- Specify the minimum caisson capacity.

4.3.2 Plans

Use a minimum scale of 1/8 inch per foot for plan drawings. Show graphic scale on the drawings. Plans shall include the following:

- Size, spacing and location of slab reinforcing.
- Indicate additional slab reinforcing at openings.
- Construction joints located and indicated with a single line and the notation "CJ or "CJ & WS" if a waterstop is required.
- Expansion joints located and indicated with a double line and the notation EJ or "EJ & WS" if a waterstop is required.
- For work involved with existing structures, field verify existing construction joints and expansion joints as appropriate to maintain integrity, especially if existing work and joints will be affected by rehabilitation, or penetrations by new work.

- Foundation mats, base slabs, and walls less than 12 inches thick shall be dimensioned in inches; members equal to or greater than 12 inches thick shall be dimensioned in feet and inches.

- Framed slabs, beams, and columns shall be dimensioned in inches.

- Size and location of all openings, 12 inches and larger, such as pipes, sleeves, ducts, stairs, elevators, hatches and roof skylights in walls, slabs, and mats; plus, any smaller openings as may be appropriate.

- Identify floor and roof elevations in decimal parts of a foot to the nearest one hundredth. Feet and inches are not acceptable (e.g., indicate floor elevation of 140'-10" as El. 140.83').

- Use a coordinate system of letters and numbers to locate columns on plans. Place the letters along the left or right side of the plan starting at the top and proceeding toward the bottom of the sheet. Place numbers left to right along the top of the plan. Use individual column numbers for plans with columns not arranged in parallel lines, such as a circular pump station.

- Include allowable safe bearing pressures for spread footings and foundation mats immediately below the plan title on foundation plans, not on note sheets.

- Design loads for major equipment, such as engine-generators, centrifuges, and large pumps, etc., shall also be shown on the construction drawings, based on estimated maximum loads (worst case scenarios) among allowable equipment options.

4.3.2.1 Pile Plans

Each pile shall be numbered consecutively for each design package. Note the following information on the pile plans, not on note sheets:

- Pile capacity.
- Type of piles (friction or bearing, straight or battered).
- Pile tip and cutoff elevations.
- Splice details.
- Locations of test and anchor piles to be installed.
- Dimension piles from column center lines and from the exterior face of the concrete walls. On plans for tanks and galleries, outline the concrete walls, and dimension the piles to the exterior face of the walls.

4.3.2.2 Caisson Plans

Each caisson shall have an identification mark, with a corresponding mark in a caisson schedule. Note the following items in the caisson schedule:

- Mark number (such as C1 or C2).
- Shaft and bell diameter.
- Top and bottom elevation.
- Reinforcement as required.

- Dimension caissons from column center lines and from the exterior face of the concrete walls. Outline the concrete walls, and dimension the caissons to the exterior face of the walls.

4.3.2.3 Foundation Mats and Slabs on Grade

Indicate mat thickness, elevation and reinforcement on plans. Provide continuous mat reinforcement in each direction, top and bottom. Show extent of all bars in plan.

- Consider the use of a concrete mud slab under mats.
- Gallery mats shall have a separate concrete fill sloped toward walls at 1/4 inch per foot. Note high and low point elevations on plans and indicate slope arrows.
- Show dimensions and locations of sump pits on the drawings. Sump pit walls shall have waterstops in all construction joints.
- Floor trenches, if required, shall be sized and located by the mechanical engineer and shown and dimensioned on the structural plans.
- Show and locate columns on plans.
- Waterstop all expansion joints and construction joints. Key-groove all construction joints except horizontal joints in walls, between base slab and wall.

4.3.2.4 Framed Floor and Roof Plans

For framed floor and roof plans, show the following items on the plans:

- Indicate slab thickness, elevation and reinforcement on plans. Use a slab schedule when the reinforcement has considerable variation or the plan is congested.
- Reinforcement size, location and spacing on plan per American Concrete Institute (ACI) 315.
- Floor depressions and changes in elevation.
- Show handrails on structural drawings and make reference to handrail standard details if the set of drawings for the project does not have separate drawings for the architectural discipline. Use a separate handrail drawing if the addition of handrails places too much information on the drawings.
- Stop handrails at sluice gate and slide gate floor stands.
- Floor slopes, high points and low points.
- Concrete beam designation keyed to a beam schedule.
- Select concrete beam dimensions to be compatible with standard coursing for masonry construction.
- Provide a minimum slope of 1/4 inch per foot for floors subject to wash down or spillages, and elsewhere as required.
- Provide a minimum slope of 1/8 inch per foot for flat roofs.
- Construction joints through slabs and beams shall be key-grooved. Waterstop construction joints in floor slabs subject to wash down and elsewhere as required.

- Slope all floor slabs to gutters, sumps or floor drains. Use minimum slab thickness in calculations of strength.

4.3.3 Sections

In general, do not use wide overall sections through structures that display little information. Larger, narrow sections applying to a particular area of the structure are preferred.

When preparing sections:

- Indicate all horizontal construction joints and waterstops.
- Show size and length of dowel legs. Carry horizontal dowel legs into mat to level of bottom mat of reinforcement.
- Show wall reinforcement in sections, size and spacing of all horizontal and vertical wall reinforcement, and show additional reinforcement, if required, at corners and intersecting walls on the plans. Indicate the size, spacing, and bar lengths of additional reinforcement.
- Consider pipe penetrations through walls for interference between pipe waterstop and polyvinyl chloride (PVC) wall waterstop. Indicate additional reinforcement on the plan or section when necessary.
- Show mat and slab reinforcement for configuration, but do not indicate size or spacing. Reinforcement size and spacing for mats and slabs shall be called out on plans.
- Indicate slab and beam pocket depths in sections.

4.3.4 Schedules

Use schedules to present size, reinforcing and other pertinent information for footings, columns, beams, slabs, and similar items of work. Include vertical dead and live loads in column schedules. Develop schedules in accordance with specific project requirements and include in the drawings. As a minimum, develop schedules for the following components and indicate, as a minimum, the following information, except that not all projects will require footing or slab schedules:

- Footing Schedule – Mark size, Top elevation; Thickness; Reinforcement, each direction, bottom, top; Remarks.
- Column Schedule – Column number; Elevation, each floor/level; Design live loads and dead loads.
- Concrete Beam Schedule – Mark; Size; Reinforcing, bottom, top; Stirrups, type, size, spacing; Remarks.
- Slab Schedule - Mark; Thickness; Reinforcement, each direction, bottom, top; Remarks.

4.3.5 Structural Notes

Develop structural notes for each project and include in the drawings as necessary to define or clarify structural requirements which may not be explicitly shown or covered by the drawings and specifications. Include governing codes, design loading.

4.3.6 Structural Abbreviations

Table 2-4-1. Structural Abbreviations

AB	Anchor Bolt	HP	High Point
ADD	Additional	IF	Inside Face
ALT	Alternate	LP	Low Point
ALUM	Aluminum	MAX	Maximum
ARCH	Architectural	MFR	Manufacturer
BM	Beam	MIN	Minimum
B, BOT	Bottom	NTS	Not to Scale
CJ	Construction Joint	OC	On Center
CL	Clear	OF	Outside Face
COL	Column	OPNG	Opening
CONC	Concrete	PCF	Pounds Per Cubic Foot
CONT	Continuous	PJF	Premolded Joint Filler
DET	Detail	PSF	Pounds Per Square Foot
DIAM, ∅	Diameter	SPECS	Specifications
DIR	Direction	STD	Standard
DP	Deep	STL	Steel
DWG	Drawing	SYMM	Symmetrical
DWL	Dowel	T	Top
EA	Each	TOC	Top of Concrete
EF	Each Face	THK	Thick
EL	Elevation	TOS	Top of Steel
EW	Each Way	T/W	Top of Wall
EJ	Expansion Joint	TYP	Typical
EXIST	Existing	UNO	Unless Noted Otherwise
FF	Far Face	V, VERT	Vertical
FD	Floor Drain	WS	Water Stop
GALV	Galvanize (Hot Dip)	WWF	Welded Wire Fabric
H, HORIZ	Horizontal	↔	Direction in which Bars Extend

4.3.7 Drawing Details

Use applicable DC Water Standard Details throughout the design in all drawings. For non-standard details, DC Water emphasizes that it expects designers to diligently and thoroughly draft details for concrete construction and especially for detailing of concrete reinforcement in accordance with ACI 315, referenced hereafter.

4.4 TECHNICAL GUIDELINES

Base all designs on the information contained within Section 4, unless otherwise directed by DC Water.

4.4.1 Standards

Structural design for the DC Water Blue Plains Advanced Wastewater Treatment Plant and all other DC Water facilities shall conform to the codes and regulations listed in this section. Reference material may be obtained from the following professional societies and standards organizations:

AASHTO	American Association of State Highway and Transportation Officials, Washington, DC
ACI	American Concrete Institute, Detroit, Michigan
AISC	American Institute of Steel Construction, Chicago, Illinois
ANSI	American National Standards Institute, New York, New York
ASCE	American Society of Civil Engineers, Reston, Virginia
ASTM	American Society for Testing and Materials
AWS	American Welding Society, Miami, Florida
AWWA	American Water Works Association, Denver, Colorado
NCMA	National Concrete Masonry Association, Herndon, Virginia
PCA	Portland Cement Association, Chicago, Illinois
PCI	Prestressed Concrete Institute, Chicago, Illinois

4.4.1.1 Codes and Regulations

Use the latest editions of the following applicable codes and regulations as adopted by Department of Consumer and Regulatory Affairs, Washington DC (DCRA). DC Water warns against complacency during design due to designers' perceived familiarity with code requirements based simply on having 'read' the codes in the past. Unfortunately, code requirements have seemingly been ignored on some past project designs. DC Water emphasizes that designers must diligently refer to and comply with all applicable code requirements in detail.

- American Association of State Highway and Transportation Officials, "Standard Specifications for Highway Bridges." American Concrete Institute, "Building Code Requirements for Structural Concrete, ACI 318."
- American Concrete Institute, "Code Requirements for Environmental Engineering Concrete Structures, ACI 350."
- American Concrete Institute, "Building Code Requirements for Masonry Structures, ACI 530/ASCE 5/TMS 402.
- American Institute of Steel Construction, "Code of Standard Practice for Steel Buildings and Bridges."
- American Welding Society, "Structural Welding Code ANSI/AWS D 1.1."
- Americans with Disabilities Act (ADA) and all amendments thereof.
- DC Construction Code Supplement.
- International Code Council International Building Code.
- National Forest Products Association, National design specification for wood construction.
- Occupational Safety and Health Act (OSHA), Public Law 91-596 and all amendments thereof.

Environmental engineering concrete structures, i.e., structures containing liquid or potentially subject to corrosion from liquid storage or conveyance, and concrete work for process buildings, shall be designed in accordance with ACI 350. Provide concrete cover over the reinforcing steel in accordance with ACI 350, considering additional requirement for corrosion protection in the aggressive environments expected at Blue Plains AWTP and other DC Water facilities.

Non-environmental type concrete structures may be designed using either ACI 318 or ACI 350.

In case of conflict between the various codes, or between the codes and specifications, the more stringent requirements, shall govern.

4.4.1.2 References

Use the latest editions of the following references:

- Aluminum Association, "Aluminum Design Manual".
- American Concrete Institute "Reinforced Concrete Design Handbook".
- American Concrete Institute “Details and Detailing of Concrete Reinforcement, ACI 315.”
- American Concrete Institute, "Building Code Requirements for Structural Concrete, ACI 318".
- American Concrete Institute, "Code Requirements for Environmental Engineering Concrete Structures – ACI 350".
- American Concrete Institute, "Specifications for Masonry Structures (ACI 530.1/ASCE 6/TMS 602)".
- American Institute of Steel Construction, “Code of Standard Practice for Steel Buildings and Bridges”.
- American Institute of Steel Construction, “Specification for Structural Steel Buildings”.
- American Institute of Steel Construction, “Steel Construction Manual”.
- American Institute of Steel Construction, "Detailing for Steel Construction".
- American Institute of Steel Construction, ‘Specification for Structural Joints Using ASTM A325 or A490 Bolts”.
- American Institute of Steel Construction, Steel Construction Manual, Volume II, Connections.
- American Iron and Steel Institute, "Specification for the Design of Cold Formed Steel Structural Members".
- American Society of Civil Engineers, "Minimum Design Loads for Buildings and other Structures" (ASCE/SEI 7).
- Concrete Reinforcing Steel Institute, "Manual of Standard Practice".
- Post Tensioning Institute, "PCI Design Handbook - Precast and Prestressed Concrete".
- Post Tensioning Institute, "Post Tensioning Manual".
- Prestressed Concrete Institute, "PCI Design Handbook - Precast and Prestressed Concrete".
- Steel Deck Institute, "Design Manual for Floor Decks and Roof Decks".
- Steel Joist Institute, "Standard Specifications for Joist Girders".
- Steel Joist Institute, "Standard Specifications for Longspan Steel Joists, LH-Series and Deep Longspan, Steel Joists, DLH-Series, K-Series".
- U.S. Army Corps of Engineers, “Specifications for Polyvinylchloride Waterstop, CRD-C572.”

4.4.2 Construction Materials

The materials to be used for construction will include concrete and metals and will meet the specifications listed below.

4.4.2.1 Concrete Work

Concrete work will meet the following specifications:

- Concrete shall be normal weight cast-in-place concrete.

- Concrete shall have a minimum 28 day compressive strength of 4,000 psi [28 MPa] and a maximum water-cement ratio of 0.45, unless otherwise indicated or specified.
- Concrete for environmental engineering concrete structure shall have:
  - a minimum 28 day compressive strength of 4,500 psi [31 MPa];
  - a maximum water-cement ratio of 0.42;
  - contain a shrinkage reducing admixture or use shrinkage compensating cement;
  - contain an integral crystalline waterproofing admixture or an integral pore-blocking waterproofing admixture; and
  - a 21-day drying shrinkage of 0.028 percent or less and a 28-day drying shrinkage of 0.032 percent or less when tested in accordance with ASTM C157 as modified by the projects specifications.
- Concrete under foundations shall have a 28 day compressive strength of 1,500 psi [10 MPa] Concrete shall be air-entrained.
- Cement shall be ASTM C 150, Type II.
- Reinforcing bars shall conform to ASTM A 615, Grade 60.
- Welded wire fabric shall conform to ASTM A 1064.
- PVC waterstops shall conform to CRD C572.
  - Use 9-inch bulb in expansion joints.
  - Use 6-inch flat in construction joints.
  - Use 4-inch flat for containment curbs.

4.4.2.2 Metal Work

Metal work must meet the following specifications:

- Steel W shapes shall conform to ASTM A 992 unless otherwise indicated or specified.
- Steel C, M, S and HP shapes shall conform to ASTM A 572, Grade 50, unless otherwise indicated or specified.
- Steel Angles, plates and bars shall conform to ASTM A 36.
- Round, square and rectangular structural steel tube members [hollow structural sections (HSS)] shall conform to ASTM A 500, Grade B.
- Steel pipe shall conform to ASTM A 53, Grade B.
- Stainless steel - ASTM 276 Type 316 or 316L; Type 316L is weldable.
- Aluminum shapes and plates - 6061-T6.
- Anchor rods for structural steel - ASTM A307 or A325.
- High Strength bolts for steel connections A 325.
- Welding electrodes for structural steel - E70XX minimum.
- Bolts in contact with corrosive liquid or chemicals shall be stainless steel.
- Bolts for aluminum and stainless steel - ASTM 276 Type 316.
- Concrete anchors for aluminum and stainless steel – ASTM 276 Type 316.
- Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products.
- Zinc Coating (Hot Dip) on Iron and Steel Hardware.

4.4.3 Material Criteria

4.4.3.1 Aluminum

Use 6061-T6 aluminum. The design of aluminum members shall conform to the allowable stresses for buildings and similar structures found in the Aluminum Construction Manual.

Aluminum shall be isolated from dissimilar metals with an elastomeric separation. Alternatively, a 4 mil (0.10 mm) dry coat of zinc chromate primer on the aluminum surface and a 2 mil (0.05 mm) dry coat of all-metal primer followed by a 3 mil (0.08 mm) dry coat of aluminum paint to the dissimilar metal Aluminum, when connected to steel, shall be fastened with stainless steel fasteners along with isolation for dissimilar metals as specified above.

Aluminum shall also be isolated from direct contact with concrete in a similar fashion.

Aluminum and galvanized steel shall not be used where they may be in contact with wastewater.

4.4.3.2 Concrete

Concrete design shall be in accordance with the most recent edition of the "Building Code Requirements for Structural Concrete" (ACI 318). Liquid retaining structures shall conform to the most recent edition of the "Code Requirements for Environmental Engineering Concrete Structures" (ACI 350).

The minimum standard for engineering drawings shall be the latest edition of ACI 315, "Details and Detailing of Concrete Reinforcement." Environmental engineering concrete structures may be designed using either the factored load method or the service load method.

The allowable concrete stresses for environmental engineering structures and foundation walls in contact with groundwater, must conform to the applicable sections of ACI 350.

The allowable concrete stresses for structures other than environmental engineering concrete structures shall conform to ACI 318.

4.4.3.2.1 Precast Concrete

Proper support for precast concrete and architectural cast stone elements shall be designed by the PDE to ensure the stability of same.

The PDE shall detail all aesthetic and functional requirements of the precast units and shall specify their structural performance. Specified performance shall include all limiting combinations of loads together with their points of application.

Precast concrete water and wastewater structures shall be designed for the minimum structural loads described in ASTM C 890, and for uplift forces due to buoyancy of the structure or its components.

Precast connections may be designed by the PDE or the detailer. If connections are to be designed by the detailer, the PDE must include all load data necessary to properly design the connections. The PDE is responsible for proper design of the support from the point of connection down to foundation.

4.4.3.3 Concrete Anchors

Design concrete anchors based on the ACI method for cracked concrete. Consult manufacturers for appropriate anchor selection. Include load capacity tables in the calculations. Use the interaction formula when considering tension and shear acting simultaneously on the anchor.

For use in locations subject to submerged conditions or otherwise exposed to weather elements, do not use mechanical anchors with expandable ends. Use epoxy adhesive anchors. Do not use adhesive anchors for direct tension in overhead applications, (which may be subject to creep over time). Use mechanical anchors or embedded anchor bolts.

Anchorage for applications which may be subject to vibration, such as blower discharge piping, duct work, and most process equipment, shall be adhesive anchors or cast-in-place anchor bolts. Anchors used in these locations shall be pull-out tested after installation.

Specify pull-out testing of anchorage provided by the manufacturer where anchorage embedment may be shallow and for cases where equipment anchorage is retro-fitted into existing concrete. Use the interaction formula when considering tension and shear acting simultaneously on the anchor. Use the following types of concrete anchors:

- Zinc-plated high-grade carbon steel for use with structural steel.
- Type 316 stainless steel anchors for use with aluminum and in corrosive environments.

4.4.3.4 Masonry Walls

Design in accordance with the latest edition of ACI 530/ASCE5.

4.4.3.5 Stainless Steel

Use stainless steels/chromium-nickel for wastewater treatment facilities.

- Use Type 316 bolts, washers and nuts, conforming to ASTM A193, when fastening aluminum to concrete or aluminum to aluminum.
- Stainless steel plate shall conform to ASTM A276.
- Use Type 316L, an extra-low carbon version of Type 316, when welding is required.
- Table 2-4-2 shows the minimum tensile and yield strength for stainless steel bolts, shapes, and plates.

Table 2-4-2. Stainless Steel Design Criteria

ASTM	Type	Tensile Strength Minimum (psi)	Yield Strength Minimum (psi)*
A276	316	75,000	30,000*
A276	316L	70,000	25,000*
A193	316	75,000	30,000*

*Note: These values are lower than those for A36 carbon steel.

4.4.3.6 Structural Steel

Structural steel design shall be done in accordance with the latest editions of the following AISC Manuals:

- AISC Specification for Structural Steel Buildings.
- AISC “Steel Construction Manual”.
- AISC "Steel Construction Manual, Volume II, Connections”.

- AISC "Detailing for Steel Construction".

The PDE shall be responsible for the adequacy of design of all structural components, including the connections. When the design of connections is left to the fabricator, the PDE shall provide acceptable types of connections and provide connection design loads on the construction documents. The PDE shall verify all connection designs, calculations and details even when these are designed by the fabricator's licensed professional engineer and shown on the fabricators shop drawings.

4.4.3.7 Waterstops

Provide waterstops in construction and expansion joints between dry areas and sources of liquid, between dry areas and the ground, and between sources of liquid and the ground. Waterstops shall be standard commercial products of the supplier.

4.4.3.8 Waterproofing of Underground Structures

Bentonite membrane waterproofing shall be provided at the exterior face of all basement walls. The waterproofing shall extend up to 6 inches below grade regardless of the elevation of maximum ground water level.

4.4.3.9 Wood

Wood shall not be used.

4.4.4 Loading

4.4.4.1 Dead Load

The dead load to be used for design is the weight of the structure and all material permanently attached to and supported by the structure. Dead loads for roof structures shall also include loads for a green roof design, or an allowance for potential future addition of a green roof design, of 50 psf, minimum, unless directed otherwise by DC Water. Unit dead loads can be found in the following publications:

- International Code Council (/) International Building Code and DC Construction Code Supplement.
- ASCE Minimum Design Loads for Buildings and other Structures (ASCE/SEI 7).
- AISC Steel Construction Manual.
- Manufacturer's criteria literature for major pieces of equipment.

Determine pipe loads in conjunction with the mechanical engineer, using the process piping drawings as a basis for developing load criteria.

4.4.4.2 Live Load

The live load to be used for design is the loading, other than dead load, that must be supported by or resisted by the structures.

Design floors and roofs supporting large pieces of equipment for either the occupancy unit live load or the equipment operating weight, including impact. The load producing maximum flexure and shear shall control the design. Take into consideration the live load immediately outside the footprint of the equipment with the operating equipment load and any potential lay down area for maintenance adjacent to operating equipment.

All elevated floors shall have a load rating suitable to support equipment removed for overhaul or replacement and including the weight of load carrying conveyances such as lift trucks or portable cranes used to transport the equipment being moved. All elevated floors shall have signage displaying the load rating of the elevated floor.

Design lifting-hook supports for the maximum hoist capacity plus the hoist weight and a 50 percent impact factor.

Design sluice gate floor-stand supports for the stall or lock-off thrust required to open the gate under full operating head. Assume that the operating thrust acts in either vertical direction.

4.4.4.3 Wind Load

The design wind pressures shall be determined by applying the average velocity pressure to the appropriate design equations of ASCE/SEI 7. The basic wind speed shall be selected from the Basic Wind Speed maps of ASCE/SEI 7. Exposure C conditions shall be used.

Unless more severe conditions are warranted, the wind load shall be calculated using the following:

Velocity Pressure Coefficient (K_z) for Exposure C
Topographic Factor (K_{zt}) = 1.00
Occupancy Category III Importance Factor (I) = 1.15

4.4.4.4 Seismic Load

Seismic loads for all structures shall be based on ASCE/SEI 7. Seismic analysis shall be by the Equivalent Lateral Force Analysis Method. The Simplified Analysis Method shall not be used. The following criteria shall be used:

- Site Classification D shall be used, unless otherwise justified.
- Importance Factor for Occupancy Category III = 1.25.

Hydrodynamic seismic loads from soil surrounding buried structures shall be considered as recommended in the geotechnical report.

The seismic effects of free water within liquid containing structures shall be considered in the design in accordance with ACI 350.3. The weight of the water at maximum operating level shall be added to the weight of the containment structure to determine the total mass on which the seismic load shall be based. For this load case only the additional environmental load factor applicable to flexural reinforcement in liquid containment structures shall be waived.

4.4.4.5 Impact Load Criteria

Impact loads shall be considered live loads and shall be added to other loads for components supporting reciprocating or rotating machines, elevators, hoists, cranes, or other equipment creating dynamic forces. The following minimum impact loads shall be used unless analysis indicates higher values are appropriate:

4.4.4.5.1 Bridge Cranes

Obtain manufacturer's criteria literature for the equipment selected from the mechanical engineer.

Provide 2-inch minimum clearance between all crane elements and the building structure.

Provide a 40-pound-per-yard crane rail with a floating connection to the runway girder. Mill the ends of the crane rail at splices. Offset splices from support points of the runway girder.

The impact loads in Table 4-3 shall be used unless analysis indicates higher values are appropriate:

Table 2-4-3. Impact Loads for Hoists and Cranes

Hoists and Cranes	Impact Loads
Vertical	Cab operated: • 25 percent of the maximum static wheel load. Pendant operated: • 10 percent of the maximum static wheel load.
Horizontal-lateral	20 percent of the sum of the rated hoist load plus the weight of the hoist and trolley.
Horizontal-longitudinal	10 percent of the sum of the rated hoist load plus the weight of the hoist, trolley, and bridge.

4.4.4.5.2 ***Monorails***

Table 2-4-4. Monorail Hoist Capacity

Design Case	Hoist Capacity
Case I: Vertical Load Only	1.50 x (Hoist Capacity + Hoist Weight)
Case II: Vertical Load + Lateral Load + Impact	Vertical: 1.10 x (Hoist Capacity + Hoist Weight) Lateral 0.05 x (Hoist Capacity + Hoist Weight)

4.4.4.5.3 ***Pillow Blocks***

Provide pillow blocks at drive-shaft steady bearings. The steady bearing support beam must have sufficient rigidity to avoid vibration that will cause wear and require subsequent replacement of the equipment. The lateral force and allowable lateral deflection at the steady bearing beam shall be determined by the mechanical engineer. The lateral deflection shall be limited to 5 mils or 0.005 inches.

4.4.4.6 Deflections

Member deflections shall be in accordance with the applicable codes, regulations and references listed in this section.

4.4.4.7 Vibration

The structure shall be designed for sufficient stiffness to eliminate dynamic response of the structure under dynamic excitation by the supported equipment.

Maintain the ratio of natural frequency of the structure to the frequency of the machinery (frequency ratio) either less than 0.50 or greater than 1.50. The latter is preferred in order to avoid resonant frequency during the startup and shut down cycle.

4.4.4.8 Thermal Effects

Calculate and account for thermal expansion and contraction for all exposed outdoor structures, not just bridges. Where appropriate, consider providing designated expansion bearings that are designed to allow for anticipated movement with appropriate materials used for any sliding surfaces.

4.4.5 Joint Criteria

4.4.5.1 Construction Joints

- Provide shear key detail for vertical construction joints in walls
- Intentionally roughen surface of horizontal construction joints in walls and at base of wall to 1/4" amplitude.
- Locate construction joints where they will least impair the strength of the structure.
- Show all construction joints on the drawings.
- Carry all reinforcement through construction joints.
- Provide a note on the drawing requiring contractor to submit alternate locations of construction joints and for construction joints in addition to those shown in the drawings, for engineer's approval.

4.4.5.2 Expansion Joints

Provide expansion joints spaced to accommodate the effects of temperature and shrinkage (refer to ACI 350). Use elastomeric joint sealant in expansion joints.

Use preformed polychloroprene elastomeric joint seals in roadways and vehicular access areas. Design preformed joint seals for a temperature differential (ΔT) of 100 degrees F. Protect edges of expansion joints when using preformed joint seals with stainless steel angles embedded in the concrete. Interrupt all reinforcement at expansion joints and provide a 2-inch clearance of reinforcement from each face of an expansion joint.

4.4.5.3 Future Additions

Provide for future expansion of facilities when directed to do so by DC Water. Provide waterstops and a protective cover to prevent damage to the elements.

4.4.6 Liquid and Lateral Load Criteria

4.4.6.1 Retaining Walls

- Factor of safety against sliding: 1.5
- Factor of safety against overturning: 1.5

4.4.6.2 Floatation

Base designs upon groundwater elevations presented in either the geotechnical report for the project or geotechnical data from previous adjacent projects. Under no circumstances shall the design groundwater level be lower than the 100-year flood level.

Only the minimum Dead load of the structure shall be included for the balancing loads resisting uplift from hydrostatic loads. Superimposed dead load included for the ceiling, pipes and other fixtures shall not be included for the estimation of the balancing loads.

100 year flood Factor of Safety = 0.9DL/Uplift = 1.25
500 year flood Factor of Safety = 0.9DL/Uplift = 1.1

4.4.6.3 Hydrostatic Pressure

Liquid lateral pressure loads shall be treated as live loads. Lateral soil loads on foundation walls shall not be utilized to resist internal hydrostatic or hydrodynamic loads. The following loading conditions shall be investigated with various combinations of compartments full and empty:

- Water at maximum operating level.
- Structures empty with exterior loadings.
- Water at emergency flood level or top of compartment level. For this load case only the additional 1.3 load factor applicable to flexural reinforcement in liquid containment structures shall be waived.

4.4.6.4 Lateral Earth Pressure

Equivalent fluid pressures shall be used for lateral earth pressures as recommended in the geotechnical report. In the absence of reliable geotechnical data, the minimum equivalent fluid values for lateral earth pressures shall be:

Above maximum groundwater elevation 65 pcf
Below maximum groundwater elevation 95 pcf

A minimum surcharge loading equivalent to 300 psf [14.36 kN/m2] shall be applied as a uniform load at grade. An at rest coefficient for lateral earth pressure of 0.50 shall be applied resulting in a lateral load due to surcharge of 150 psf [7.18 kN/m^2] against the exterior surface of foundation walls for a distance equal to the lesser of 20 feet [6.0 m] or down to the top of the base slab.

Surcharge loading due to surface applied line and point loads shall be in accordance with the Figures 2-4-1 and 2-4-2.

4.4.6.5 Seismic Lateral Pressures

Hydrodynamic seismic loads from soil surrounding buried structures shall be considered as recommended in the geotechnical report.

The seismic effects of free water within liquid containing structures shall be considered in the design in accordance with ACI 350.3. For this load case only the additional environmental factor applicable to flexural reinforcement in liquid containment structures shall be waived.

All structures, including liquid containment structures, shall be designed to transfer seismic base shears to the bearing soil strata. Passive soil pressure on foundation walls shall not be assumed to resist lateral loadings.

Hydrodynamic seismic forces shall be determined in accordance with ACI 350.3, *Seismic Design of Liquid-Containing Concrete Structures and Commentary.* Alternately, hydrodynamic forces may be determined using the method developed by Westergaard (Figure 2-4-3).

4.4.6.6 Walls in Open Tanks and Channels

Walls in open tanks and channels (locations with no top slab) must be designed to be cantilevered from the foundation for the resistance of lateral loads. They shall not be dependent on walkways running along the top for any support or bracing. Walkways shall not be designed to support walls below.

4.4.6.7 Protection of Structures from Water

Concrete and masonry building foundation walls, walls of water-retaining structures, and manholes and vaults shall be protected from exterior water, including ground water, storm water, and flood water, by waterproofing or damp-proofing. The decision whether to provide waterproofing or damp-proofing will be made on structure by structure basis, and shall be subject to approval by DC Water. Protection against water shall be provided up to the higher of 6” above finish grades or the 100-year flood level.

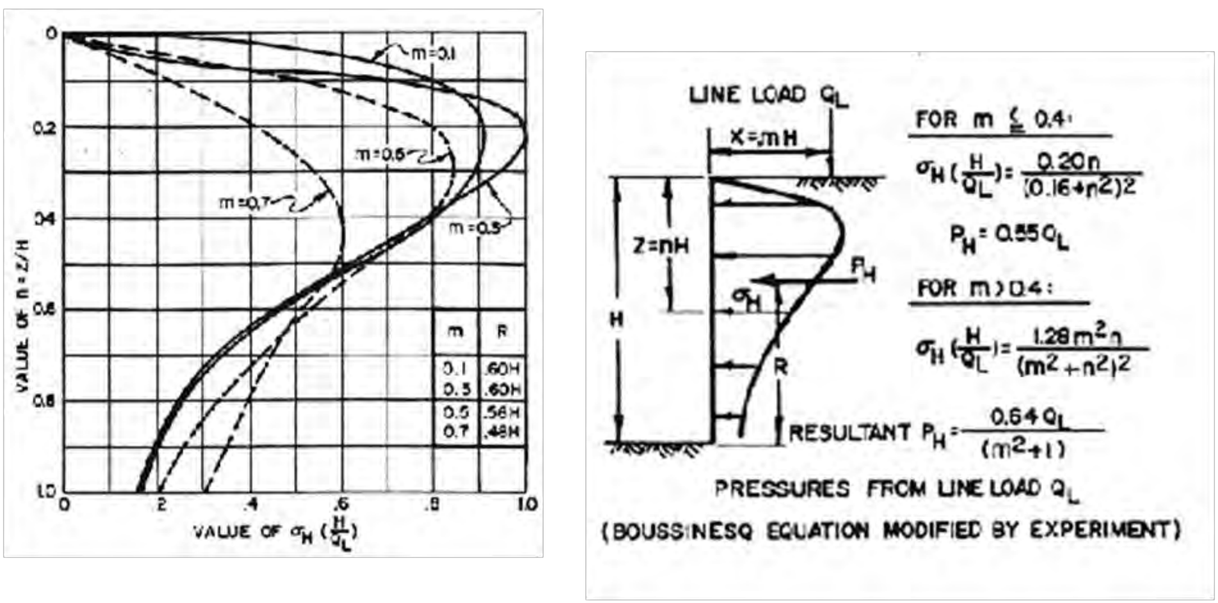

Figure 2-4-1. Pressure on Foundation Wall Due to a Surface Line Load

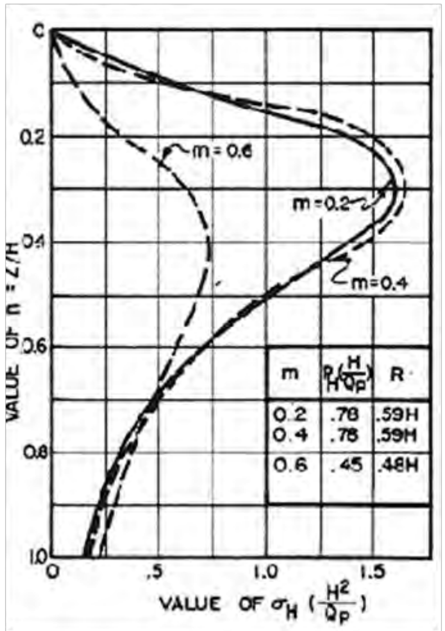

Figure 2-4-2. Pressure on Foundation Wall Due to a Surface Point Load

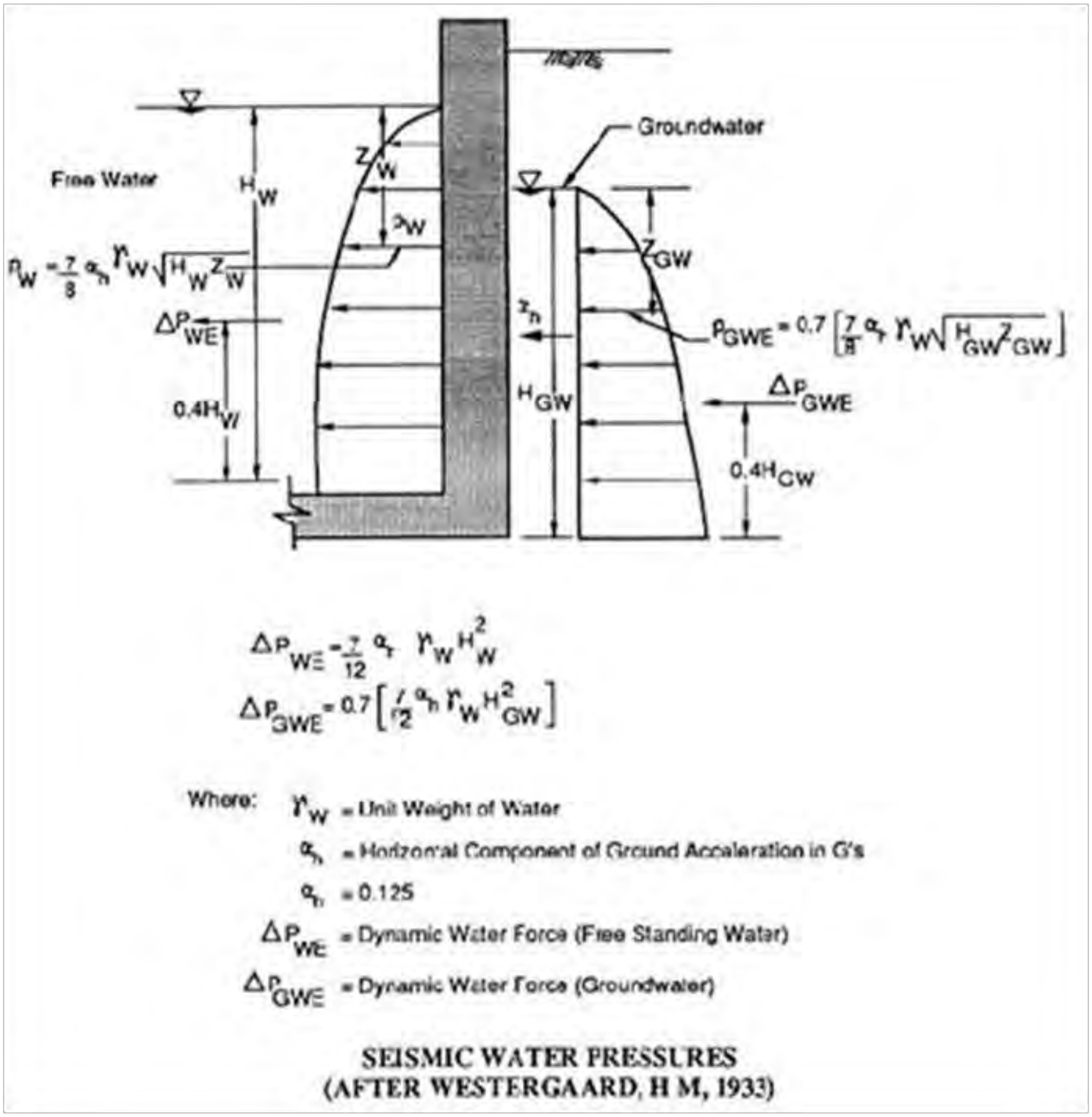

Figure 2-4-3. Hydrodynamic Seismic Forces

4.4.7 Design Calculation

See Volume 1 of this design manual, and Section 1, General of this volume for general calculation requirements. Additional requirements specific to the structural discipline include:

- Provide complete structural analysis and design incorporating all gravity loads, lateral loads, and dynamic forces imposed upon the structures. Lateral forces consist of loadings from soil, liquid, wind, and earthquake. Dynamic loads consist of loadings from equipment. Consider load combinations that produce maximum shear, bending moment and deflection of structural elements.
- Consider all loads and forces from their point of incidence upon a structure down to the foundation.
- Include references to all supporting documentation including codes, texts, reports and handbook data and list all design assumptions. List all coefficients such as load factors, impact factors, and safety factors.
- Check all components for the effects of settlement, shrinkage and buoyancy, as required.
- For renovation of existing structures, live load capacity of all load bearing elements, including floors and elevated slabs, walls, columns and roofs shall be checked for conformance with the Building Code for the proposed use. Provide all necessary computations.
- The initial calculation sheets shall indicate the design dead loads and live loads used in the subsequent calculations. Final calculations shall include a statement noting that any use of the calculations after construction shall be subject to verification of as-built record drawings.
- When engineering design software is used for analysis and design of structures, the designer shall verify the results by manual checks where possible. Alternatively, for complex models where manual checks are not possible, the designer shall analyze the structure by two independent programs to check for the consistency of results. Results within a 5 percent variation shall be considered accurate when the results from both of the programs meet code requirements.
- Designer shall verify that the current versions of industry standard commercial analysis programs are used for analysis. In the case where an older version being used, the designer shall obtain bug reports for all later versions to verify that there have been no critical bug fixes that may adversely impact the design and ultimately the safety of the structure.
- For review of design calculations when standard commercial analysis programs are used, the submittal shall include input data files along with viewer for the program used. If a viewer is not available, the EOR shall be available to demonstrate the input data and results with a live application to the structural reviewers in working sessions with the designers.

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY
(DC Water)

"SERVING THE PUBLIC - PROTECTING THE ENVIRONMENT"

PROJECT
DESIGN MANUAL
VOLUME 2 - FACILITIES DESIGN

SECTION 5 – MECHANICAL PROCESS

August 2018

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AUTHORIZATION FORM

Revision Number	**Date**	**Content**
March 2013		Project Design Manual Volume 2 - Facilities Design Section 5 - Mechanical Process
December 2014	12/09/2014	Section 5 - Mechanical Process
May 2016	05/04/2016	Section 5 - Mechanical Process
August 2018	08/06/2018	Section 5 - Mechanical Process

This 2018 version was authorized by:

11/30/2018

David Parker PE, Senior Technical Advisor, Department of Wastewater Engineering — Date

SECTION 5 MECHANICAL PROCESS LOG OF REVISIONS (From the 2010 version)		
Paragraph	**Brief Description of Revision**	**Date**
Global	-Changed ‘DC WASA’ to “DC WATER”. ‘-Deleted dates of standards/codes and referred to “latest version”. -Deleted references to Volume 5 (Standard Details)	
Front-end	Added list of Acronyms and Abbreviations.	
5.2.1.1	Show pipe and valve IDs on M and I drawings	05/29/2014
5.2.2.1	Pipe and valves ID’s shall be shown on drawings.	
5.2.2	Specs to require provision of tag ID’s & Maximo ID’s on ALL equipment, including hand-operated gates and valves.	
5.2.2	Request vendors’ certifications on special equipment, to comply with specs without exclusion.	05/29/2014
5.2.3	Added Blower systems to the list of calculations requirements.	
5.3.1	Replaced BOCA Code with IBC and IMC.	
5.3.3.1	-Use Mega Flange adaptors only where approved. -Added elastomeric expansion joint option, subject to approval. -Avoid oversize openings for pipe penetrations. Use positive seals. -Slab penetration counterbore to avoid seal falling thru opening. -Added Fig. 2-5-1. Slab Penetration with Counterbore. -Remote instrument indicators to be visible at operating floor.	12/15/2015 02/22/2016 12/31/2015
5.3.3.2	Added prohibition against copper pipe in areas with H2S Added 316 SST for small diameter accessory piping & fittings	09/30/2014 11/02/2015
5.3.3.3	Added notes for flow meter velocities, flanges, and gaskets. Requirements for matching flanges and gaskets. SST fasteners and isolation accessories on DI flanges.	09/29/2015 09/29/2015 02/22/2016
Table 2-5-1	Changed PSW pipe <4” from PVC to SST; Added threaded joints option for PSW pipe < 4”. Deleted PVC option for Seal Water (SW) piping <4”; Added threaded joints option. Add Gen Note 11 to not use copper piping in areas with H2S. Changed grit slurry piping from FRP to HDPE. Added sulfuric acid service to table. Added 316 SST for small diameter accessory piping & fittings Added Note 14 - Ball valve & Camlock fittings for PSW flushing connections	09/30/2014 02/03/2016 09/30/2014 02/03/2016 09/30/2014 09/29/2015 09/29/2015 11/02/2015 08/06/2018 08/06/2018

	New Note 15 – Install vacuum breakers on PSW wall hydrants where appropriate.	
Table 2-5-2	Added footnote for velocities through flow meters.	09/29/2015
Table 2-5-3	Simplified table to just a few ranges of pipe sizes.	
5.3.3.4	Deleted Coal Tar Enamel Coating Slope air and gas piping to low point and valved drain.	05/29/2014
5.3.3.6	Locate flow meters in galleries. Pipe fittings minimum spacing from meters. Provide bypass piping to allow meter removal and maintain pumping.	05/29/2014
5.3.3.7	Miscellaneous valve configuration requirements. Orientation criteria for plug valves. Added preferred design features of combination Air Release Valves	05/30/2014 08/06/2018
5.3.3.9	Allow reduced pipe insulation thickness if sound attenuation is not needed. Provide insulation and heat trace to 4 feet below grade.	
5.3.3.11	Hangers and Supports – Added reference to Structural manual for pipe support design factor of safety. Added pipe support design & testing requirements for vibration	08/06/2018
5.3.3.12	Added requirements for manufactured anchors. Require DC Water approval of anchor type if subject to vibration. Specify pull testing	
5.3.3.12	Pipe restraint to minimize forces on equipment.	05/29/2014
5.3.3.13	Updated Pipe Service Area IDs and Codes, Table 2-5-5. Updated Fluid ID, Pipe Codes, Table 2-5-6 Updated valve numbering guidelines. Added Table 2-5-7, Valve Codes	05/29/2014
5.3.3.13	Show all pipes and valve ID's, & valve tag ID's on drawings. Added Pipe and Valve Numbering guidance.	
Table 2-5-5	Added Table 2-5-5 for Pipe Service Areas designations. Added Service area designations for non-process buildings/areas.	12/08/2014
Table 2-5-6	Added Table 2-5-6 for Fluid ID and Pipe Codes designations. Added revisions to Table 2-5-6 Fluid Identification, Pipe Codes Added column and a note for Pipe & Valve color schedule	12/09/2014 08/06/2018
Table 2-5-7	Added revisions to Table 2-5-7 Valve Codes	12/08/2014
5.3.4.2	Changed cast gates to stainless steel slide gates.	10/22/2014
5.3.5	Added new paragraphs: General Equipment Guidelines; Equipment Foundations; Equipment Power Transmission; Equipment Layout; Equipment Lubrication; and Miscellaneous	05/29/2014

	Equipment Considerations. Pumps and Accessories - Added reference to Appendix A.	
5.3.5.4	Added equipment accessory fittings required to facilitate lubrication maintenance. Added to include desiccant breathers.	12/02/2015 12/15/2015
5.3.5.5	Added provide pump stop control with high pressure switch.	
5.3.6	Pumps and Accessories - Added reference to Appendix A.	
5.3.6.1	Submersible pumps lifting provisions. Flush and drain for all pumps.	05/29/2014
5.3.6.2	Sump pumps requirements	05/29/2014
5.3.6.3	Added provisions for pump removal; flushing and draining pumps; pump testing; and sloping sump pump discharge lines.	05/29/2014
5.3.6.4	Added criteria for seal water system, and added new Figure 2-5-2, Seal Water Configuration. Revised Fig 2-5-2 to label SW header. Rev. Fig 2-5-2 to show seal water backup source. Added check valve on main line and solenoid on backup source	12/02/2015 02/22/2016 05/04/2016 05/25/2016
5.3.6.5	Added provide pump stop control with high pressure switch.	
5.3.8.2	Blowers and Compressors Equipment Layout – Added elastomeric option for air piping expansion joint material at blowers.	
5.3.9.1	Chemicals tanks to have 30” manways for access; and overflow provisions to avoid damage and overflow to drain. Rotary lobe pumps for polymers to use elastomer coated rotors, and designed to also pump water.	05/29/2014 11/05/2014
5.3.10.1	Use injection quills for injecting corrosive chemicals in pipelines.	05/29/2014
5.3.12	Added new paragraph - Operability and Maintainability Considerations. PDE to provide written narrative of design features for O&M	05/29/2014
Appendix A	Added Appendix A - DC Water Preferred Pumping Equipment Systems by Application.	

SECTION 5 - MECHANICAL PROCESS
TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMNS AND ABBREVIATIONS

ACFM	actual cubic feet per minute
AGMA	American Gear Manufacturers Association
ANSI	American National Standards
AOR	acceptable operating range
API	American Petroleum Institute
ARV	air release valve
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWTP	Advanced Wastewater Treatment Plant
AWWA	American Water Works Association
BOCA	Building Officials and Code Administrators
CAD	computer-aided design
CMAA	Crane Manufacturers Association of America, Inc.
CPVC	chlorinated polyvinyl chloride
CW	chilled water, city water
dbA	A-weighted decibels
DC Water	District of Columbia Water and Sewer Authority
DC	District of Columbia
DI	ductile iron
DP	differential pressure
EJMA	Expansion Joint Manufacturers Association
FM	Factory Mutual
fpm	feet per minute
fps	feet per second
FRP	fiberglass reinforced plastic
gpm	gallons per minute
GR	grit slurry
HVAC	heating, ventilation, and air conditioning
Hz	hertz
IBC	International Building Code
ICC	International Code Council
ICC-ES	International Code Council Evaluation Service
ID	identification
IMC	International Mechanical Code
$lbs/hr\text{-}ft^2$	pounds per hour per square foot
LR	long radius
MJ	mechanical joints
mph	miles per hour
MSS	Manufacturers Standardization Society
NEMA	National Electrical Manufactures Association
NPSH	net positive suction head
O&M	operation and maintenance
OD	outside diameter
ORP	oxidation reduction potential
OSHA	Occupational Safety and Health Act
PCCP	prestressed concrete cylinder pipe
PDE	Project Design Engineer
POR	preferred operating range
PSC	primary scum
psi	pounds per square inch
psia	pounds per square inch absolute
PSL	primary sludge
PSW	process service water, plant service water
PVC	polyvinyl chloride
rpm	revolutions per minute
RSL	return sludge
RWW	raw wastewater
scfm	standard cubic feet per minute
SS	stainless steel
SSC	secondary scum
TSC	thickened scum
TSL	thickened sludge
UL	Underwriters Laboratories
V	volts
VOCs	volatile organic compounds
WSL	waste sludge

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PROJECT DESIGN MANUAL
VOLUME 2 – FACILITIES DESIGN

5. MECHANICAL PROCESS

5.1 GENERAL REQUIREMENTS

This section presents general technical guidance for mechanical process design. Mechanical process systems covered include process piping, pumping systems for water and wastewater, chemical systems, materials handling systems and various equipment for wastewater treatment facilities. The mechanical process requirements outlined in this section are general in nature and apply to all design packages. Specific mechanical process requirements for each design package will be developed in the concept design phase and presented in individual conceptual design reports.

The design philosophy for the mechanical process engineer is to provide an integrated piping and equipment layout that provides operational flexibility, efficient energy management, quality equipment and materials through a complete, accurate, and detailed specification and systems that are easily serviced and maintained.

5.2 FORMATS

5.2.1 Mechanical Process Drawings

Mechanical process drawings shall be arranged in the following order:

1. Legend (abbreviations, symbols, codes, notes)
2. Schematics, Flow Diagrams
3. Floor Plans
4. Sections
5. Details

5.2.1.1 Drafting Requirement

Refer to DC Water Drafting Standards (CAD) Manual, for overall drawing format, scale requirements, and reference to DC Water Standard Details. The following are additional drafting requirements for process mechanical drawings:

1. Four (4)-inch piping and smaller may be shown as a single line in plans and sections when the scale is not larger than 1/4" = 1'-0".
2. Six (6)-inch piping and larger shall be shown as a double line regardless of scale.
3. Fittings, flanges, valves and appurtenances in flanged piping shall be scaled to their proper dimensions (laying length, diameter) regardless of pipe size and drawing scale.
4. Piping shall be located horizontally in plans, by dimensions and scale from the centerline of pipe to walls or other structures, and vertically by showing centerline elevations.
5. Labeling of pipe fittings is not required unless special connections or specific fittings are necessary.
6. Pipes shall be identified by size, pipe code (DC Water) and header number, and shown on the drawings.

7. Pipe materials shall not be labeled on piping drawings.
8. All valves shall be numbered and include the equipment tag identifications on the drawings, and valve operators shall be shown on the drawings in their intended position to provide proper clearances and avoid conflicts.
9. Show vent locations (high points) and drain locations (low points) on all piping.
10. Pipe and valve identification numbers shall be shown on both the M drawings and I drawings.

5.2.1.2 Legend (Abbreviations, Symbols, Codes, Notes)

A mechanical process legend shall be provided on the first sheet of the mechanical process drawings. The legend shall be shown in tabular form and include abbreviations, symbols, codes and notes. DC Water standard symbols and codes shall be used to identify piping, valves, fittings and appurtenances. Standard abbreviations, symbols and codes are provided in the CAD Manual. General mechanical process notes shall be provided on the drawings as necessary to further define or clarify mechanical process requirements which may not be explicitly shown or covered by the drawings and specifications.

5.2.1.3 Schematics, Diagrams

Schematic drawings and flow diagrams shall be shown on the mechanical process drawings to provide complete depictions of process configurations, piping and equipment interconnections, valve and fitting arrangements, etc. Isometric drawings shall be used for chemical feed systems, seal water systems and pneumatic systems to accurately show the correct relationship of piping, equipment, valves, and ancillary connections. Header numbers shall be shown on flow diagrams and schematic drawings.

5.2.1.4 Floor Plans

Refer to the CAD Manual for overall drawing format and scale requirements. Use building shell drawings common with other disciplines to show mechanical process plans and sections. All equipment and piping shall be located from the inside of walls and/or from centerlines of columns. Show the locations of all inline instrumentation and label it with the correct instrumentation designation. Coordinate the locations of these items with the instrumentation and electrical engineers.

All piping must be labeled according to size and service. Header numbers, as designated by DC Water, shall be shown on the plans. Place a north arrow at the top left corner of each plan drawing. Show detail plans in the same orientation as the site or floor plan from which the detailed item is taken.

5.2.1.5 Sections

The number of sections shown should be sufficient to fully describe the facility and the complexities of the facility. Show all elevations in feet and hundredths of a foot. Sections shall show all floor high- and low- point elevations, top-of-wall elevations, centerline elevations of pressure piping, invert elevations of piping with gravity flow, centerline of equipment, channel high and low invert elevations and tank/basin elevations, maximum and minimum water surface elevations, and weir crest elevations.

5.2.1.6 Details

Refer to DC Water Standard Details for applicable mechanical process details. Additional details shall be developed by the design engineer as required for the specific project. Modification of DC Water Standard Details, if required to meet specific project conditions, shall be approved by DC Water or its designated agent. Such modified details shall be shown as additional details, and not as DC Water Standard Details.

5.2.2 Specifications

Refer to DC Water Guideline Specifications for applicable standard process mechanical specifications. The design engineer shall develop additional process mechanical specifications as required for the specific project. Specifications shall be provided in approved format. Specifications shall require the construction contractor to provide and install equipment identification tags and the Maximo identifications in addition to manufacturers' nameplates for ALL equipment addressed in this section, including valves and gates, both motor-actuated and hand-operated, pumps, screens, tanks, motor drivers, hoists, and bridge cranes.

If any required equipment is deemed characteristically unusual, critical, relatively expensive, or requires custom fabrication, and there are fewer than three known vendors, request written certification from the known vendors to affirm their intention to bid and their ability and intention to comply with specified technical and performance requirements, without exclusion.

5.2.3 Calculation Requirements

Refer to Section 1 of this volume for general calculation requirements and submittal requirements. The Project Design Engineer (PDE) shall prepare and submit calculations for all major mechanical process systems. Required calculations include, but are not limited to, the areas listed below, as applicable to the specific project.

- *Process piping* - pressure loss and surge calculations
- *Pipe support systems* - load and thrust analyses
- *Pump systems* - pump selections, submergence calculations, net positive suction head (NPSH) calculations, system curves, seal water requirements
- *Blower systems* – blower selections, system curves (winter and summer), flow control valves sizing
- *Service water* - quantity and pressure demands
- *Chemical systems* - chemical dosages, storage and feed requirements
- *Processes and process equipment* - sizing and design requirements

5.3 TECHNICAL GUIDELINES

All mechanical process designs must adhere to Volume 5, Standard Details, unless otherwise approved by the reviewing authority.

5.3.1 Codes, Regulations and Standards

At a minimum, the <u>latest version</u> of the following codes, regulations and standards should be observed by the designer:

- American Gear Manufacturers Association (AGMA)
- American National Standards Institute (ANSI)
- American Petroleum Institute (API)
- American Society of Mechanical Engineers (ASME)
- American Society for Testing and Materials (ASTM)
- American Water Works Association (AWWA)
- API 618 Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services – Section 7.9.4.2.5.2.4 Piping Design Vibration Criteria

- ASME/ANSI B31.1, Power Piping
- ASME/ANSI B31.3, Process Piping
- DC Water & Sewer Authority Standards
- Expansion Joint Manufacturers Association (EJMA) Standards
- Hydraulic Institute Standards, current edition
- International Building Code (IBC), International Code Council (ICC)
- International Mechanical Code (IMC), International Code Council (ICC)
- Manufacturers Standardization Society of the Valves and Fittings Industry, Inc.
- National Electrical Manufacturers Association (NEMA) Standards
- Occupational Safety and Health Act (OSHA) regulations

5.3.2 Testing (Factory, Field, Process)

The PDE shall establish factory, field and process testing requirements for mechanical process systems for inclusion in the contract specifications. In developing equipment testing requirements, the PDE shall review existing DC Water specification requirements and consult with DC Water Engineering and Operations personnel.

5.3.3 Piping Systems

This section presents guidelines for process piping systems design, construction materials, pressure-loss and surge calculations, and related requirements. For non-process piping requirements, refer to Section 2, Civil and Section 6, Plumbing. Process piping outside of buildings and structures will be shown on a yard piping plan included in the civil drawings. Refer also to Volume 3, Infrastructure Design, for technical guidance regarding water distribution and wastewater collection systems outside the limits of wastewater treatment plant and pumping facilities, as well as yard piping installation requirements within the facility limits.

5.3.3.1 Piping Design Considerations

Show piping in a manner that will facilitate supporting the piping system. Design piping to provide for thermal expansion and flexibility and for an economical pipe support system. Piping systems must include allowances for water hammer and all dynamic loads. Certain piping systems will require special water hammer analysis.

Piping connections into piping systems of different service ratings must conform to the specifications of the higher service rating up to and including the first isolation valve. Use expansion joints for all connections to equipment, both the suction and discharge. Piping layout and support system shall be configured such that no vertical or horizontal loads will be imposed on the equipment. All non-rigid joints and connections must be restrained. Use one of the following methods to make connections to existing piping:

- Sleeve type (Dresser) coupling
- Grooved type (Victaulic) coupling
- Bolted split-sleeve coupling
- Flange Adaptors (MegaFlange), only where approved by DC Water
- Expansion joint (316L stainless steel; or elastomeric if approved by DC Water)
- Replacement back to nearest valve or fitting

Make piping runs as short and direct as possible. Piping shall not be run through electrical rooms or above any electrical equipment or motor control centers. Arrange piping to provide for access to equipment and to facilitate both normal maintenance of the equipment and removal of the equipment if needed for maintenance, repair or inspection.

Piping and valving arrangements shall include provisions for operational redundancy so no single point of failure will force shut down of the process. All unions and couplings to disconnect pipes should be provided immediately downstream of isolation valves. All pipe systems should be capable of being isolated and dismantled for repair without supply side shut down. Leave adequate clearance at pipe flanges, unions, couplings, and valves to facilitate disassembly of piping.

An isolation valve shall be installed immediately following any tee or reduction in size at a multidirectional union of any liquid or solid liquid mix (including but not limited to slurry, scum and sludge piping) pipe of 1-inch diameter or greater, such that diverted piping can be maintained and breaks repaired without requiring a system shutdown.

For wall or slab penetrations:

- Use wall castings with waterstops for all pipe penetrations below grade, submerged, within two feet of a maximum water surface, or for any penetration between a potentially dry area and a potentially submerged area. Mechanical sealing devices are not acceptable for these conditions.
- Show first pipe joint outside of structure and refer to appropriate detail. The first joint shall provide a flexible joint to the structure. Isolation joints shall be used on all ferrous pipe.
- Use wall sleeves with mechanical elastomeric seal (link seal) or “Omni-Seal” type for all other penetration openings in new construction, generally considered as between two ‘dry’ areas, and for all floor penetrations. Provide gas-tight seals where required. In general, sleeves should be sized only for the pipe outside diameter (OD) and the seal mechanism, and typically not as large as the pipe flange OD, which may result in excessive annular space to be sealed.
- Penetrations of existing slabs for pipes 4” and larger, where subject to wetting or drainage, shall have mechanical elastomeric seals, and be designed to prevent the possibility of the seal dropping through the slab. A counterbore in the top of slab penetration, sized in coordination with the seal outside diameter, may be considered as an option. A seal and counterbore arrangement shall not be allowed to support the weight of the pipe. See Figure 2-5-1, Slab Penetration with Counterbore.
- For penetrations of process floors, generally for pipes smaller than 4”, in areas subject to wetting and wash down, use projecting pipe/wall sleeves or curbs, or both, to prevent drainage or leakage through floor penetrations, for safety and for protection of equipment and electrical apparatus at lower levels. Avoid using curbless flush hatches on upper floors, which may leak onto lower levels when the area is hosed down.

Core drilling through existing walls and slabs is acceptable for piping penetrations with double link seals connecting to water holding structures. Refer to Section 4, Structural, for pipe penetration requirements through existing and proposed concrete structures. Structural penetrations and openings for access, equipment, piping, etc., shall be coordinated with the structural engineer and shall be shown and dimensioned, properly detailed and referenced on the structural drawings. Specify that core drilling of multiple openings shall avoid cutting of adjacent reinforcing bars. Provide sufficient vertical spacing between waterstops on all wall castings and sleeves and wall keyway waterstops located in concrete walls.

All underground piping shall have cleanout connections to allow removal of blockages.

All piping shall be designed to include freeze protection assuming no available building or process heat.

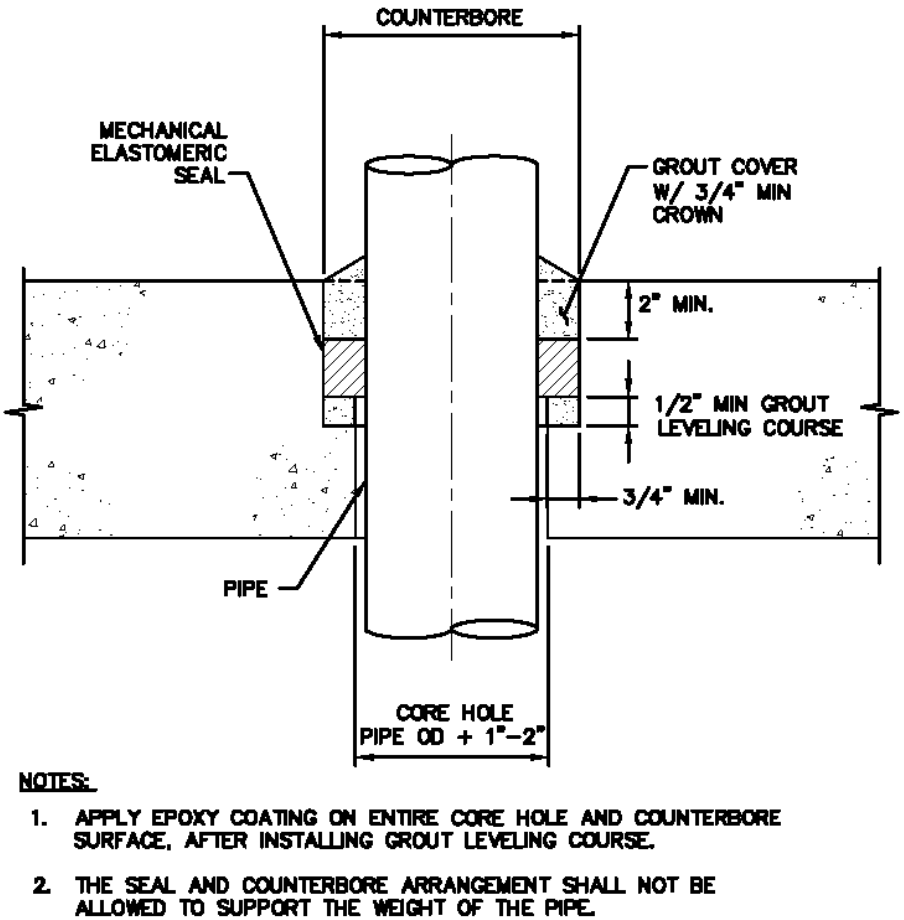


Figure 2-5-1. Slab Penetration with Counterbore

All piping shall be routed to avoid interference with the removal or service of equipment. Any piping that unavoidably interferes with the removal or service of equipment shall be capable of being isolated by valves for draining and temporary partial removal in convenient locations. Overhead piping shall have the following minimum headroom clearances from floor to bottom of pipe flanges, pipe supports or structural beams:

Area	Headroom Clearance
Process areas, galleries and buildings (vehicle traffic)	12'-0" (Note 1)
Process areas, galleries and buildings (foot traffic)	8'-0"
General Yard Areas	12'-0" (Note 1)
Main Access Roads	15'-0"
Railroads (above top of rail)	22'-6"

Note 1: Consider clearance needs for specific area and vehicle access requirements. Minimum may need to be increased as appropriate.

Any piping that unavoidably does not clear personnel standing height, shall be painted red or shall have permanent safety flagging to warn of collision hazard.

Locate all valves, instruments, control valves, relief valves, or other frequently operated equipment so that it is conveniently accessible from grade or an operating platform. Provide valves located 6'-6" or greater above the operating level with a chain wheel operator. Chains must clear the operating level by a minimum of 3'-6" and be of corrosion-resistant material. Provide valve position indicators and remote instrument indicators that are visible from the operating level. These indicators should be facing the direction where an operator would reasonably expect to view the indicator. Provide sufficient access at control valves for removal and maintenance.

Provide all electric actuators located 6'-6" above the operating level or not accessible within 3 feet with a separate disconnect and control station mounted on a wall, column or pedestal.

For sludge and scum piping, provide flushing connections at the invert of all blind flanges, low points, and elsewhere as required to flush pump suction and discharge lines. Provide all process piping with suitable connections for draining and flushing, and venting. Provide all low points with a minimum 2½-inch valved drain to ensure complete drainage and flushing of piping and equipment. Provide a 2½-inch valved vent at all high points of lines that are not otherwise vented to atmosphere. Provide manual air relief on dead legs and high points in solids pipelines and pipe the air release to the nearest process drain

Provide solids pipelines with hard piped plant service water (PSW) connection and manual valve for flushing, sized to provide 3 fps minimum velocity.

Where practical, locate isolation valves that are positioned in branch line connections from a main so that lines drain away from the valve. For all systems containing solids (scum, sludge, raw wastewater, etc.) locate tees to horizontal branches only and locate all isolation valves in a horizontal position and adjacent to the header piping, not the equipment. All fasteners on stainless steel piping systems shall be stainless steel.

Carbon steel, stainless steel, chlorinated polyvinyl chloride (CPVC), and polyvinyl chloride (PVC) piping systems shall contain a minimum number of flanges. Use flanges only at valves, equipment, tanks and supports and in areas where removal may be required for maintenance. Where flanges are used, supply full face gaskets of material appropriate for the contents of the pipeline, if any valves are specified with raised face flanges, coordinate for properly mated gaskets and piping flanges, and get DC Water approval if ring gaskets are proposed. All bolts used in piping flange connections shall have positive means to prevent loosening of the bolts in service.

Provide pump suction intakes with flange and flare long radius (LR) elbow or straight flange and flare fitting. Maintain the crown of suction lines level. Do not use sludge shoes. Install flexible couplings, located between the pump and the isolation valves, on each pump suction and discharge to facilitate pump removal and locate anchors between the pump suction and discharge flange and any couplings and non-rigid joints.

Provide service water connections (3/4 inch) and PSW connections (1 inch) at all working levels. Locate these so that all areas can be reached by a 50-foot section of hose.

Place swing check valves in a horizontal position for all systems.

Piping for process drainage shall be sloped at 2 percent minimum. In any area where solids may spill during routine maintenance, provide wash down hoses and reels, with capability to connect a portable hot water generator for washing down. Provide floor drains in close proximity to collect spillage and wash down water. Do not locate drain piping above electrical equipment or within electrical control rooms.

5.3.3.2 Piping Materials of Construction

The materials of construction for the various piping systems to be used in the treatment plant and pumping stations are generally as shown in Table 2-5-1, Process Piping Materials. Small diameter accessory piping and fittings, such as for installation of pressure gauges and other field instrumentation, shall generally be 316 stainless steel, except where indicated otherwise for chemical services. Precautions must be taken to separate dissimilar metals. **Do not use copper piping except only as approved by DC Water.** A customized process piping schedule, similar to Table 2-5-1, shall be shown on the contract drawings. The piping schedule shall define the requirements for the piping systems applicable to the specific project.

5.3.3.3 Piping Design Criteria

Table 2-5-1 presents recommended process piping materials, joint types, and valve types.

Whenever flanges are used, do not allow mixed mating between flat face and raised face flanges. Flat face flanges, typically on equipment and valves made with cast iron or other brittle materials, are common for low temperature, low pressure applications. Use full face gaskets only on flat face flanges, to ensure full and equal contact between flanges. Raised face flanges, widely used on all forged steel flanges, including on equipment and valves, require raised face gaskets. If specified equipment or valves with flat face flanges are connected to piping or valves with raised face flanges, then specify a modified forged flange with the raised face machined off to make it a flat face.

Specify that flange bolts on ductile iron pipe used in submerged applications and for PSW service shall be stainless steel, and, if used on ductile iron flanges, shall be provided with insulation / isolation accessories such as isolating gaskets, bolt sleeves, and washers.

No tappings are allowed on ductile pipe. Use saddle tees or tees for branch connections. All pipe drops off the header shall immediately have an isolation valve, followed by a union joint, no matter the height. In some cases, an additional valve at operating height may be required.

Table 2-5-2 presents recommended velocity limits for selection of pipe sizes for liquid process pressure piping systems. Velocities through flow meters should be higher than those in the host pipeline. At some conditions, the velocity range may be exceeded, but in no instance should the velocity be greater than 10 fps or less than 1 fps. Velocities in sludge and scum systems should be at least 3 to 4 fps to avoid elevated sludge friction multipliers and associated losses. Velocities in grit slurry lines should be a minimum of 5 fps.

Table 2-5-3 indicates velocities and capacities of air piping systems, and recommended pipe sizes for air flow rates up to 375,000 scfm.

Table 2-5-1. Process Piping Materials

Legend	Service	Piping				Valving			Remarks
		Material	Schedule/ Class	Lining/ Coating	Joint Type	Shut-Off	Check	Throttling	
ALP	Air Low Pressure Process	Exposed: 316L SST Buried: ≤ 30" DI ≥ 36" Steel, lined and coated	Note 5 Class 53 Note 5	- - - - Bitumastic	Welded/ Flanged Push-On (PO) Welded	Butterfly	Split disc	Butterfly	Notes 2, 8 Note 4
CA	Compressed Air	316L SST	Note 5	- - - -	Welded/ Flanged	Ball	Swing	Globe	Note 2
NaOH	Caustic	CPCV, Chlorinated polyvinyl chloride	Sch. 80	- - - -	Socket Weld	Diaphragm	Ball	Diaphragm	Notes 6, 7
$FeCl_3$	Ferric Chloride	CPVC	Sch. 80	- - - -	Socket Weld	Ball/ Diaphragm	Ball	Diaphragm	Notes 6, 7
GR	Grit	HDPE	Note 5	Note 10	Flanged/ Butt fusion	Pinch	- - - -	-------	Notes 2, 10

Table 2-5-1. Process Piping Materials (continued)

Legend	Service	Piping				Valving			Remarks
		Material	Schedule/ Class	Lining/ Coating	Joint Type	Shut-Off	Check	Throttling	
Inf./Eff.	Influent/ Effluent	Exposed: ≤ 24" – DI ≥ 30" – Steel Buried: ≤ 54" - DI ≥ 60" – PCCP (Prestressed Conc Cylinder pipe), Or Steel	Class 53 Note 5 Class 53 - - - Note 5	Cement - - - - Cement - - - - Urethane/ Urethane	Flange/Split Coupling. Weld/Flg Push-On Bell & Spigot Welded, Bolted split sleeve coupling	Plug Butterfly Plug/ Butterfly Butterfly Butterfly	- - - - - - - - - - - - - - - - - - - -	Butterfly Butterfly Butterfly Butterfly Butterfly	Notes: 1, 2, 4, 13 Note 4
Meth.	Methanol	316L SS	Note 5	- - - -	Weld/Flg	Ball	Ball	Diaphragm	Note 7
Poly	Polymer	PVC or CPVC	Sch. 80	- - - -	Socket Weld	Ball	Ball	Diaphragm	Notes 6, 7
PSW	Process Service Water	4" or larger: DI 3": DI, or 316/316L SST Less than 3": 316/316L SST	Class 53 Note 5 Note 5	Cement, w/ bituminous seal coat - - - -	Exposed: Flanged, or Grooved Cplg Buried: PushOn Flanged, or Welded (316L SST), or Threaded (316 SST)	Gate, Resilient wedge, Non-rising stem (NRS) open left NRS Gate open left, or SST Ball SST Ball	Rubber Flapper Swing Swing/Ball	Globe Globe, SST Globe SST Globe	Notes: 1, 2, 4, 14, 15 For all shut-off valves less than 4", provide a union joint downstream

Table 2-5-1. Process Piping Materials (Continued)

Legend	Service	Piping				Valving			Remarks
		Material	Schedule/ Class	Lining/ Coating	Joint Type	Shut-Off	Check	Throttling	
W / CW	Potable Water	For Cold Water (Potable) / City Water, Piping and valve types, see Section 6 - Plumbing							
PD	Process Drain	≥ 4" – DI < 4"- PVC	Class 53 Sch. 80	Cement -----	Exposed:Flg/Grve Cplg. Buried: Push-On Socket Weld	Up to 24" – Knife Gate Plug	--------	--------	Note 2
SAM	Sample	PVC	Sch. 80	- - - -	Socket Weld	Ball	Ball	Ball	
SCR	Screen-ings	316L SS	Note 5	-----	Exposed: Flg/Bolted Split Sleeve Cplg.	Pinch	------	- - - -	Notes 1, 4
SC	Scum	DI	CL 53	Glass Note 10	Exposed: Flg/Bolted Split Sleeve Cplg. Buried: Push-On				Notes 2, 9, 10
SW	Seal Water	316L SST	Note 5	- - - -	Welded, Flanged, Threaded, or Vic-Press.	Gate/Ball	Swing	Needle, or Globe	
SL	Sludge:	DI	Class 53	Primary: Glass Note 10 Secondary & Nitrif: Cement	Exposed:Flanged, or Grooved Coupling. Buried: Push-On	Up to 24" – Knife Gate	Rubber Flapper Swing	Pinch	Notes: 1, 2, 4, 10, 13
$NaH(SO_3)$	Sodium Bisulfite	CPVC	Sch. 80	- - - -	Socket Weld	Diaphragm	Ball	Diaphragm	Notes 6, 7

Table 2-5-1. Process Piping Materials (Continued)

Legend	Service	Piping				Valving			Remarks
		Materi al	Schedule/ Class	Lining/ Coating	Joint Type	Shut-Off	Check	Throttling	
NaOCl	Sodium Hypochlorite	Titanium	Sch. 40	- - - -	Welded/ Flanged	Diaphragm	Ball	Diaphragm	Notes 6 and 7
SA	Sulphuric Acid	316L SS	Note 5	- - - -	Welded	Plug / Ball	Ball		Note 12
WPL	Waste Pickle Liquor	CPVC	Sch. 80	- - - -	Socket Weld	Diaphragm	Ball	Diaphragm	Notes 6 and 7

Notes:

1. Minimum wall thickness for use with grooved couplings shall be per AWWA C606, except use Class 56 for 18-inch pipes and larger.
2. Provide flanges at equipment and valves only or as shown on the drawings. Flange bolts on DI pipe for submerged applications and for PSW service shall be SST. Provide isolation sleeves if used on ductile flanges.
3. Split couplings shall be used on all piping where foam spray nozzles are located.
4. Where push-on joints are listed provide restrained push-on piping joints and fittings with restrained mechanical joints (MJs).
5. For steel, stainless steel, and HDPE piping, specify wall thicknesses, gauge, schedule, or dimension ratio according to pipe size and service.
6. Chemical piping located outside or subject to freezing/crystallization temperatures shall be heat traced and insulated. Where buried insulate and heat trace to 4’-0” below grade.
7. Buried chemical piping shall be double-walled containment piping system.
8. Insulate ALP piping within buildings and galleries and where required for personnel protection.
9. Use LR bends for scum services and primary sludge.
10. For grit slurry, scum, and sludge applications, PDE shall evaluate pipe lining alternatives and make recommendation(s) of proposed linings to DC Water for acceptance. Include consideration of ceramic epoxy lined ductile iron pipe as an alternative to glass-lined ductile iron.
11. General Note: Do not use copper piping in any area subject to H2S exposure.
12. Valves for SA should be constructed of cast Alloy 20 for acid strength above 70%.
13. Use 316L SST for small diameter accessory piping and fittings for pressure gauge installations or other field instruments, for wastewater and sludge services, and general chemical services, except where indicated otherwise for chemical services.
14. All PSW flushing connections in process piping shall have a 1-inch ball valve, and, if any such connections are not to be hard-piped, provide a 1-inch SST female Camlock fitting. All hoses shall have 1-inch aluminum Camlock male fittings.
15. For interior and exterior wall hydrants on PSW, consider whether vacuum breakers should be installed, e.g., if hose may be sometimes connected to flushing connection on sludge piping.

Table 2-5-2. Recommended Velocity Limits for Liquid Process Pressure Piping Systems

Piping System Type	Velocity Ranges (fps)		
	Minimum	Desirable[3]	Maximum
Pump Intake	3	3.5	4 – 5
Suction Header	3	4	6 [1]
Suction Piping to Pump	3	4	6 [2]
Pump Discharge Piping	3	6	10
Discharge Header	2	3.5 – 5	8
Gravity Pipelines	2	4 – 5	8

[1] For water systems, use 2-3 fps maximum in suction header.
[2] For water systems, use 5 fps maximum in suction piping to pump.
[3] Does not apply to velocities through flow meters which should be higher. See Section 8A, Instrumentation and Process Control.

Table 2-5-3. Recommended Air Piping Design Capacity and Velocities

Pipe Size (inches)	Air Flow (scfm)		Velocity (fpm)	
	Minimum	Maximum	Minimum	Maximum
10” or smaller	0	1,800	1800	3000
12” – 24”	1,800	14,000	2,700	4,000
30” and larger	14,000	-	3800	6500

5.3.3.4 Pressure-Loss Calculations

This section provides design guidelines for pressure-loss calculations for liquid process piping systems and aeration piping systems.

Liquid Process Piping Systems

Friction losses in pressure piping systems are normally determined by using the Hazen-Williams equation. The following "C" values are recommended guidelines for design purposes:

Table 2-5-4. Recommended Hazen-Williams "C" Values

Pipe Material	Recommended "C" Value	
	Design	New Pipe
Ductile Iron (Cement Lined)	120	150
Ductile Iron (Glass Lined and ceramic epoxy lined)	130	150
Carbon Steel (Epoxy Phenolic Lined)	120	150
CPVC, PVC	130	150
Concrete Cylinder Pipe, Cement Lined	110	140
Stainless Steel	130	150

For sizing of pumping and piping systems, it is recommended that the system be conservatively designed using probable minimum and maximum "C" values. The "C" values in Table 2.5.4 should be adjusted if necessary for severe service applications, such as piping subject to severe corrosion from chemical action, abrasion from grit, or grease and scum accumulation.

For sludge and scum systems, use a suitable multiplication factor based on the percent solids and the velocity to compute headloss in the pipeline. The most important criteria for sludge and scum systems are to calculate system losses based on the expected range of flow rates and solids concentrations.

Aeration Piping Systems

All air and gas piping shall be sloped to a low point and provided with a valved drain. The head loss in aeration systems will include the following:

- Diffuser loss: based on the diffuser manufacturer's data plus a clogging allowance of 6 to 8 inches of water for coarse bubble diffusers.
- The submergence of the diffusers.
- Silencer and filter losses, based on manufacturer's data.
- Piping and valving losses.
- Control valve sizing, minimum 1 psi differential pressure (DP).

5.3.3.5 Surge Calculations

For each piping system, the PDE shall consider the impact of hydraulic transient conditions and shall follow precautions in the design to minimize or abate the impacts of hydraulic surge and water hammer.

5.3.3.6 Flow Measurement

Refer to Section 8, Instrumentation of this volume for design guidance on flow measurement facilities. Locate flow meters in galleries rather than in vaults. Do not locate any pipe fittings within 5 diameters upstream and 3 diameters downstream of any flow or density meters. For piping configuration and bypass arrangements, note the following:

For all Magnetic Flow meters:

- Provide flow meter in vertical as preferred configuration
- Provide isolation valves upstream and downstream of meter.
- Provide piping support to allow flow meter to be removed with balance of pipe remaining supported.
- Pipe anchoring and joint design to have provisions for removing flow meter
- Provide flushing taps between isolation valves to periodically flush flow meter.
- Provide locking ball valves on flushing taps.
- Provide straight section immediately upstream or downstream of meter for ultrasonic meter installation. Size, material and wall thickness of this pipe shall be tagged.
- Provide minimum straight lengths required by manufacturer to avoid turbulence and to render accurate readings

Flow meters shall be installed without bypass if:

- Redundant system is available
- Flow meter can be replaced with a planned outage

Flow meters shall be installed with bypass around flow meter if:

- Flow has to be maintained in pipe line at all times and there is no opportunity for planned outages

Bypass configuration:

- Provide bypass piping configuration to allow meter removal without disrupting pumping operation.
- Single isolation valve in bypass line.
- Bypass line to be equipped with flushing taps and locking ball valves on either side of isolation valve.

Rationale for guideline:

- Magnetic flow meters are non-intrusive. Flow can be maintained through meter regardless of whether meter is functioning. If meter is out of service, a flow through the non-working meter is equivalent to a non-metered by-pass flow.
- If flow metering value is critical to process, the ultrasonic will provide flow indication at a lower accuracy until magnetic flow meter is repaired/replaced. Straight length and accurate information on pipe including wall thickness is required for ultrasonic.

- If scum and grease buildup is of concern in the flow meter throat, then the same concern should exist through the entire pipe where the scour velocity is lower. Provisions should be made to clean entire pipe length.
- Flushing taps will allow periodic flush of flow meter section.

5.3.3.7 Valve Configurations and Selection

All wetted equipment (pumps, control valves, etc.) shall have valve configuration to allow isolation and removal of equipment. If control valves or instruments have bypass lines to allow removal of the device, the bypass line shall have two isolation valves, one on each end of the bypass line. Connection from each isolation valve to the bypass line shall be flanged to allow removal of the bypass line if desired.

Strategically locate manual valves such that dead legs are minimized. Allow ample space for access to and maintenance of valve and gate operators. Provide adequate clearances for rising stem valves and gates in all positions.

Mud valves actuators shall be pedestal mounted with hand wheel at operator level. No mud valves shall be located upstream of fine screens.

All manual valves shall have corrosion resistant and ultraviolet resistant identification labels or tags attached that are readable and legible from the nearest operating work surface. Tag numbers and colors shall be in accordance with DC Water requirements.

Provide motor operators on flow control valves and isolation valves that are designed to fail in last position. The downstream isolation valve in the flow element / flow control valve train shall be a combined function check valve.

Air Release Valves (ARV) – ARVs and combination vacuum and air release valves shall be selected based on features appropriate for the applications. Preferences include 316 stainless steel construction, with features designed for service with media containing grit, solids and grease when applicable; a float that is direct-connected without a lever type linkage, to avoid a common failure point; an assembly designed to minimize the time required to perform maintenance, and, if buried, to minimize the necessity for maintenance personnel to enter a manhole and confined space. See PDM Volume 3 for additional criteria for ARVs in clean water applications. Installations shall include an isolation valve (in the normally open position) between the ARV and the process pipeline.

Plug Valve Applications – Verify manufacturers' recommendations for proper orientation of all valves. For fluids containing suspended solids, orientation of plug valves is critical to prevent solids from accumulating in the valve body, which restricts the plug movement. Install plug valves for sludge and suspended solids applications with the flow against the face of the plug in the closed position and the valve stem horizontal, with the plug rotating to the top of the pipeline in the open position. Make sure the operator is also in the correct orientation for operation, and make sure there is no interference with adjacent piping or equipment. The following are guidelines for various plug valve services:

- **Suspended Solids Service:** For horizontal piping, install valves with the flow entering the seat end of the valve and the shaft in a horizontal position with the plug up when open. For vertical piping, install plug valves with the seat end up regardless of flow direction.

- **Clean Liquid Service:** For both horizontal and vertical piping, install valves in the direct pressure orientation (pressure opposite the seat end).

- **Air and Gas Service:** Install valve in the direct pressure orientation (pressure opposite the seat end). Lubricate plug face before installation. Gear actuators are required for gas service applications.

- **Pump Isolation Service:** Install the discharge valve with the seat downstream from the pump and the plug rotating to the top of the pipeline in the open position.

Valve selections for the various piping services in wastewater treatment facilities and pumping stations are shown in Table 2-5-1, Process Piping Materials. Provide heaters for motor-operated valves installed in severe service and outdoor locations.

5.3.3.8 Pipeline Pigging

Pipeline pig launching and recovery stations have been provided on several pipelines at the Blue Plains Advanced Wastewater Treatment Plant (AWTP). These facilities are not currently used and new installations are probably not required on future projects. However, the option should be evaluated and discussed with DC Water Operations staff during the design of appropriate projects.

5.3.3.9 Pipe Insulation and Heat Tracing

Certain process piping systems will require insulation or insulation and heat tracing. The following process piping systems shall be insulated:

- Aeration or air piping located in galleries and buildings and for areas for personnel safety considerations.
- Piping in galleries and buildings subject to surface condensation.
- Piping exposed and subject to freezing.

Aeration or air piping could have surface temperatures of up to 350 degrees F. For personnel safety considerations, interior air piping shall be insulated for protection of personnel, and jacketed for sound attenuation for large systems such as central blower facilities. Use 3- to 4-inch thick insulation, or as required to meet safety and sound attenuation requirements. For applications where sound attenuation is not important, a lesser thickness insulation may be considered if calculated to be adequate for worker safety or for protection of materials susceptible to high temperatures. Eliminate insulation at T316L SS bellows expansion joints.

For interior piping subject to surface condensation, use insulation with a minimum thickness of 2 inches for piping larger than 12 inches, 1 inch thick for 1½-inch through 12-inch piping, and 1/2-inch thick for 1-inch and smaller piping.

Insulate and heat-trace the following process piping:

- Exposed exterior piping containing liquids subject to freezing.
- Exterior chemical piping both exposed and in pipe chases where the pipe is subject to freezing, or where chemical crystallization may occur at temperatures above freezing.
- When insulated and heat-traced exterior piping continues to be buried, terminate insulation and heat-tracing 4 feet below grade.
- All insulated outside piping must be jacketed.
- Hot water piping.

Select the insulation and heat tracing in accordance with the following criteria:

- Minimum design outdoor temperature: 0 degrees F.
- Maximum design wind velocity: 50 mph.
- Maintain product temperatures above crystallization and freezing points.

Use self-regulating heating cables for all nonmetallic piping. Provide insulation and heat tracing of buried piping to a minimum of 6 inches below the frost line. Allow for additional feet of piping to be heat-traced where valves are located in the pipeline.

5.3.3.10 Pipe Testing Requirements

Specify all process piping to be tested either hydrostatically or pneumatically. Design pressures and specific testing requirements shall be provided in the specifications for each design package. Include provisions in the piping system design and testing specifications to provide system isolation for testing and to accommodate limitations in allowable pressures against the various types and sizes of valves and instruments. Test piping at a minimum of 150 percent of the design working pressure.

Specifications for testing pipe support systems shall include:

- Each piping system, whether design is provided by the PDE or the Contractor, shall be tested.
- Wet testing after each piping and support system is complete shall be performed to confirm compliance with specifications. Wet testing shall include operation of the connected mechanical device, e.g., pump, blower, mixer, etc., to demonstrate that the connected piping system is adequately supported and vibrations are adequately attenuated and meet specified design criteria under the full range of operating conditions. Each pipe support system wet test shall be witnessed for approval by DC Water
- An independent testing firm shall be used to perform vibration measurements and compare to specified vibration and displacement limits during testing of pipe support systems. Accelerometers and/or proximity probes shall be used in measuring vibration and displacements of piping systems to confirm pipe support criteria for control of vibration is achieved. A minimum of one measurement shall be conducted on each straight run of pipe in both horizontal and vertical directions.
- Vibration and displacement measurement devices shall be placed as directed by DC Water based on visual observation or motion sensor camera recording of piping systems during operation.
- Where the resonance with imposed vibration and/or shock exceeds design criteria, including referenced codes and standards during operation, suitable dampers, restraints, anchors, etc., shall be added to remove or control these effects.
- Record vibration data or displacements over the full range of operating conditions for connected rotating equipment for each piping system. Piping system segments which exceed allowable vibration criteria shall be remedied by the Contractor and retested.

5.3.3.11 Pipe Hangers and Supports

Except as otherwise noted below, or at the discretion of the PDE, show piping 12 inches and smaller on the drawings without a detailed pipe support system. Guidelines for the support system shall be included in the specification section for piping support systems and shall be designed by the installation contractor.

For piping support systems designed by others, the PDE shall clearly delineate in the construction contract documents the loads and forces to be supported and/or resisted. Information shall include, but is not limited to, static loads from the pipe and fluid conveyed or used for testing, pipeline appurtenances, insulation, and any other static or dynamic loads, including vibrations, surge, and shock loads to which the pipeline may be subjected. The PDE shall verify that the building structure is adequate to support the imposed loads.

Piping support systems for piping larger than 12 inches and multiple parallel pipes supported by a single support system, regardless of pipe size, shall be designed by the PDE and conform with the criteria outlined in this section.

Piping support design shall be in accordance with ANSI B31.1, ANSI B31.3, and API 618, Section 7.9.4.2.5.2.4 Piping Design Vibration Criteria. Piping support systems must be designed and documented to handle all dead loads imposed by the weight of the pipe, fluid, insulation, piping system components, and test pressure as well as all live loads and dynamic loads imposed by vibrations, surges, shock loads, and testing and operation of the system. Piping support systems shall have a minimum factor of safety equal to 5.0, or otherwise in accordance with structural design requirements in Section 4 - Structural.

Predicted piping vibration magnitude shall be limited to the following per API 618:

- Constant allowable vibration amplitude of 0.5 mm peak-to-peak (0.02 in. peak-to-peak) for frequencies at or below 10 Hz.
- Constant allowable vibration velocity of approximately 32 mm/sec peak-to-peak (1.25 in./sec peak-to-peak) for frequencies between 10 and 200 Hz.

Allow free expansion and contraction of the piping to prevent excessive stress resulting from service and testing conditions or from weight transferred from the piping or attached equipment. Equipment shall not serve as a piping support. Piping shall be supported so that no loads are transferred to the nozzles of connecting pumps. Support piping independently of existing piping and supports. Support piping independently that connects to piping where a support detail and location are provided on the drawings. Provide sway braces or vibration dampeners to control the movement of piping due to vibration.

Pipe movement resulting from thermal expansion shall be accommodated with due regard to the piping system components such as expansion joints and expansion loops. Hanger rods or sway struts may be offset up to one half the expected thermal movement depending upon the application. Movements larger than this shall be accommodated with supports allowing travel.

Piping shall be supported independently of any equipment connections and without imparting any vertical or horizontal stresses to align the pipe with the equipment.

Where trapeze hangers are used, rods shall be sized as if the entire load is on one rod. Spacing for the most limited span shall be used where different materials and sizes are concurrently carried. Hanger spacing shall be in accordance with Manufacturers Standardization Society MSS-SP-69, Table 3.

Arrange hangers for concentrated loads, such as valves, flow meters, expansion joints, and inline pumps, to control stress and deflection to within limits of ANSI B31.1. Provide independent support for concentrated loads.

CPVC and PVC piping and valves shall be supported in a channel framing system or other approved support system designed in accordance with standards from the pipe manufacturers. Piping shall be braced to minimize sway. Valves in nonmetallic piping shall be firmly supported to prevent the transfer of force to the pipe joint during normal valve operation.

Other design criteria for hangers and supports include the following:

- Do not support pipes from other pipes.
- Restrain all non-rigid pipe couplings such as sleeve couplings.
- Use standard components as described in MSS-SP-58.
- Use standard hanger designs in accordance with MSS-SP-69.
- Design support system to preclude movement or sway during operation.
- Specify materials to prevent corrosion due to contact of dissimilar metals and environmental exposure.

5.3.3.12 Pipe Anchorage

The PDE shall design all anchorage systems. All piping shall be suitably restrained and supported to impose minimal forces on stationary-mounted equipment under all operating conditions. See Hydraulic Institute standards for allowed forces on equipment. As part of the design, the PDE shall provide load calculations and thrust analyses. Design anchors to transmit loads to the structure; anchors shall not permit movement of the pipe relative to the structure. Do not attach anchors to secondary steel members, such as girts, purlins, or intermediate floor beams; attach anchors to main structural members designed for the anchor forces.

Use ASTM A312 Type 316 stainless steel for concrete anchors and hardware. Beam clamps shall be forged or cast and shall be restrained.

Install an anchor between the pump suction and discharge nozzles and the expansion joint or non-axially rigid coupling. If the expansion joint or coupling is installed between the pump nozzle and a piping anchor, the force developed by the pressure will be transmitted to the pump nozzle. If the anchor is installed between the pump and the expansion joint or coupling the pump is isolated. Reference: ANSI/HI 1.4 paragraph 1.4.3.5

For installation of manufactured anchors in existing structures, the designs shall be based on the accepted values in the specific product's International Code Council Evaluation Service (ICC-ES) Reports. Provide calculations to DC Water for review. Selection of anchor types in any location subject to vibration shall be subject to acceptance by DC Water. Specify that pull testing must be performed on the anchors after installation.

5.3.3.13 Pipe and Valve Numbering and Color Coding

All pipelines 1 inch and larger, and all process valves 1 inch and larger shall be numbered and identified on the drawings and field painted designated colors, all as shown hereafter.

See Table 2-5-5 for Pipe Service Areas Identification (ID) and Codes; and Table 2-5-6 for Fluid ID, Pipe Codes. All pipe headers except Chemicals, PSW, and City Water (CW) shall be numbered by Service Area ID-Fluid ID-Running Number. Format: XX-XXX-XXX. Example: 07-016-001.

Table 2-5-5. Pipe Service Areas

ID	Service Area	CODE
00	**PLANTWIDE - City Water**	*
01	**Primary**	**PTF**
02	**Secondary**	**STF**
03	**Nitrification/Denitrification**	**NITD**
04	**Dual Purpose**	**DPSB**
05	**Multimedia**	**F&D**
06	**Solids (other than SPB)** • *Gravity* • *PSSDB*	 **GT** **PSSDB**
07	**Solids Process Building** • *DAF* • *Blend Tank* • *Centrifuge* • *DSLF/SSLS* • *FDF/WWBS* • *Dry Polymer* • *Odor Control* • *Screenings*	**SPB** **DSLF** **FDF**
08	**PLANTWIDE Process Service Water**	*
09	**PLANTWIDE Chemicals**	*
10	**MPT/CHP** • *Predewatering* • *Cambi* • *Digestion* • *CHP*	**MPT** **CHP**
11	**Filtrate Treatment**	**FTF**
12	**TDPS/ECF** • *Tunnel Dewatering Pumping Station* • *Enhanced Clarification Facility*	 **TDPS** **ECF**
13**	**Central Operation Facility**	**COF**
14**	**Central Maintenance Facility**	**CMF**
15**	**Supply Building 2 (Buildings & Grounds)**	**B&G**
16**	**Warehouse/Visitor Center**	**WVC**
17**	**Gatehouse A**	**GATEA**
18**	**Gatehouse B**	**GATEB**

* Plantwide Service Areas. **Rev 12-08-2014 - ARI

Table 2-5-6. Fluid Identification, Pipe Codes, Color Schedule

ID	Fluid	Pipe Code	Service	Color Schedule**
01	Ferric Chloride	FC	Chemical	
02	Waste Pickle Liquor	WPL	Chemical	
03				
04	Polymer	POLY	Chemical	
05*	Polymer	POLY	Chemical	
06	Sodium Hypochlorite	SH	Chemical	
07	Sodium Bisulfite	SOB	Chemical	
08	Sodium Hydroxide	CS	Chemical	
09	Sulfuric Acid	SA	Chemical	
10	Chemical Waste (Drain)	CHW	Chemical	
11	Phosphoric Acid	PHA	Chemical	
12	Stage 1 - Scrubber Recirculation (Acid)	OSRCA	Chemical	
13	Stage 2 - Scrubber Recirculation (Base)	OSRCB	Chemical	
14	Standby - Scrubber Recirculation	OSRCSB	Chemical	
15	Lime	LIME	Lime	
16	Methanol	MeOH	Methanol	
17	Methanol (Vapor)	MeOH	Methanol	
18	Oil	OIL	OIL	
19*	Propane Gas	PROPANE	Propane Gas	
20*	Carbon Dioxide	CO2	Fire Suppression	
21				
22				
23				
24				
25				
26	Primary Sludge	PS	Sludge	
27	Gravity Thickened Sludge	GTS	Sludge	
28	Secondary Waste Sludge	SWS	Sludge	
29	Secondary Return Sludge	SRS	Sludge	
30	Nitrification Waste Sludge	NWS	Sludge	
31	Nitrification Return Sludge	NRS	Sludge	
32	Flotation Thickened Sludge	FTS	Sludge	
33	Blended Sludge	BS	Sludge	
34	Centrifuge Sludge Feed	CSF	Sludge	

ID	Fluid	Pipe Code	Service	Color Schedule**
35	Screened Blended Sludge	SBS	Sludge	
36	Thermal Hydrolysis Feed	THF	Sludge	
37	Thermal Hydrolyzed Sludge	THS	Class A-Sludge	
38	Digested Sludge	DS	Class A-Sludge	
39	Digester Sludge Recirculation	DSR	Class A-Sludge	
40	Digester Sludge Recirculation & Feed	DSRF	Class A-Sludge	
41	Final Dewatering Recirculating Sludge	FDRS	Class A-Sludge	
42	Press Sludge Feed	PSF	Class A-Sludge	
43				
44	Filtrate Sedimentation Waste Sludge	FSWS	Sludge	
45	Filtrate Reactor Cyclone Sludge	FRCF	Sludge	
46	Filtrate Waste Sludge	FWS	Sludge	
47	Dewatering	DW	Sludge	
48	Tunnel Shaft Dewatering	TSDW	Comb. Sewer	
49	Tunnel Dewatering	TDW	Comb. Sewer	
50	Primary Influent	PI	Comb. Sewer	
51	High Rate Clarifier Effluent	HRCE	ECF	
52	High Rate Clarifier Sludge	HRCS	ECF	
53				
54				
55				
56	Process & Service Water	PSW	PSW	
57	Low Pressure Process & Service Water	LP-PSW	LP-PSW	
58	Seal Water	SW	PSW	
59	Flushing Water	FW	PSW	
60	Washdown Water	WW	PSW	
61	Make-up Water	MW	LP-PSW	
62				
63	Cooling Water Supply	CWS	PSW	
64	Cooling Water Return	CWR	PSW	
65*	Foul Water	FOW		
66	City Water	CW	City Water	
67	Cold Potable Water	CW	City Water	
68	Hot Potable Water	HW	City Water	

ID	Fluid	Pipe Code	Service	Color Schedule**
69	Tempered Water	TW	City Water	
70*	City Service Water City Water Non-Potable	CSW CWNP	City Water	
71	Fire Protection	FP	City Water	
72	Fire Department Connection	FDC	City Water	
73*	Boiler Feed Water	BFW	City Water	
74*	Chilled Water Supply	CHWS	CWS	
75*	Chilled Water Return	CHWR	CWS	
76	Spent Washwater	SWW	Recycle	
77	Centrate	CENT	Recycle	
78	Washwater Drain	WWD	Recycle	
79	Washwater Return	WWR	Recycle	
80	Tempered Water Return	TWR	Recycle	
81	Dilution Water	DLW	Recycle	
82	Filtrate Dilution Water (Reclaimed Sec. Eff.)	FDLW	Recycle	
83	Filtrate Reactor Decant	FRDCT	Recycle	
84	Filtrate	FLT	Recycle	
85	Recirculation	REC	Various	
86				
87				
88				
89				
90				
91	Primary Scum	PSC	Scum	
92	Biological Scum	BSC	Scum	
93	Grit Slurry	GR	Grit Removal	
94	Hydraulic Oil Supply	HOS	Equipment	
95	Hydraulic Oil Return	HOR	Equipment	
96	Filter Washwater (Backwash)	FWW	Filter Media	
97	Air Scour	AS	Filter Media	
98	Lubricating Oil Supply	LOS	Equipment	
99	Lubricating Oil Return	LOR	Equipment	
100				
101	Process Air	PA	Air	
102	Compressed Air	CA	Air	
103	Instrument Air	IA	Air	
104	Sample	SAM	Sample	
105	Foul Air	FA	Foul Air	

ID	Fluid	Pipe Code	Service	Color Schedule**
106	Sanitary Force Main	SFM	Sanitary Waste	
107	Sanitary Sewer	SAN	Sanitary Waste	
108	Drain, Waste, Vent	DWV	Sanitary Waste	
109*	Siloxane Regeneration Air	SRA	CHP	
110*	Regeneration Exhaust Air	REA	CHP	
111	Drains	DRN	Drains	
112	Vent	VENT	Drains	
113	Sump Pump Discharge	SPD	Drains	
114	Roof Drain	RD	Drains	
115	Roof Drain Overflow	RDO	Drains	
116	Storm Drain	SD	Drains	
117	Overflow	OF	Drains	
118	Process Drain	PD	Drains	
119	Boiler Blowdown	BD	Drains	
120	Natural Gas	NG	Gas	
121	High Pressure Natural Gas	HPNG	Gas	
122*	High Pressure Digester Gas	HPDG	Gas	
123	Low Pressure Digester Gas	LPDG	Gas	
124	Medium Pressure Digester Gas	MPDG	Gas	
125	Foul Gas	FG	Gas	
126	Low Pressure Steam	LPS	Steam	
127	Medium Pressure Steam	MPS	Steam	
128	High Pressure Steam	HPS	Steam	
129*	Steam Condensate	SCON	Steam	
130*	Flash Steam	FS	Steam	
131*	Gas Condensate	GCON	Gas	

* Rev 12-09-2014 – ARI
** Check with DC Water for latest schedule of painting colors for piping and valves

- Chemicals, PSW, and CW pipe headers shall be numbered by Plantwide Service Area ID-Service Area-Fluid ID-Running Number.
  Format: XX-XX-XXX-XXX
  Example: 00-02-066-001
- After passing through a valve the running number shall increase by one.
- After passing through a piece of equipment the running number shall increase by ten.
- If further header numbers are needed in the future in existing piping due to the addition of a valve, etc., add an .alpha to the existing header number. Example: 09-07-008-003.A.
- When existing piping is modified in a design, any existing pipe remaining shall retain the existing numbering.
- For redundant piping systems, add a .numeric at the end of the pipe header number to differentiate the redundant piping.
  Example: 06-016-001.1 and 06-016-001.2

<u>Valve Numbering Guidelines:</u>

- See Table 2-5-7 for Valve Codes
- All process valves 1-inch and larger shall be numbered. All chemical valves regardless of size shall be numbered. These numbers are for valve equipment tag identifications, and are distinct from Maximo tag identifications for asset classification for process and plumbing valves 2-inch and larger, and all sizes chemical valves.
- For valves not adjacent to equipment, the valve is numbered by Valve Code-Downstream Pipe Header Number.
  Example: KGV-05-16-001
- Anytime there is a duplication of a valve number (e.g., at a tee) add a ‘dot.alpha’ to the end of the number to differentiate.
  Example: KGV-05-16-001.A and KGV-05-16-001.B
- For isolation valves adjacent to a piece of equipment the valve is numbered by Valve Code-Equipment ID. If there is more than one isolation valve, the valves shall be differentiated by adding ‘dot.alpha’ to the end of the number.
  Example: BFV-DSLFOS2.A and BFV-DSLFOS2.B
- For any valves that are located between an equipment isolation valve and a piece of equipment, e.g., a check valve, the valve shall be numbered by Valve Code-Equipment ID.
- Show all valve numbers and valve equipment tag identifications on the drawings.

Table 2-5-7. Valve Codes

Valve	Code
Air Release Valve	ARV
Angle Valve	AV
Ball Check Valve	BCV
Ball Valve	BV
Butterfly Valve	BFV
Check Valve	CV
Cone Valve	CNV
Corporation Stop	CS
Diaphragm Valve	DV
Diverter Plug Valve	DPV
Flap Valve	FV
Gate Valve	GV
Globe Valve	GLV
Plug Valve	PV
Knife Gate Valve	KGV
Mud Valve	MV
Needle Valve	NV
Pinch Valve	PIV
Tapered Plug Valve	TPV
Pressure Reducing Self Regulating Valve	PRRV
Pressure Reducing Valve, Pilot Actuated	PRVA
Pressure Relief Valve	PRV
Pressure Relief and Vacuum Valve	PRVV
Rupture Pin Relief Valve	RPRV
Two-Way Solenoid Valve	TWSV
Three-Way Valve	TWV
Vacuum Breaker	VB
Vacuum Relief Valve	VRV
Pressure Sustaining Valve*	PSV
Solenoid Valve*	SV

*Rev 12-04-2014 - ARI

5.3.4 Channels and Troughs/Gates and Valves

5.3.4.1 Channel and Trough Design

Channels and troughs shall be designed to achieve self-cleansing velocities. Bottom corners of channels should be filleted, minimum 45 degree slope. Pockets and corners where solids can accumulate shall be eliminated. Suitable gates should be placed in channels to seal off unused sections which might accumulate solids. Provide all channels which may not be in use for considerable periods of time valved drains. Provide a means such as a downward acting gate to remove scum and floatables from channels where floatable collect.

5.3.4.2 Equipment Selection

- Use stainless steel slide gates for tank, channel or facility isolation where a relatively non-leaking gate closure is required and where a facility must be isolated on loss of power.
- Stainless steel slide gate leakage: Not to exceed 0.05 gpm/foot of sealing perimeter.
- Use stop logs for isolation of channels that are rarely isolated and where the expense of a permanently installed gate is not warranted; also use stop logs or roller stop logs for isolation of other gates and valves for servicing.
- Use rectangular butterfly valves for channel isolation and for flow control when installed in conjunction with a flow meter.
- Select materials of construction with consideration of longevity, corrosion resistance, maintenance requirements, leakage requirements, and resistance to chemicals being introduced upstream. All slide gates, stems, hardware and fasteners shall be Type 316/316L stainless steel.

All gates that are equipped with gear operators shall be suitable for and capable of withstanding the loads imposed by the use of an electric or hydraulic portable drill operator. Equip all slide gates that are used for modulating service with hydraulic cylinder operators; electric operators are not acceptable for this service. Gates for use in an explosive environment, such as wet well areas where other than a manual operator is used, shall be equipped with an explosion-proof electric motor or hydraulic cylinder operator. Locate hydraulic power units in a non-explosive environment. Equip all electric motor operators with a manual, geared operator. Electric motor operators and controls located outdoors shall be provided with heaters.

5.3.4.3 Equipment Layout

Design criteria are presented below for stainless steel slide gates, stop logs, and rectangular butterfly valves.

Stainless Steel Slide Gates

The preferred arrangement for a stainless steel slide gate is in a seating condition, although an unseating condition allows service to be performed on the dry side of the gate. Provide sufficient space above the gate for full opening and removal of stem and gate.

Install all gates on stainless steel thimbles or on existing cast iron thimbles. If mounting on existing cast iron thimbles clean the thimbles and install a 1/4-inch elastomeric gasket.

> Provide “F” thimbles for all gates except provide “E” thimbles for all gates that are connected to a piping system.

For "F" thimbles provide full depth of wall up to 36-inches. For walls thicker than 36-inches provide a minimum 36-inch thimble depth.

Direct bolting of gates to concrete walls is only acceptable for new concrete construction that conforms to ACI tolerances and only if approved by DC Water.

Use self-contained gates for all stainless steel slide gates.

For channel isolation, the top of the gate shall be a minimum of 1'-0" above the maximum water surface elevation.

Provide dual stems for upward opening gates wider than 60-inches when the opening width is greater than or equal to twice the height of the slide. Provide dual stems for downward opening gates wider than 48-inches when the opening width is greater than or equal to the height of the slide.

Provide two gearboxes for all upward opening gates 60- inches wide and larger and with opening widths greater than twice the gate height. Provide two gearboxes for all downward-opening gates 48- inches wide and larger and with opening widths greater than twice the gate height.

Stems shall have a minimum diameter of 1-1/2 inches. Design stems based on the type of operator, length of stem and safety factor required:

Operator	Safety Factor
Hand wheel	2.50
Gear	2.50
Electric motor	1.30 x stall torque
Hydraulic cylinder	1.25 x output of cylinder at pressure relief valve setting

Use the resulting forces, including safety factor, from the gate operation in designing the slide gate frame.

Avoid use of non-rising stems if practical. This type of stem cannot be lubricated and debris can accumulate in the threads and cause sticking of the gate. Provide covers for rising stems and gate position indicators.

Use flush-bottom gates for installation at channel or tank inverts.

Unless electric or hydraulic operators are required, gates 24 inch by 24 inch and smaller shall be equipped with hand wheel operators; gates larger than 24 inch by 24 inch shall be equipped with geared operators. If smaller gates are frequently operated, a geared operator may be appropriate. The above are guidelines and judgment must be exercised for each gate used.

Electric motor or hydraulic operators are required when the gate meets any of the following criteria:

- Gate requires open/close control from a remote location.
- Gate requires modulation from a remote signal.
- Gate requires quick closure or opening such as in a loss of power mode.

- Gate is to be operated more frequently than once a week.
- Vertical movement of the gate is greater than 6'-0".
- Gate area is greater than 36 square feet.
- Access to the gate is not sufficient to use a portable drill operator.

Stop Logs

Stop log sections shall be provided such that top of the gate extends a minimum of 1'-0" above the maximum water surface elevation. Stop logs installations shall be designed with appropriate guides or grooves.

Where practical, provide a monorail with an electric motor hoist and trolley above stop log assemblies, with the monorail extending to an area where the gate sections can be properly stored. Where monorails are not practical, a jib crane may be used.

Rectangular Butterfly Valves

Standard valves are available up to 144 inches by 144 inches. Where valves larger than this are required, use multiple valves. Provide electric or hydraulic operators. Provide heaters in outdoor motor operators and controls.

Use three-sided valves for open-channel installations and four-sided valves for closed-conduit installations. For open channel installations, the top of the valve shall extend a minimum of 1'-0" above the maximum water surface elevation.

5.3.4.4 Leakage Tests

Factory and field tests shall be specified for all gates and valves. Guidelines for leakage testing for various gates and valves are listed below:

Stainless Steel Slide Gates

- Factory Test: Leakage test all gates to the design unseating head with a resulting leakage rate not to exceed 0.05 gpm per foot of gate seal perimeter.
- Field Test: Perform a leakage test on all gates at design head, where practical, with a resulting leakage rate not to exceed 0.05 gpm per foot of gate seal perimeter.

Stop Logs

- Field Test: Perform a leakage test on all stop logs at design head, where practical, with a resulting leakage rate not to exceed 0.05 gpm per foot of gate seal perimeter

Butterfly Valves

Perform field leakage test with criteria being bubble tight shutoff and zero leakage.

5.3.4.5 Controls

Controls for channel gates and valves shall be as required by the instrumentation drawings and as detailed in the appropriate instrumentation and mechanical specifications. Gates that are equipped with hydraulic cylinder operators and accumulators that are provided for fail-safe closure on loss of power shall be provided with controls to allow closure within the time required for the particular application.

5.3.5 General Equipment Guidelines

5.3.5.1 Equipment Foundations

Equipment pads and mounting bases should be installed level within tolerances as recommended by the equipment manufacturer. Welded construction equipment bases shall be stress relieved after the welding process. Mounting surfaces for motors and gear reducers shall be machined to establish a flat plane and be coplanar within 0.001 inch.

All shims used to align and level equipment shall be die-cut manufactured shims of stainless steel with the thickness etched (not stamped or printed) on the shim. The maximum total number of shims used to precision level and align equipment at any one shim location is three. The total thickness of shims at any one point shall be not less than 0.125 inch to allow adjustment for future equipment variation, settlement, or other adjustments; and no more than 0.250 inch.

5.3.5.2 Equipment Power Transmission

All power transmission couplings shall be precision aligned and a written record provided for the angle and offset after alignment and the thickness of shims used at each shim point. Critical speed of all rotating equipment and the critical speed frequency of the motor shall be at least 25 percent above the maximum motor operating speed, or 25 percent less than the minimum motor operating speed. Vibration levels of a pumping unit when installed shall not exceed the limits recommended by the Hydraulic Institute, or specified vibration limits, whichever is more stringent.

All belt drives are to be precision aligned and belt tension set by manufacturer's recommendation and measurement method. Any power transmission belt guard shall be designed to allow disassembly and removal of the guard with conventional hand tools. If any portion of a power transmission belt guard weighs in excess of 30 pounds, lifting lugs, eye bolts, or other hardware shall be provided to facilitate removal by a lifting device. Coupling and belt guards shall have door openings to allow inspection. Opening of door must require the use of tools. Expanded metal mesh is an acceptable alternative to allow visual inspection into guarded components. Provide securely mounted equipment guards for couplings, belts, chain drives, extended shafts, and exposed moving parts. Provide spacer shaft type couplings on end suction pumps to allow removal of the rotating assembly.

5.3.5.3 Equipment Layout

Provide minimum clear space around equipment as required by applicable codes, industry standards, manufacturers' recommendations, or 3 feet, whichever is greater. Maintenance access requirements, especially, on large equipment, shall be considered when establishing the layout, including the need to completely remove each equipment unit at some future time. A major component removal plan is required for all process equipment. Show access for lifting and transporting removed equipment using conventional material handling equipment such as forklift trucks, mobile cranes, and semi-trailer trucks. Provide walking access to all process equipment without having to climb over or crawl under pipes, electrical conduits, or other obstructions. Arrange equipment and piping in a manner to avoid tripping hazards.

Equipment requiring periodic service shall be located at a height convenient to personnel, providing easy access to adjustment points, test points, and filling and draining points. Arrange equipment so that access to malfunctioning components does not require disassembly of adjacent equipment. Ensure that ample clearance is provided in hazardous areas for personnel encumbered by personal protective equipment. Install large or critical equipment motors and actuators above grade where possible and above potential flooding levels, or otherwise select motors and actuators that can operate in submerged conditions periodically.

5.3.5.4 Equipment Lubrication

Equipment shall be provided with lubrication accessory fittings such as ball valves, nipples, and or quick connects as appropriate to facilitate changing oil and filtering efficiently. Oil lubricated gear reducers and other lubricated equipment as appropriate shall have vent systems with desiccant breathers designed to prevent the entry of water vapor into the gear case. All lubrication used in the initial fill of new equipment shall be filtered prior to use. All oil-lubricated equipment, including motors, shall have a provision to allow sampling of lube oil for analysis. Grease fittings for equipment shall be brought to a single location at operator level for ease of access.

5.3.5.5 Miscellaneous Equipment Considerations

Provide, to the maximum extent practical, similar pieces of equipment furnished by the same manufacturer to maintain uniformity. Use hinged doors on equipment instead of removable panels/plates unless recommended otherwise by the manufacturer. Provide convenient access for frequently-serviced items including traps that require periodic cleaning, pump vent piping, oil reservoirs, hydraulic quick-connect couplings, and dehydrating canisters.

All rotating equipment shall have running time meters. All powered and/or rotating equipment more than 6-feet tall above its supporting deck shall have a permanent connection to allow maintenance staff to connect a portable accelerometer without needing to climb a ladder

Noise readings must be recorded for all newly installed equipment to demonstrate compliance with applicable codes and standards.

5.3.6 Pumps and Accessories

This section presents guidelines for pumping system design, equipment selection and layout, construction materials, equipment testing, and related requirements. See also Appendix A – DC Water Preferred Pumping Equipment Systems by Application

5.3.6.1 Pumping Design Considerations

Design wastewater pumping systems to handle the expected range of flows from initial minimum to peak storm or wet weather flow. Process pumping systems must also be designed to handle the entire range of solids concentrations for the particular process. Materials of pump construction shall be selected to accommodate expected service requirements for raw wastewater, grit, sludge, scum, chemical feed systems, seal water, sample acquisition, etc.

All pumping systems must be capable of handling the peak design flow with the largest capacity unit out of service (defined as *firm capacity*).

All dry pit pumps shall be driven directly through motors or gear reducers and equipped with flexible couplings or through extension shafting. Do not specify close-coupled or built-together pumps. Provide guards on all pump drives, couplings and shafting regardless of size or application.

Equip all submersible pumps with explosion-proof motors and explosion proof discharge assembly rated explosion proof by Underwriters Laboratories (UL) or Factory Mutual (FM). All submersible pumps must be provided with a hoist or other mechanical lifting system, such as guide rails, hooks and cables for ease of removal. The removal device must allow the removal of the pump in a single lift.

All pumps and motors shall have a maximum noise level of 85 dbA at three feet from the equipment.

All pumps shall be designed capable of being isolated and flushed and drained.

5.3.6.2 Pumping Equipment Selection

For the majority of projects proposed to be undertaken by DC Water, planning reports will have been completed prior to initiation of the design phase and will generally include recommended pump selections for various applications. During the early stages of the design, the PDE shall confer with DC Water regarding pump selections, materials and features required for specific process applications. Specifications for a number of pump types and drives have been developed under previous DC Water projects. The PDE shall review and update available specifications, or where no specification exists, develop new specifications to suit project requirements. The following are general pump selection requirements:

Pumps shall be selected for a combination of parameters; these include:

- Highest possible efficiency for energy management.
- Lowest practical speed for equipment longevity.
- Hydraulic characteristics of the pumping system.
- Solids handling capability, where applicable.
- Chemical handling capability, where applicable.

Select centrifugal pumps so that the pump will operate within its Preferred Operating Range (POR) or if not practical due to system requirements Acceptable Operating Range (AOR).The low range is especially critical when selecting pumps for variable-speed applications.

Select centrifugal pumps that handle solids so that pumps are specified with the minimum number of vanes possible for the conditions of service.

The following types of equipment are not acceptable:

- Equipment that is intended to operate at its maximum capacity or strength, thus stressing the machinery to its limits.
- Pumps requiring use of their maximum-diameter impeller, or pumps operating outside the manufacturer's AOR.
- Pumps to be used for raw wastewater service with dual or twin volutes for pumps 36 inch and smaller.

Sump pumps - Standardize on brand/models to facilitate interchangeability with shelf spares. DC Water prefers plug-in type in lieu of hard-wired, to avoid requiring multi trades to remove a sump pump. Use non-contact level controls (ultrasonic) to avoid floats getting stuck with debris. Avoid expensive chemical resistant Vanton pumps in non-chemical areas; use regular submersible units instead.

Select pumps based on system head curves for a range of expected “C” values, usually from 120 to 150 but dependent on piping material, and for the expected solids concentrations from that of water to whatever minimum, average, and maximum that can be expected from a particular service such as sludge, scum, or grit.

Check all pump systems for available NPSH. Where possible, as a minimum, NPSH available shall be at least 5 feet more than what is required by the pump.

Maximum rotating speed for all process pumps shall generally be 1,200 rpm. Lower speeds such as 600 rpm to 900 rpm are more desirable. This may not be practical for small end-suction pumps, chemical metering pumps, and high-pressure pumps, which shall have a maximum rotating speed of 1,800 rpm. Do not use rotating speeds of 3,600 rpm unless absolutely required.

In order to properly specify the pumping equipment and the conditions of service for any system, use a Process Pump Schedule. Table 2-5-8 shows a sample schedule form completed for an application using variable-speed pumps and one using two-speed motors. Other design parameters, such as characteristics of materials for the pump casing or impellor, may also be included in the table.

System head curves shall be developed for all centrifugal pump systems and shall be displayed on the contract drawings. As a minimum, system curves and pump selection shall show the following:

- System curves for minimum and maximum “C” values and range of static heads, corrected for solids handling systems.
- All flow conditions (minimum, average, maximum, and seasonal variations).
- Selected pump performance curves.
- Station loss curve for entire range of pump performance capabilities. Pump operation for the minimum speed required with one pump, multiple pump operation for all combinations of pumps at full speed, and multiple pump operation at reduced speed to meet system flows.

Table 2-5-8. Example Process Pump Schedule

Name	Raw Wastewater	Reclaimed Secondary Effluent
Number of Units	6	4
Pump Designation	RWW-1,2,3,4,5,6	RSEP-1,2,3,4
Pump Type	Vertical Solids Handling Centrifugal	Vertical Solids Handling Centrifugal
Design Rating Point (based on [___] pumps operating in parallel)	42,000 gpm @ 90 feet	6,200 gpm @ 30 feet
Minimum Efficiency at Design Rating Point, percent	84	84
Secondary Operating Point (single pump operation, Full Speed)	84,000 gpm @ – 43 feet	–8,500 gpm @ 19 feet
Minimum Efficiency at Secondary Operating Point, %	65	68
Minimum Speed Operating Point	__________ gpm @ ____ feet	________ gpm @ ____ feet
Minimum Shutoff Head (feet)	98	48
NPSH required (feet)	Design Rating Point: 10Secondary Point: 15	Design Rating Point: 24Secondary Point : 30
Min. Solids Passing (inches)	5.5	4
Min. Suction/Disch. (inches)	36"/36"	10"/10"
Maximum Pump RPM	330	585
Motor Horsepower	1,500	75
Motor Data (V, Ph, freq.)	480V, 3-phase, 60 Hz	480V, 3-phase, 60 Hz
Drive type	Direct/shafting, variable frequency drives	Direct/shafting, two-speed motors
Motor Enclosure	WPII	TEFC
Motor Speed, rpm	360	600
Seal Type	Split Mechanical (1)	Split Mechanical (1)

Notes:

1. Provide split seals suitable for no flush.

Select all pump drives so that the horsepower requirements of the pump from shutoff to maximum operating conditions do not exceed the motor nameplate rating. Motors operating in the service factor under any conditions are not acceptable.

5.3.6.3 Pumping Equipment Layout

Where possible, arrange pumps so that the suction and discharge piping are located on the same side of the pump. This arrangement allows space for maintenance and repair of the pump and motor. Arrange pumps so that there is a minimum of 3'-0"clearance between pumps, and sufficient clear space above pumps for rigging and removal of components. For larger pumps, provide a clear space equivalent to the pump volute. Provide sufficient clear space above pumps for rigging and removal of components. For large, vertical solids handling pumps, a platform may be required for access to the pump bearing frame, oil reservoirs and pump seals.

All pumps shall be installed on a minimum 6-inch high concrete housekeeping pad. Piping arrangements shall include provisions for vent, drain, gauges and seal water, and flushing water (PSW) as appropriate. For pumps handling chemicals or hazardous materials, provide means as required for positive flushing and draining the pumps in preparation for maintenance. All sludge and wastewater pumps shall have taps on suction and discharge for flushing and draining, and for capability to be filled with PSW when set as standby. Provide flushing and draining taps or fittings at locations in between the pump suction and discharge isolation valves so that the pumps may be flushed while isolated. Hard piping to PSW supply and drain is not mandatory. Refer to paragraph 5.3.12 for additional operability and maintainability considerations.

Each pump shall have a connection at nearby suction and discharge piping to allow pump performance testing. Connections are to have lockable isolation valves and blind flange or pipe cap to prevent accidental opening.

Provide positive easy access for ALL valves, both motorized and manual, including submerged and overhead valves. Use the following guidelines to determine the layout of the various types of pumping systems for suction and discharge piping.

Suction Piping:

Equip pump suctions with an isolation valve and a flexible coupling. The coupling must be located between the isolation valve and the pump. Locate an anchor between the coupling and the pump.

Locate eccentric reducers with the flat portion of the reducer on top to prevent accumulation of air in the piping run. Locate gauges on the suction piping at a sufficient distance upstream of the reducer so that gauge readings will not be affected. For large suction piping (36 inches and larger), motor operators for suction isolation valves should be considered.

For solids handling and end-suction-type pumps, provide a sufficient length of straight suction piping upstream of the pump. The length of the piping will depend on the velocity at the pump suction. The length will vary from 3 to 10 pipe diameters depending on the velocity at the pump nozzle. Suction piping velocities shall conform to Table 2-5-2.

For vertical pumps, LR reducing elbows or turbo-free elbows are preferred. The reduction in size should be limited to one or a maximum of two sizes larger than the suction elbow inlet diameter for LR reducing elbows and at least two sizes for a turbo-free elbow. Suction piping and fittings shall be designed in accordance with ANSI/HI 9.8 and the pump manufacturer′s recommendations.

Provide suction piping from a tank or wet well with a well-rounded entrance (bellmouth). If a flare elbow is used, the bellmouth shall be no closer than one-third and no greater than one-half the diameter of the bellmouth from the invert. Where an elbow is not used, the bellmouth shall be installed at the invert of the wet well or tank.

The wet well or tank floor shall be sloped toward the suction with the slope starting at a distance of 12 inches to 18 inches beyond the outermost edge of the bellmouth. Slopes shall be 60 degrees for raw wastewater, sludge and scum wells.

Discharge Piping:

Arrange pump discharge piping so that all discharges for a given set of pumps are at the same elevation as the pump and rise up after all connections are made to the discharge header. If this is not convenient, the discharge piping shall rise up to a header and enter the header in the horizontal with the discharge isolation valve in the horizontal or vertical and the connection to the located at the horizontal centerline of the header. Piping that discharges up into the bottom of a header should be avoided.

Discharge lines from sump pumps and return pumps shall be sloped back to the sump to avoid accumulations of grit in the pipeline. Design piping to achieve 3 fps minimum velocity to re-suspend any settled solids.

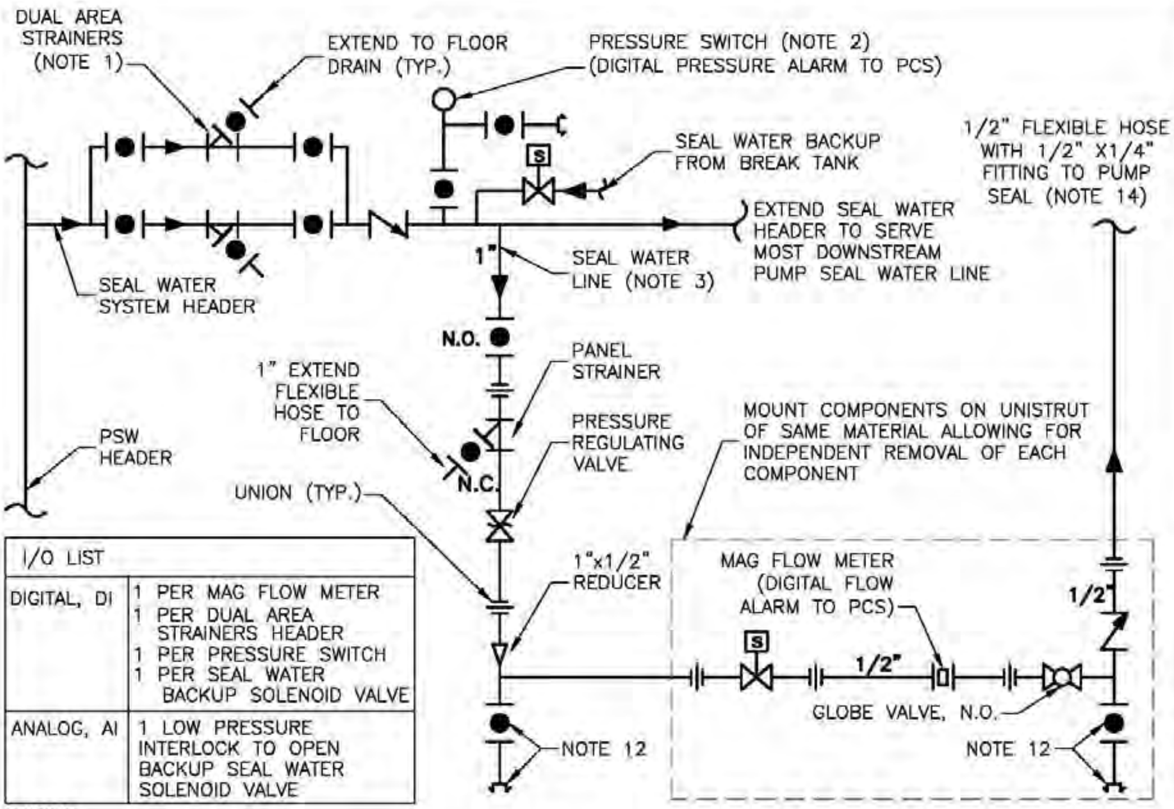
Provide each pump discharge piping with a check valve, isolation valve, and flexible coupling. Locate the flexible coupling between the check valve and the pump. Locate an anchor between the coupling and the pump. Do not place discharge piping and valves directly above a pump or motor. Locate gauges and flow meters to reduce the effect of directional and pipe size transitions on instrument readings.

5.3.6.4 Pump Seals

Equip all pumps with mechanical seals and arrange layouts to provide easy access to seals and bearings for maintenance. The preferred type of seal is a split mechanical seal. Where this type does not fit the pump, use a double mechanical seal. In either case, provide the seals with water flush. Provide a seal water system header from the process service water (PSW) system in accordance with Figure 2-5-2, Seal Water Configuration. Make sure pressure gauges, or connections for portable pressure gauges, are isolated with ½” SST ball valves.

Provide a system using city water source as a back-up to the process service water system. All split seals shall be installed capable of being used continuously without water (PSW) flush. For vertical pumps with split seals provide vent piping in accordance with API Plan 13.

Do not use packing with seal water unless approved by DC Water. Do not use packing with grease seals for any service. Supply flushing water to the seal at approximately 10 to 15 psi above the pump discharge pressure. Where packing is permitted, use split gland follower.



I/O LIST	
DIGITAL, DI	1 PER MAG FLOW METER 1 PER DUAL AREA STRAINERS HEADER 1 PER PRESSURE SWITCH 1 PER SEAL WATER BACKUP SOLENOID VALVE
ANALOG, AI	1 LOW PRESSURE INTERLOCK TO OPEN BACKUP SEAL WATER SOLENOID VALVE

NOTES:

1. AREA STRAINER: PROVIDE TWO 3MM Y STRAINERS ON SEAL WATER SYSTEM HEADER PRIOR TO 1ST SEAL WATER LINE SERVICED BY HEADER. USE STAYFLOW YSF1/2/3 STAINLESS Y STRAINER WITH BALL VALVE FOR DRAIN AND PROVIDE FITTINGS TO MATCH HEADER PIPE.
2. PROVIDE PRESSURE SWITCH DOWNSTREAM OF AREA STRAINERS, ON THE SEAL WATER SYSTEM HEADER WITH LOCAL INDICATION, ISOLATION VALVE, AND BRANCH FOR TESTING THROUGH QUICK CONNECTION. PROVIDE HARD INTERLOCK TO OPEN SEAL WATER BACKUP SOLENOID ON LOW PRESSURE SIGNAL (ADJUSTABLE). ALL SHALL BE 1/2" SIZE. AREA STRAINER AND PRESSURE SWITCH SHALL BE ACCESSIBLE FOR OPERATION AND MAINTENANCE. PRESSURE SWITCH SHALL BE UNITED ELECTRIC CONTROLS 2W3A WITH RANGE OF 0 TO 100 PSIG.
3. TYPICAL FOR EACH NON-CHEMICAL PUMP AND PUMPS NOT REQUIRING BACK PRESSURE.
4. LOCATE PANEL AT LOCATION OF EXISTING PANEL OR LOCATE TO AVOID INTERFERENCE WITH MAINTENANCE ACCESS TO PUMP OR REMOVAL OF PUMP COMPONENTS.
5. SEAL WATER PIPING, VALVES, AND APPURTENANCES SHALL BE 316L STAINLESS STEEL. JOINTS SHALL BE VIC-PRESS, SOCKET WELDED, OR NPT CONNECTION FOR INSTRUMENTS/APPURTENANCES/TRANSITIONING.
6. IN LOCATIONS SUBJECT TO FREEZING PROVIDE INSULATED STAINLESS STEEL CABINET WITH ELECTRIC HEAT TRACING AND THERMOSTAT
7. PANEL STRAINER: PROVIDE 1" IFC SERIES Y300 STAINLESS STEEL THREADED Y- STRAINER WITH OPENINGS AS REQUIRED BY DOWNSTREAM PUMP SEAL AND INSTRUMENTATION.
8. PRESSURE REGULATING VALVE: CASH ACME TYPE EB-25 SS PRESSURE REGULATOR WITH OUTLET PRESSURE RANGE OF 20-90 PSIG.
9. SOLENOID VALVE: SEAL WATER BACKUP TO BE SIZED SAME AS SEAL WATER HEADER AND CONNECTED TO PRESSURE SWITCH (NC TO OPEN ON LOW HEADER PRESSURE). INDIVIDUAL PANEL UPSTREAM OF MAG METER USE CLA-VAL 1/2" 136-01 SS SOLENOLD VALVE WITH MANUAL OPERATOR.
10. FLOW METER: IFM SM6001 MAG METER WITH A MEASURING FLOW RANGE OF 0.030-6.604 GPM, IF SEAL WATER REQUIREMENT IS AT OR BELOW 0.03 GPM, THEN REPLACE FLOW METER WITH PRESSURE SWITCH ASSEMBLY MODEL 2W3A BY UNITED ELECTRIC CONTROLS WITH RANGE OF 0-100 PSIG.
11. INTERLOCK SOLENOID VALVE, AND DOWNSTREAM FLOW METER OR PRESSURE SWITCH WITH PUMP STARTING CIRCUITS (LOCAL CONTROL PANEL).
12. PURGE WITH 1/2" BALL VALVE AND QUICK DISCONNECT FOR PORTABLE PRESSURE GAUGE OR HOSE CONNECTION.
13. GLOBE AND CHECK VALVES ALOYCO SS VALVES WITH PRESSURE CLASS OF 150 PSI, THREADED CONNECTION.
14. PROVIDE STAINLESS STEEL FLEXIBLE HOSE BETWEEN THE SEAL WATER SYSTEM AND THE PUMP SEAL FOR EASE OF INSTALLATION AND FLEXIBILITY OF THE PIPING SYSTEM. LIMIT LENGTH OF HOSE TO 4 FT.

Figure 2-5-2. Seal Water Configuration

5.3.6.5 Pump Controls

Specific control requirements shall be developed for each particular design application. General control requirements are highlighted below.

- All seal water systems must be equipped with a mag flow meter at each pump for flow indication and control. Each flow meter must be equipped to sound an alarm indicating a no-flow condition for the seal water. Consider if shut-off valves and a bypass around the flow meter are needed.
- Large pumps (e.g., for raw wastewater or plant effluent) shall be equipped with bearing temperature and vibration detectors.
- Provide all pumps with a device for low wet well level stop. This device shall be a pressure level set-point switch, or level probe in stilling well, or float switch as appropriate to the installation.
- Provide device to stop pumps by high pressure switch to avoid pumping at shutoff head.
- Provide all motors with overload protection, and provide submersible motors with a moisture and temperature detection system.
- Where variable frequency drives are provided, pump ramp-up shall be straight-line ramping.

5.3.6.6 Pump Drive Equipment

All motors shall have a 1.15 service factor. Large motors, such as those for the raw wastewater pumps, shall have a service factor of 1.0. For those motors with a 1.0 service factor, select a motor with a nameplate versus load of about 1.15.

All gear reducers shall have a minimum 1.50 service factor based on the motor nameplate rating and shall be selected at standard speed reductions.

For extended shaft applications, provide hollow tube type drive shafts with needle-bearing universal joints and a splined joint on the section immediately above the pump. Shafting shall be designed in accordance with pump manufacturer's recommendations with due consideration given to shaft materials, support of intermediate bearings, shaft alignment, and lubrication/cooling of bearings and joints. Guards shall be provided for all rotating shafts in accordance with applicable safety regulations.

5.3.7 Bar Screens, Screening Handling and Removal Systems

The following information provides general design guidelines for mechanical bar screens:

5.3.7.1 Screen Equipment Layout

Mechanically cleaned screens are typically located in hazardous areas; therefore, the electrical components must be of explosion-proof construction. Screen channels should be covered with grating or be protected with handrails. In laying out the screens, provide the following:

- A minimum of 3'-0" clearance between adjacent screens.
- Isolation gates upstream and downstream of the screens.
- A means to drain the screen channel when isolated.
- A means of access into the screen channel.
- A bridge crane or monorail system with a manually operated chain hoist over each mechanically cleaned screen; the hoist or crane shall also be capable of servicing the isolation gates.
- A suitable distance upstream of the bar screen to allow the flow to straighten out due to any change in direction; this distance should be in the range of the bar rack width times the maximum screen

channel velocity.
- Minimize the controls located in the classified area.

5.3.7.2 Screen Materials of Construction

The materials of construction for climber-type screen components shall generally be Type 316L stainless steel. Components made of 304 stainless steel are not acceptable.

5.3.7.3 Screen Controls

Under normal operation, screens for raw wastewater service shall be controlled by a repeat cycle timer. In the stop/start cycle for the screens, provide an automatic override of the timer so that operation will be continuous based on a set high head loss across the screen. Use a bubbler and differential pressure instruments or ultrasonic sensors to provide the head loss across the screen, or use a float switch system to trigger screen operation.

5.3.7.4 Screen Drive Equipment

Drives shall have a 1.50 service factor based on the nameplate horsepower and not on the horsepower required for operation. Equip gear reducers with a mechanical torque overload device. Consider variable speed drives to allow for adjustments in operating speed for varying flow conditions.

5.3.8 Blowers and Compressors

The following provides general design guidelines for blower and compressor systems. Proposed process upgrades incorporating blowers and compressors are planned for the Blue Plains AWTP and remote pumping stations. Refer to facility planning documents for conceptual design requirements for specific projects.

All blowers and compressors shall have a maximum noise level of 90 dbA at three feet from the equipment. Specify silencing appurtenances, enclosures, insulation, etc., as required to achieve required noise level. Provide air dryers for compressors, if required.

5.3.8.1 Blowers and Compressors Equipment Selection

Select equipment such that the design point is within the mid-range of the available operating range. Consider efficiency and cost-effectiveness. Do not select equipment that is intended to operate at its maximum capacity or strength, thus stressing the machinery to its limits.

Select and specify all blowers based on actual cubic feet per minute (ACFM) with the following conditions:

Actual Conditions:

- Temperature Range (Ta): 0-100 degrees F
- Barometric Pressure at site (Pb): 14.69 psia
- Relative Humidity Range (RHa): 50 percent to 90 percent
- Saturated Vapor Pressure (PVa): 0.9492 @ 100 degrees F
- Inlet Pressure (Pa): Pb - Intake Losses

Select the number of blowers so that the maximum operating conditions can be met with the largest unit out of service, and the minimum conditions can be met efficiently.

The capacity range for blower selection is as follows:

Rotary Positive-Displacement or Screw Compressors:	10 to 15,000 ACFM
Air or Magnetic Bearing Turbo Compressors	250 to 10,000 ACFM
Multistage Centrifugal:	250 to 25,000 ACFM
Multistage Centrifugal (horizontally split):	5,000 to 100,000 ACFM
Single-Stage Centrifugal:	5,000 to 200,000 ACFM

Rotary positive-displacement blowers should be selected for applications where the discharge pressure may vary greatly, such as in air-lift pumps or in tanks where there is a large variation in water surface elevations. Rotary positive-displacement blower motors must be sized not only for the operating capacity and pressure but for blower capacity at the pressure relief valve setting.

Centrifugal blowers should be sized with an allowance rise to surge above the operating pressure.

5.3.8.2 Blowers and Compressors Equipment Layout

All blowers shall be equipped with separate intake filters and silencers. Filters for a system need not be dedicated to one blower but may be a larger filter common to the system. For systems with common filters, intake isolation valves and vacuum relief are required.

Provide all blowers with the following:

- Discharge silencers.
- Blow-off silencers located as close to the blowers as possible to minimize noise.
- Blow-off butterfly valves, which may be manually operated if the blowers are not to be automatically started; larger systems should provide motorized valves for both manual and automatic or remote-started systems.
- Discharge check valves and isolation valves.
- A monorail with hoist for small units and a bridge crane for larger units to facilitate maintenance of the equipment.
- Stainless steel expansion joints on the intake and discharge of all blowers to isolate equipment and piping. Alternatively, elastomeric expansion joints may be considered if approved by DC Water for a specific application.

Intake piping must not enter centrifugal blowers at right angles. The intake piping should enter the blower axially and be a straight run of pipe as long as practical but not less than 3 to 5 pipe diameters with transitions made in a gradual manner. Piping must not produce strain on the blower that could cause misalignment and maintenance problems. It is preferred to use 45 degree bends and wyes in lieu of 90 degree bends and tee's for the blower discharge piping

Provide sufficient space for normal operation and preventive maintenance. This requirement is especially important for larger units that are equipped with oil lubrication and other ancillary systems.

Rotary Positive-Displacement Blowers

In addition to the above requirements, provide all blowers with a pressure-relief valve located downstream of the blower between the discharge silencer and the discharge isolation valve. All rotary positive-displacement blowers shall be equipped with thermometers and manometers. Provide traps for digester gas service.

Air Compressors

Provide single-stage units for pressures up to 100 psi, and provide two-stage units for pressures greater than 100 psi. Provide sufficiently and conservatively sized air receivers. All units shall be dual units mounted on or adjacent to a single air receiver.

5.3.8.3 Blowers and Compressors Materials of Construction

Materials of construction and hardware shall be selected with regard to type of service, location, required service life and expense. Consider special requirements for digester gas service, instrumentation air and exposure to chemicals.

5.3.8.4 Blowers and Compressors Controls

Specific control requirements will be developed for each particular design application.

5.3.8.5 Blowers and Compressors Drive Equipment

Single-stage and multistage centrifugal blowers shall be driven directly through constant-speed electric motors.

Rotary positive-displacement blowers shall be driven through V-belt drives or through gear reducers with variable frequency drives. All drives shall have a service factor of 1.50 based on the motor nameplate horsepower rating.

Air compressors for plant air and pneumatic valve operators shall be driven through V-belts with a service factor of 1.50 based on nameplate horsepower rating.

5.3.9 Chemical Storage and Feed Systems

The following discussion pertains to the use of sodium hypochlorite for disinfection, and sodium bisulfite for dechlorination. The requirements for other chemicals are similar with due consideration given to the properties of the specific chemical. Other chemicals proposed for continued use at the Blue Plains AWTP include ferric chloride, waste pickle liquor, sodium hydroxide, methanol and polymer. Consider such properties as corrosiveness, crystallization, temperature, boiling point, freezing point and other properties that require special handling or materials of construction.

The concentration of sodium hypochlorite solution will be 12.5 to 15 percent as delivered. For design, use a 10 percent solution for feed applications and pump sizing. The solution is very corrosive and precautions must be maintained.

The sodium bisulfite solution will be delivered at 36 to 44 percent and designed for feeding at 38 percent. Provide for dilution of the sodium bisulfite, since the 38 percent solution will crystallize at temperatures in the 40 degrees F range. Dilution to 30 percent reduces the saturation temperature to 25 degrees F from

40 degrees F at 38 percent strength. In addition, consideration must be given to the fact that the sodium bisulfite solution may reach temperatures as high as 125 degrees F during bulk transportation or storage.

It is important that the equipment location, piping and valving be designed to maintain a positive separation of sodium hypochlorite and sodium bisulfite. The mixing of hypochlorite and bisulfite will produce a violent temperature reaction. Where both chemicals are piped through a common area, keep the piping separate. Require that the delivery stations clearly identify the chemical by name and formula, and include a warning about mixing.

For all chemical feed systems, the PDE shall prepare and submit chemical dosage and equipment sizing calculations as part of the preliminary design documents.

Since the chemicals to be used are potentially toxic, special precautions must be taken. The design should provide a self-contained breathing apparatus in front of the entry to the interior chemical areas and gas detection systems with alarms for both chlorine gas and sulfur dioxide at low points in galleries where sodium hypochlorite and sodium bisulfite are conveyed. Gas detection systems and alarms for other types of combustible and/or toxic gases shall be provided where appropriate.

Provisions must be made for cleaning and rinsing bulk storage tanks. It is important on common standby/spare tanks to ensure that they are clean enough to accept the other chemical. Provide sample ports to test tank contents.

All piping exposed to the outside shall be insulated and heat traced. Provide a method to heat the contents of sodium bisulfite tanks. This shall be done whenever ambient temperatures are expected to be in or below the crystallization temperature.

Provide a method to drain all of the contents of chemical piping to safe areas, and to flush to drain after use. For example, sodium hypochlorite may be able to be drained to remote day tanks such as odor control system sodium hypochlorite storage tanks.

Provide spill containment for chemical delivery areas and containment for all chemical storage tanks with level alarms in the containment and curbed areas to indicate an overflow, tank leakage, or pipe leakage. Provide for controlled discharge of contained spill to ultimate disposal.

Chemicals will be diluted as they are being fed for dispersion across diffusers and for carrying velocity. Use the criteria in Table 2-5-9 for dilution rates.

Table 2-5-9. Chemical Dilution Requirements

Chemical	Application	Dilution Ratio
Sodium Hypochlorite	Disinfection	20:1
Sodium Hypochlorite	Return Sludge	20:1
Sodium Hypochlorite	Plant Water	40:1
Sodium Bisulfite	Dechlorination	90:1

5.3.9.1 Chemicals Equipment Selection

Tanks

Chemical storage tanks shall have access ladders with manholes provided in the top and side for each tank. If personnel access is planned for the manholes, manholes shall be 30-inch minimum diameter. The tank bottoms shall slope toward the lowest outlet or drain connection. All tanks shall have provisions to handle inadvertent overfilling without damage to the vessel, and shall have high-level overflow to drain.

Tanks shall be top-loaded and provided with a drop pipe to discharge chemicals near the bottom. Provide connections on the tank top for level-sensing instrumentation.

Pumps

Hose-type metering pumps are preferred. Select pumps for the capacity and head requirements for each application. Pumps must be resistant to the chemical environment. Select pumps for continuous service.

When selecting rotary lobe pumps for pumping low viscosity polymers, specify rotors to be non-wetted cast iron core coated with abrasion-resistant elastomeric coating such as Viton or other acceptable material. If available, consider exchangeable lobe tips with screw profile for low-pulsation pumping. Stacking of lobes is not acceptable due to maintenance difficulty and possibility of shaft wear. Pumps must also be designed with appropriate tolerances to pump water to occasionally flush out the system.

Valves

Valves shall be provided for isolation, control, and specialty applications. All valves must be equipped with visual position indication.

Isolation valves may be manual or automatic. Valves shall be line size.

In general, all 2-inch and smaller valves for chemical service, except polymer, shall be diaphragm type; 2 -1/2-inch and larger valves may be lined ball or butterfly valves. For polymer service, all sizes, use ball valves. Refer to Table 2-5-1, Process Piping Materials, for piping materials and valve types.

Piping

Except as otherwise required for chemical resistance compatibility (e.g., methanol), interior chemical piping shall generally be CPVC, titanium for sodium hypochlorite. Where buried chemical service is necessary, use double wall containment piping with zoned leak detection. Exposed chemical piping in galleries is preferred over buried piping.

5.3.9.2 Equipment Layout

Tanks

Arrange tanks so that all chemical tanks of one type are located inside a common containment area. As a minimum, containment capacity shall equal to 110 percent of the volume of one tank. For more than two tanks, the PDE shall use best professional judgment with regard to containment volume. Containment areas shall be provided with a sump for use with a portable pump to dispose of spills and washdown waste.

Provide 30-inch diameter access manholes in the top and the side of tanks. Equip manholes with hinges or davits for ease of access. Tank bottoms shall slope toward the lowest outlet connection or drain.

For environmental and safety reasons, maintain as much space as reasonable between the piping and equipment containing sodium hypochlorite and sodium bisulfite. In addition to the containment area, maintain a buffer zone.

The tanks shall have the capacity to receive bulk load deliveries plus a volume. Provide individual loading stations for each chemical. Common standby tanks shall have two separate loading stations. Spill containment provisions shall be provided at each unloading station.

Pumps

All pump suction piping shall be checked for NPSH and shall conform to the minimum requirements of at least two manufacturers. This is especially critical for diaphragm metering pumps.

Valves

Arrange all valves for access for manual operation and servicing. The first isolation valve on all bulk tanks shall be a lined, metal-body diaphragm, ball or butterfly valve for durability. Provide sample valves to perform testing of tank or line contents. All control valves shall be lined metal.

5.3.9.3 Controls

Chemical systems shall be automated to allow remote safe operation. However, local control will be required. Instrumentation such as tank levels, sodium hypochlorite and sodium bisulfite control valves status and alarms shall be as specified in the instrumentation section of this manual.

Provide all electrically operated equipment, such as pumps and valves, with local controls as specified in Section 9, Electrical.

In case of any piping or tank leaks, bulk storage tank discharge valves should close automatically.

5.3.9.4 Drive Equipment

All motors shall be of the chemical-duty type. Design criteria for drive equipment is as follows:

- Service factor - 1.15
- Insulation - Class F
- Maximum Motor speed - 1,800 rpm
- Couplings - flexible, all metal type
- Drive and coupling guards

All motors shall conform to the requirements specified in Section 9, Electrical. Gear reducers shall have a service factor or 1.50 times the nameplate horsepower rating.

Metering hose pumps shall be equipped with variable-frequency drives for capacity control.

5.3.10 Odor Control Systems

The following are general design guidelines for odor control systems of the types envisioned for use at

DC Water facilities. Refer to DC Water facility planning and/or conceptual design documents for project-specific odor control requirements. Odor control systems shall be designed to meet local and federal regulatory requirements for air quality.

5.3.10.1 Design Considerations

To keep odor control system size to a minimum, all air flows to be treated should be kept to as small as possible. This must be accomplished within the constraints imposed by the indoor design conditions for ventilation systems. (Refer to Section 7 of this volume for heating, ventilation, and air conditioning (HVAC) design criteria.) Possible methods for reducing air flows include:

- Minimizing the space requiring ventilation.
- Separating areas with high emission rates from areas with lower emission rates so that different ventilation rates can be used for each area.

The odor control systems shall be designed to reduce hydrogen sulfide, methyl mercaptans, and other odor-producing sulfur compounds in the airstream. Wet packed tower scrubbing systems will generally be used as the primary odor control system. Depending on specific project requirements, single or two-stage wet scrubbing may be provided. If removal of insoluble volatile organic compounds (VOCs) is a consideration, a final stage carbon absorption unit may be necessary.

The chemicals used in the wet scrubbing system shall be sodium hypochlorite and sodium hydroxide (caustic soda). Provisions shall be made in the design of wet scrubbing systems to allow other chemicals such as potassium permanganate, hydrogen peroxide, or chlorine dioxide to be used if required.

All wet scrubbers, recirculation pumps, chemical metering pumps, and chemical storage tanks must be installed within a curbed containment area. The curbed area must have sufficient volume to contain 125 percent of the liquid that could spill into it. Where mixing of chemicals could cause a hazardous situation, provide separate curbed areas and spill alarms.

Adequate access must be provided for servicing all components. Provide access hatches for replacement of wet scrubber packing and activated carbon. Provide platforms and ladders where necessary to permit service.

Design wet scrubbers with a single, coarse atomization nozzle that makes contact with 90 percent of the packing surface, with no portion of the spray directly contacting the scrubber wall. Provide mist eliminators for all wet scrubbers.

Chemicals shall be added by metering pumps. The feed rate shall be controlled by pH and oxygen-reduction-potential (ORP) sensors in the scrubbing liquid. Injection of corrosive chemicals into pipelines shall be accomplished with an injection quill into the flow of the receiving pipe to prevent localized corrosion at the point of addition.

The carbon adsorption stage shall use horizontal carbon adsorbers to reduce VOCs in the air stream. Provide a system for in-place regeneration of the carbon using hot air as the regeneration medium.

Relative humidity greater than 50 percent can reduce the adsorption on the carbon bed of organics with low molecular weight and a low boiling point. Therefore, the relative humidity of the gas stream after leaving the wet scrubber must be reduced before the gas stream enters the carbon bed. This can be done by raising the temperature of the gas slightly with a finned tube heating coil. The maximum temperature of gas entering the carbon bed shall be 85 degrees F.

Insulate all carbon adsorbers and ducts conveying regeneration air to minimize heat loss to the space. Place the regeneration air flow in the opposite direction of the normal gas flow to aid in stripping VOCs from the carbon.

5.3.10.2 Equipment Selection and Sizing

Concentrations of hydrogen sulfide and VOC for use in system design shall be presented in the conceptual design reports for the individual design packages.

Size chemical systems based on the average hydrogen sulfide concentration. Base the size of metering pumps and chemical feed equipment on the peak concentrations. Size storage tanks to provide five days' storage at the average concentration.

Wet scrubbers shall be packed towers of vertical countercurrent design. Design scrubbers to operate within a range of 1,500 lbs/hr-ft^2 to 2,000 lbs/hr-ft^2. Design scrubbers to remove 99 percent of hydrogen sulfide.

Make provisions for operating wet scrubbers with a blow-down rate of up to 5 percent to prevent salt buildup in the scrubbing solution and the packing. Provide a system for automatic blow-down.

Design radial flow carbon adsorbers for a maximum velocity of 100 feet per minute. The carbon for use in the bed shall be activated carbon.

Design the carbon system for regeneration in place with water. Install grease filters upstream of the carbon units

Where carbon systems are used, provide a means to dispose of the water used in the regeneration process.

5.3.10.3 Equipment Layout

To avoid pressurizing wet scrubbers, locate main system exhaust fans downstream of wet scrubbers and upstream of carbon adsorbers. Where long runs of duct work are required ahead of wet scrubbers, use booster fans to overcome the frictional and dynamic losses.

Design wet scrubbers and fans so that they can be operated in series if two stages of wet scrubbing are required.

5.3.11 Materials Handling Systems

Design criteria for hoists, bridge cranes, and conveyors are presented in this section.

5.3.11.1 Hoists

Hoists shall be provided, as a minimum, for the following services: Equipment removal; Equipment repair and maintenance; and Placement and removal of stop logs.

All hoists specified for frequent use or for lifting of over 1,000 pounds shall have motorized hoists and trolleys. Provide all hand hoists with an overload clutch that will prevent greater than 150 percent of the rated pull where the rated pull is 40 to 80 pounds. Base lifting capacity and total vertical lift on the maximum expected for the service and location.

Provide a number of small chain hoists for normal maintenance of all rotating equipment. Provide equipment such as pumps, blowers, and screens with lifting hooks properly located and suitable for these small hoists. Select hoists rated for a minimum of 500 pounds lifting capacity.

Use totally enclosed, non-ventilated motors, except for those in hazardous areas; these shall be explosion-proof.

Design all hoists in accordance with their service classification. This classification has been established by the Hoist Manufacturers Institute and is shown in Table 2-5-10. Hoist and trolley speed ranges have also been established by the Hoist Manufacturers Institute and are shown in Table 2-5-11. The ranges shown should be considered maximum speeds. The trolley speeds for use in wastewater treatment plants and pumping stations shall be limited to 20 fpm to 30 fpm.

Table 2-5-10. Hoist Duty Service Classifications

Hoist Class	Service Classification	Typical Areas of Application
H1	Infrequent	Powerhouse and utilities or infrequent or standby handling. Hoists are used primarily to install and service heavy equipment, where loads frequently approach hoist capacity, with periods of use being infrequent and widely scattered.
H2	Light	Light machine shop and fabricating industries and service and maintenance work, where loads and use are randomly distributed with capacity loads infrequently handled, and where total running time of equipment does not exceed 10-15 percent of the work period.
H3	Standard	General machine shop, fabricating, assembly, storage and warehousing, where loads and use are randomly distributed, with total running time of equipment not exceeding 15-25 percent of the work period.
H4	Heavy	High-volume handing in steel warehousing, machine shops, fabricating plants, mills, and foundries. Manual or automatic cycling operations in heat-treating and plating operations. Total running time of equipment normally approaches 25-50 percent of work period, with loads at or near rated capacity frequently handled.
H5	Severe	Bulk handling of material in combination with buckets, magnets, or other heavy attachments. Equipment often cab-operated. Duty cycles approaching continuous operation are frequently necessary. User must specify exact details of operation, including weight of attachments. **(not used at DC Water facilities)**

Table 2-5-11. Hoist and Trolley Speeds (fpm)

Capacity (tons)	Class H1 and H2		Class H3		Class H4	
	Hoist	Trolley	Hoist	Trolley	Hoist	Trolley
2	10-15	25-75	12-30	40-100	25-50	100-150
3-5	10-15	25-75	12-30	40-100	20-40	100-150
6-7.5	10-15	25-75	12-25	40-100	15-30	100-150
8-10	7-10	25-75	10-20	40-100	15-30	100-150
11-15	7-10	25-75	10-15	40-100	10-20	100-150
16-20	5-10	25-75	10-15	40-100	10-15	100-150

5.3.11.2 Bridge Cranes

Provide bridge cranes for the following types of service:

- Large pumping stations
- Maintenance facilities
- Large blower and compressor facilities
- Large screening facilities

Use top running cranes for capacities 15 tons and larger and top running or underhung cranes for less than 15 tons. For large cranes, provide access to the bridge from the operating floor. Access must conform to OSHA requirements. All motors shall be totally enclosed, fan-cooled motors, except for those in hazardous areas. These motors shall be explosion-proof.

Designate the service classification of all bridge cranes. This classification has been established by the Crane Manufacturers Association of America, Inc. (CMAA) and is shown in Table 2-5-12. Suggested operating speeds have been established by the CMAA and are shown in Table 2-5-13.

Speeds for use in wastewater treatment plants and pump stations shall not exceed the following:

Equipment	Speed
Hoist	15 fpm
Trolley	20 to 30 fpm
Bridge	40 to 60 fpm

Table 2-5-12. Crane Duty Service Classifications

Crane Class	Service Classification	Typical Areas of Application
A	Stand-by or Infrequent Service	This service class covers cranes that may be used in installations such as powerhouses, public utilities, turbine rooms, motor rooms and transformer stations where precise handling of equipment at slow speeds with long, idle periods between lifts is required. Capacity loads may be handled for initial installation of equipment and for frequent maintenance.
B	Light Service	This service covers cranes that may be used in repair shops, light assembly operations, service buildings, and light warehousing, where service requirements are light and the speed is slow. Loads may vary from no load to occasional full-rated loads, with two to five lifts per hour, averaging ten feet per lift.
C	Moderate Service	This service covers cranes that may be used in machine shops, paper mill machine rooms, or other applications where service requirements are moderate. In this type of service, the crane will handle loads that average 50 percent of the rated capacity with 5 to 10 lifts per hour, averaging 15 feet, not over 50 percent of the lift at rated capacity.
D	Heavy Service	This service covers cranes that may be used in heavy machine shops, foundries, fabricating plants, steel warehouses, container yards, lumber mills, and standard-duty bucket and magnet operations where heavy-duty production is required. In this type of service, loads approaching 50 percent of the rated capacity will be handled constantly during the working period. High speeds are desirable for this type of service with 10 to 20 lifts per hour averaging 15 feet, not over 65 percent of the lift at rated capacity.
E	Severe Service	This type of service requires a crane capable of handling loads approaching a rated capacity throughout its life. Applications may include magnet, bucket, or magnet/bucket combination cranes for scrap yards, cement mills, lumber mills, fertilizer plants, and contained handling, with twenty or more lifts per hour at or near the rated capacity.
F	Continuous Severe Service	This type of service requires a crane capable of handling loads approaching rated capacity continuously under severe service conditions throughout its life. Applications may include custom-designed specialty cranes essential to performing the critical work tasks affecting the total production facility. These cranes must provide the highest reliability with special attention to ease-of-maintenance features.

Table 2-5-13. Operating Speeds for Bridge Cranes (fpm)

Capacity (tons)	Hoist			Trolley			Bridge		
	Slow	Medium	Fast	Slow	Medium	Fast	Slow	Medium	Fast
3	20	35	70	25	150	200	200	300	400
5	20	35	70	125	170	200	200	300	400
7 ½	20	35	70	125	150	200	200	300	400
10	20	30	60	125	150	200	200	300	400
15	15	30	60	125	150	200	200	300	400
20	15	25	40	125	150	200	200	300	400
25	15	25	30	125	150	200	200	300	400
30	15	25	30	100	125	175	150	250	250
35	10	15	25	100	125	150	150	250	350
40	8	15	25	100	125	150	150	250	350
50	5	10	20	72	125	150	100	200	300
60	5	10	20	75	100	150	100	200	300
75	5	10	18	50	100	125	75	150	200
100	5	8	12	50	100	125	50	100	150
150	5	8	12	30	50	100	50	75	100

5.3.11.3 Conveyors

For conveyors for grit and screenings services, use the following guidelines:

- For belt conveyors, avoid drip pans; in lieu of a drip pan provide a concrete containment curb that can be easily sluiced and cleaned.
- Provide all appropriate safety and ANSI interlocks and shutdowns.
- Limit inclines for troughed belt conveyors to 20 degrees; double belt conveyors can be used up to 90 degrees.
- Provide access to at least one side of the conveyor for proper maintenance and to two sides for shuttle conveyors.
- Use Type 316L stainless steel conveyor supporting frame to provide corrosion protection.
- Belt speeds should not exceed 100 fpm.
- Conveyor width should be capable of handling the maximum expected load and maximum expected weight of the material to be conveyed.
- Care should be taken to allow the proper distance from the operating floor to the top of the conveyor in order to allow space for all system components.

5.3.12 Operability and Maintainability Considerations

All equipment shall be selected, designed, laid out, and integrated as required with process piping, power supply, and instrumentation controls as required to facilitate and optimize operability and maintainability. Refer to Section 10, Operation and Maintenance Standards, of this volume, for general guidance on operations and maintenance (O&M) standards, standard operating procedures, and O&M manuals.

The PDE shall provide, either as part of an O&M manual, or separately but suitable for inclusion in an O&M manual, comprehensive and detailed equipment-specific explanatory narratives to address requirements, design provisions, and itemized procedures applicable to operability and maintainability of each type of equipment. Each narrative shall include considerations as applicable, but not limited to, the following:

- Clear spacing around and above equipment
- Access to seals and bearings for ease of disassembly of rotating equipment
- Locations of pumps suction and discharge piping
- Isolation valves provided, including easy access thereto
- Safety provisions (electrical; physical; avoiding chemicals exposure; etc.)
- Pumps flushing and draining procedures, including disposal of any hazardous materials
- Lifting hooks, hoisting mechanisms and rigging requirements or provisions
- Adequate slack in power cords to allow moving of pumps or other equipment without disconnecting
- Removal of pumps or other equipment for temporary maintenance or replacement
- Other considerations as appropriate.

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APPENDIX A

DC WATER PREFERRED PUMPING EQUIPMENT SYSTEMS BY APPLICATION

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APPENDIX A - DC WATER PREFERRED PUMPING EQUIPMENT SYSTEMS BY APPLICATION

SYSTEM LEGEND	RAW WASTEWATER RWW			
Pump Type:	Solids Handling Centrifugal-Dry Pit	Solids Handling Centrifugal-Submersible	Screw	Vertical Turbine Solids Handling
Pump Setting:	Horizontal or vertical	Vertical, Rail Mounted	Inclined @ 22, 30 or 38 Degrees	Vertical Wet Pit
Seal Type:	Split Mechanical (1)	Tandem Mechanical	None Required	Split Mechanical
Seal Water:	Required	None Required	None Required	Required
Drive Type:	Direct or Shafting	Close-Coupled	Gear Reducer & V-belt	Direct
Instrumentation:	FS-Seal Water Flow Solenoid Valve-Seal Water Seal Water Pressure Low Flow Switch	Moisture Detection Temperature	Grease pump operation- interlock with screw pump starting	FS-Seal Water Flow Solenoid Valve-Seal Water Seal Water Pressure Low Flow Switch
Gauges:	Pressure Gauge Suction and Discharge	Discharge Pressure Gauge	-------------------	Discharge Pressure Gauge
Pump Appurtenances:	-------------------	-------------------	-------------------	-------------------
Notes:	(1) Capable of continuous use without water flush			

APPENDIX A - DC WATER PREFERRED PUMPING EQUIPMENT SYSTEMS BY APPLICATION

SYSTEM LEGEND	GRIT SLURRY GR	
Pump Type:	Recessed Impeller	Hose
Pump Setting:	Horizontal or vertical	Horizontal
Seal Type:	Split Mechanical or Hydrodynamic (1)	None Required
Seal Water:	Required	None Required
Drive Type:	V-Belt or Direct	Gear Reducer or V-Belt
Instrumentation:	FS-Seal Water Flow Solenoid Valve-Seal Water Seal Water Pressure Low Flow Switch	PSH-Discharge LSH-Pump Housing Liquid Level
Gauges:	In-Line Pressure Sensors Suction and Discharge	In-Line Pressure Sensors Suction and Discharge
Pump Appurtenances:	-------------------	Pulsation Dampeners Suction and Discharge
Notes:	(1) Capable of continuous use without water flush	If pinch valves are used for suction isolation, sleeves with vacuum rating for suction lifts

SYSTEM LEGEND	PRIMARY SLUDGE PSL				
Pump Type:	Recessed Impeller	Hose	Chopper	Plunger	Screw Centrifugal (only if stringy materials are present)
Pump Setting:	Horizontal or vertical	Horizontal	Horizontal or vertical	Horizontal	Horizontal or vertical
Seal Type:	Split Mechanical or Hydrodynamic (1)	None Required	Cartridge Mechanical	None Required	Split Mechanical or Hydrodynamic (1)
Seal Water:	Required	None Required	No Flush Water	None Required	Required
Drive Type:	V-Belt or Direct	Gear Reducer or V-Belt	V-Belt or Direct	Gear Reducer or V-Belt	V-Belt or Direct
Instrumentation:	FS-Seal Water Flow Solenoid Valve-Seal Water Seal Water Pressure Low Flow Switch	PSH-Discharge LSH-Pump Housing Liquid Level	-------------------	PSH-Discharge	FS-Seal Water Flow Solenoid Valve-Seal Water
Gauges:	In-Line Pressure Sensors Suction and Discharge	In-Line Pressure Sensors Suction and Discharge	In-Line Pressure Sensors Suction and Discharge	In-Line Pressure Sensors Suction and Discharge	In-Line Pressure Sensors Suction and Discharge
Pump Appurtenances:	-------------------	Pulsation Dampeners Suction and Discharge	-------------------	Pulsation Dampeners Suction and Discharge	-------------------
Notes:	(1) Capable of continuous use without water flush		Seal water required only for packing. Water or oil for mechanical seals		(1) Capable of continuous use without water flush

APPENDIX A - DC WATER PREFERRED PUMPING EQUIPMENT SYSTEMS BY APPLICATION

SYSTEM, LEGEND	PRIMARY SCUM PSC SECONDARY SCUM SSC THICKENED SCUM TSC	PRIMARY SCUM PSC SECONDARY SCUM SSC THICKENED SCUM TSC	PRIMARY SCUM PSC SECONDARY SCUM SSC THICKENED SCUM TSC	PRIMARY SCUM PSC SECONDARY SCUM SSC THICKENED SCUM TSC
Pump Type:	Recessed Impeller	Hose	Chopper-Dry Pit	Chopper-Submersible
Pump Setting:	Horizontal or vertical	Horizontal	Horizontal or vertical	Vertical, Rail Mounted
Seal Type:	Split Mechanical or Hydrodynamic (1)	None Required	Cartridge Mechanical	Tandem Mechanical
Seal Water:	Required	None Required	No Flush Water	None Required
Drive Type:	V-Belt or Direct	Gear Reducer or V-Belt	V-Belt or Direct	Close-Coupled
Instrumentation:	FS-Seal Water Flow Solenoid Valve-Seal Water	PSH-Discharge LSH-Pump Housing Liquid Level	-------------------	Moisture and Temperature Detection
Gauges:	In-Line Pressure Sensors Suction and Discharge	In-Line Pressure Sensors Suction and Discharge	In-Line Pressure Sensors Suction and Discharge	In-Line Discharge Pressure Sensor
Pump Appurtenances:	-------------------	Pulsation Dampeners Suction and Discharge	-------------------	Recirculation/Mixing System
Notes:	(1) Capable of continuous use without water flush		Seal water required only for packing Water or oil for mechanical seals	

APPENDIX A - DC WATER PREFERRED PUMPING EQUIPMENT SYSTEMS BY APPLICATION

SYSTEM LEGEND	RETURN SLUDGE RSL		
Pump Type:	Solids Handling Centrifugal-Dry Pit	Screw Centrifugal-Dry Pit (Delete if not used w/ PSL)	Vertical Turbine Solids Handling
Pump Setting:	Horizontal or vertical	Horizontal or Vertical	Vertical Wet Pit
Seal Type:	Split Mechanical (1)	Split Mechanical (1)	Split Mechanical (1)
Seal Water:	Required	Required	Required
Drive Type:	Direct or Shafting	Direct or Shafting	Direct
Instrumentation:	FS-Seal Water Flow Solenoid Valve-Seal Water	FS-Seal Water Flow Solenoid Valve-Seal Water	FS-Seal Water Flow Solenoid Valve-Seal Water
Gauges:	Pressure Gauge Suction and Discharge	Pressure Gauge Suction and Discharge	Discharge Pressure Gauge
Pump Appurtenances:	-------------------	-------------------	-------------------
Notes:	(1) Capable of continuous use without water flush	(1) Capable of continuous use without water flush	

APPENDIX A - DC WATER PREFERRED PUMPING EQUIPMENT SYSTEMS BY APPLICATION

SYSTEM LEGEND	WASTE SLUDGE WSL		
Pump Type:	Solids Handling Centrifugal-Dry Pit	Screw Centrifugal-Dry Pit (Delete if not used w/ PSL)	Recessed Impeller-Dry Pit
Pump Setting:	Horizontal or vertical	Horizontal or Vertical	Horizontal or vertical
Seal Type:	Split Mechanical (1)	Split Mechanical (1)	Split Mechanical (1)
Seal Water:	Required	Required	Required
Drive Type:	Direct or Shafting	Direct or Shafting	Direct or Shafting
Instrumentation:	FS-Seal Water Flow Solenoid Valve-Seal Water	FS-Seal Water Flow Solenoid Valve-Seal Water	FS-Seal Water Flow Solenoid Valve-Seal Water
Gauges:	Pressure Gauge Suction and Discharge	Pressure Gauge Suction and Discharge	Pressure Gauge Suction and Discharge
Pump Appurtenances:	-------------------	-------------------	-------------------
Notes:	(1) Capable of continuous use without water flush	(1) Capable of continuous use without water flush	(1) Capable of continuous use without water flush

APPENDIX A - DC WATER PREFERRED PUMPING EQUIPMENT SYSTEMS BY APPLICATION

SYSTEM LEGEND	THICKENED SLUDGE TSL					
Pump Type:	Recessed Impeller	Hose	Chopper-Dry Pit	Rotary Lobe	Screw Centrifugal	Progressing Cavity
Pump Setting:	Horizontal or vertical	Horizontal	Horizontal or vertical	Horizontal	Horizontal or vertical	Horizontal
Seal Type:	Split Mechanical (1)	None Required	Cartridge Mechanical	Mechanical	Split Mechanical (1)	Split Mechanical (1)
Seal Water:	Required	None Required	No Flush Water	No Flush	Required	Required
Drive Type:	V-Belt or Direct	Gear Reducer or V-Belt	V-Belt or Direct	Gear Reducer or V-Belt	V-Belt or Direct	Gear Reducer or V-Belt
Instrumentation:	FS-Seal Water Flow Solenoid Valve-Seal Water Seal Water Pressure Low Flow Switch	PSH-Discharge LSH-Pump Housing Liquid Level	-------------------	PSH-Discharge	FS-Seal Water Flow Solenoid Valve-Seal Water	PSH-Discharge N0 Flow-Suction Piping
Gauges:	In-Line Pressure Sensors Suction and Discharge	In-Line Pressure Sensors Suction and Discharge	In-Line Pressure Sensors Suction and Discharge	In-Line Pressure Sensors Suction and Discharge	In-Line Pressure Sensors Suction and Discharge	In-Line Pressure Sensors Suction and Discharge
Pump Appurtenances:	-------------------	Pulsation Dampeners Suction and Discharge	-------------------		-------------------	Stator Temperature Sensor
Notes:	(1) Capable of continuous use without water flush		Seal water required only for packing Water or oil for mechanical seals		(1) Capable of continuous use without water flush	(1) Capable of continuous use without water flush

APPENDIX A - DC WATER PREFERRED PUMPING EQUIPMENT SYSTEMS BY APPLICATION

SYSTEM, LEGEND SYSTEM, LEGEND	EFFLUENT, EFF PROCESS SERVICE WATER, PSW				
Pump Type:	Solids Handling Centrifugal-Dry Pit	Propeller/Mixed Flow	Submersible Propeller/Mixed Flow	Turbine	Screw
Pump Setting:	Horizontal or vertical	Vertical	Vertical	Vertical	Inclined @ 22 or 38 Degrees
Seal Type:	Split Mechanical (1)	Split Mechanical	Tandem Mechanical	Split Mechanical	None Required
Seal Water:	Required	Required	None Required	Required	None Required
Drive Type:	Direct or Shafting	Direct	Direct or Gear Reducer	Direct	Gear Reducer & V-belt
Instrumentation:	FS-Seal Water Flow Solenoid Valve-Seal Water Seal Water Pressure Low Flow Switch	FS-Seal Water Flow Solenoid Valve-Seal Water	Moisture and Temperature Detection	FS-Seal Water Flow Solenoid Valve-Seal Water	Grease pump operation- interlock with screw pump starting
Gauges:	Pressure Gauge Suction and Discharge	Discharge Pressure Gauge	-------------------	Discharge Pressure Gauge	-------------------
Pump Appurtenances:	-------------------	-------------------	-------------------	-------------------	-------------------
Notes:	(1) Capable of continuous use without water flush				

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY
(DC Water)

"SERVING THE PUBLIC - PROTECTING THE ENVIRONMENT"

PROJECT
DESIGN MANUAL
VOLUME 2 - FACILITIES DESIGN

SECTION 6 – PLUMBING

August 2018

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AUTHORIZATION FORM

Revision Number	Date	Content
Draft	9/18/2010	Project Design Manual Volume 2 - Facilities Design Section 6 - Plumbing
March 2013	March 2013	Project Design Manual Volume 2, Facilities Design Section 6 - Plumbing
September 2014	September 2014	Section 6 - Plumbing
December 2015	December 2015	Section 6 - Plumbing
August 2018	August 2018	Section 6 - Plumbing

This 2018 version was authorized by:

12/20/2018

Denise Edwards PE, Supervisor, Electrical and Mechanical Design — Date

SECTION 6 PLUMBING LOG OF REVISIONS (From the 2010 version)		
Paragraph	**Brief Description of Revision**	**Date**
Global	-Deleted dates for specific standards/codes and referred to the "latest version". -Deleted reference to Vol 5 Standard Details; replaced w/ "Obtain Standard Details from DETS"	
Page 2-6-vi	Added List of Acronyms and Abbreviations	
6.1.2.1 Potable Water	Changed reference of the noted size of the secondary city water connection to the Blue Plains site from 8-inch to 16-inch. Deleted reference to 1996 City Water Protection report.	
6.3	Added requirements for equipment Tag identifications, and showing Tag IDs on drawings, and specifying contractor requirements to provide ID Tags and Maximo IDs.	
6.3.1.4 Safety	Added additional requirements for frost-proof emergency showers and eye-wash units	
Table 2-6-1A	Updated pipe codes	
6.3.2.11 Backflow Preventers	Added reference to the DC Water Cross Connection Control Policy Manual, and added provisions for access and periodic testing.	
6.1.2.2	Show PSW piping on Mechanical Process drawings, not Plumbing drawings.	05/30/2014
6.3	Show tag Ids for valves 1-inch and larger	05/30/2014
6.3.1	Added floor penetrations. Use stainless steel link seals. Use concrete for fire-rated seals. Provide core-drilled holes and non-shrink grout for pipe penetrations.	05/30/2014
6.3.2.1	Avoid wet pipes over electrical rooms and equipment. Provide wash stations for roof mounted equipment.	05/30/2014
6.3.2.3	Referred to Section 5 for valve numbering	05/30/2014
Table 2-6-1	Deleted PSW and SW and referred to Section 5 Added caution against CU pipe in areas w/ H_2S exposure	05/30/2014 10/22/2014
Table 2-6-2	Added caution against CU pipe in areas w/ H_2S exposure	10/22/2014
6.3.2.8	Provide freeze protection for all plumbing.	05/30/2014
6.3.2.9	Added water heater options.	05/30/2014
6.3.2.11	Moved backflow preventer requirements from Para. 6.3.1 to 6.3.2.11 Backflow Preventers	05/30/2014
6.3.3	Fire protection for roof mounted equipment. Referred to Vol 3 for hydrant spacing outside Blue Plains. Added fire protection plan reviews.	05/30/2014 05/30/2014 05/30/2014
6.3.5	Dry air systems to have moisture indicator.	05/30/2014
6.2.1	Requirements for riser diagrams and tabular data	12/02/2015

6.3	Redundancy requirements for critical equipment	12/02/2015
6.3.1	Coordination with site, structural, and HVAC designers	12/02/2015
6.3.1.5	Energy considerations for hot water usage	12/02/2015
6.3.2.2	Hose bibbs on potable water to be served by backflow preventer -Require vacuum breakers for interior spigots and exterior wall hydrants, and conform to ASSE requirements Pipe labeling per DC Plumbing code	12/02/2015 07/26/2018 07/26/2018
6.3.2.11	Added requirements for reduced pressure backflow preventer assemblies -RPZ BFP assemblies to conform to ASSE 1013.	12/02/2015 07/26/2018
6.3.3	-References to NFPA 10, 14, 70, 72, 75, and 2001. -Fire protection criteria in electrical & computer rooms. -Added requirements for standpipe systems. -Deleted requirement for fire hose stations per DC Water - Office of Emergency Management, and DC FEMS.	12/02/2015 12/02/2015 12/02/2015 12/31/2015

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SECTION 6 - PLUMBING
TABLE OF CONTENTS

LIST OF TABLES

ACRONYMNS AND ABBREVIATIONS

ADA	Americans with Disabilities Act
ALB	air, laboratory
ANSI	American National Standards Institute
ARCI	acid resistant cast iron
ARD	acid-resistant drain
ARV	acid-resistant vent
ASME	American Society of Mechanical Engineers
ASPE	American Society of Plumbing Engineers
ASSE	American Society of Sanitary Engineering
AWTP	Advanced Wastewater Treatment Plant
CAD	computer-aided design
CFR	Code of Federal Regulations
CI	cast iron
CISP	cast-iron soil pipe
CLCI	cement-lined cast iron
CLDI	cement-lined ductile iron
CO_2	carbon dioxide
CPVC	chlorinated Polyvinyl Chloride
CU	copper
CW	cold water (potable), city water
D	drain
DC	District of Columbia
DC Water	District of Columbia Water and Sewer Authority
DFU	Drainage Fixture Units
DI	ductile iron
DIW	deionized water, distilled water
DP	design package
DWV	drain-waste-vent copper
FCO	floor clean-out
FD	floor drain
FEMS	(District of Columbia) Fire and Emergency Medical Services
FP	fire protection
FRP	fiberglass-reinforced plastic
GALVS	galvanized steel
H_2S	hydrogen sulfide
HVAC	heating, ventilation, and air conditioning
HW	hot water (domestic)
IBBM	iron body, bronze-mounted
LPG	propane gas (liquefied petroleum gas)
MCC	Motor Control Center
NFPA	National Fire Protection Association
NICET	National Institute for Certification in Engineering Technologies
NPSH	net positive suction head
O&M	operation and maintenance
OS&Y	outside screw and yoke
OSHA	Occupational Safety and Health Act
PDE	Project Design Engineer
PP	polypropylene
psi	pounds per square inch
psig	pounds per square inch gauge
PSW	process and service water (non-potable)
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride
RD	roof drain
RPZ	Reduced Pressure Zone
S	sanitary sewer (gravity)
SDS	Safety Data Sheet
SPD	sump pump discharge
SST	stainless steel
STL	steel
SW	seal water
UA	air, plant utility
V	vent
VAC	vacuum (laboratory)
WCO	wall clean-out

PROJECT DESIGN MANUAL
VOLUME 2 – FACILITIES DESIGN

6. PLUMBING

6.1 GENERAL REQUIREMENTS

The requirements in this section are supplementary to the other applicable requirements included elsewhere in Volumes 1 through 3 of the Project Design Manual, and District of Columbia Water and Sewer Authority (DC Water) Guideline Specifications.

The plumbing requirements outlined in this section are general and apply to all design packages (DP). Specific plumbing requirements for each DP are contained within the individual DP conceptual design reports and will supplement the requirements and guidelines outlined in this section.

This section presents general requirements for the preparation of drawings and design analysis for plumbing systems consisting of water supply, sewage collection, floor drainage, roof drainage, and special waste; fuel gas systems; fuel oil systems; compressed air systems; vacuum systems; laboratory utilities; and fire protection systems.

Plumbing systems will be provided in all buildings requiring plumbing to a point five feet outside the foundation wall. Each project design engineer (PDE) will be responsible for systems located in his DP limits of work. The PDE will coordinate design and layout of his systems with other plant systems and utilities to avoid conflicts in location and alignment. Interaction with PDEs of adjacent DPs and existing as well as planned concurrent construction will be required to confirm design integrity and consistency between work areas.

The plumbing design will incorporate the basic principles of environmental sanitation and safety so that the plumbing systems can be acceptably installed and adequately maintained. All structures to have human habitation will be provided with an adequate supply of safe, potable hot and cold water, which must be protected from backflow, backpressure, or back-siphonage from unsafe or questionable water sources. All drainage systems will be of adequate size and design to guard against fouling, deposit of solids, and clogging. All piping, fixtures and equipment will be of durable material and free of defective workmanship so that they provide satisfactory service and a reasonable expected life.

6.1.1 Plumbing Codes

Plumbing systems will be provided in all buildings requiring plumbing to a point five feet outside the foundation wall and will be designed to conform to the International Plumbing Code, the International Energy Conservation Code, District of Columbia code supplements, and all other applicable regulatory requirements. The PDE is responsible to use the latest editions of all applicable codes, accepted standards, and regulations.

Fuel gas systems will be provided for all buildings requiring fuel gas and will be designed to conform to the International Fuel Gas Code and all other applicable regulatory requirements.

Fuel oil systems will be provided for all buildings requiring fuel oil and will be designed to conform to the International Mechanical Code and all other applicable regulatory requirements.

Fire protection systems will be provided for all buildings requiring fire protection and will be designed to conform to the International Fire Code edition, National Fire Protection Association (NFPA) standards, and all other applicable regulatory requirements.

Laboratory utilities, compressed air systems, and vacuum systems will be provided for all buildings requiring such and will be designed to conform to the applicable NFPA standards, and all other applicable regulatory requirements.

6.1.2 Existing Water System

6.1.2.1 Potable Water

Potable water to the Blue Plains Advanced Wastewater Treatment Plant (AWTP) is supplied through two active connections to the City′s water system. The main 24-inch supply line on the north side of the plant is connected to the City′s system through a check valve and a meter. The secondary supply is through a 16-inch line on the northeast side of the plant and is connected through the water meter only.

The city water system was upgraded in 1994 to improve water supply flow and pressure to the plant. Therefore, an adequate amount of city water at the required pressure is currently available at the plant. The potable water is currently used for showers, sinks, drinking fountains, water closets, urinals, water heaters, eyewash stations and emergency showers. All eyewash/showers shall be designed to discharge 20 gpm for duration of 15 minutes and be supplied with tempered water in accordance with American National Standards Institute (ANSI) Z358.1. Emergency eyewash and showers shall be provided, as appropriate, in all odor control facilities, chemical storage and loading areas as well as chemical mixing and dilution facilities, in all laboratories, and effluent quality test stations. The choice of either eyewash stations, showers or combination eyewash/ shower stations shall be guided by first aid recommendations found in Safety Data Sheets (SDS) for the hazardous material present.

There is no central hot water heating system for the plant. Individual water heaters are typically provided to supply hot water where it is needed. For any system where the developed length along the piping system to the most remote fixture is 50 feet or more, use inline hot water circulation pumps to ensure that the water temperature is maintained at the most remote fixture. Consider electric water heaters mounted under the sink in remote areas such as galleries, screen buildings, electrical buildings, and laboratories.

6.1.2.2 Process and Service Water

Process and Service Water (PSW) is included in Section 5, Mechanical Process of this volume. PSW shall be shown on Mechanical Process drawings, and not on Plumbing drawings.

6.2 FORMATS

6.2.1 Riser Diagrams

Show riser diagrams as isometric drawings. Draw separate riser diagrams for the following items:

- Sanitary drain, waste, and vent
- Hot, tempered and cold water
- Fire standpipe

- Automatic sprinklers
- Storm drain
- Special piping systems that require risers for clarity

The riser diagram will show schematically all components (straight pipe sections, fittings, equipment, valves, devices, fixtures, drains, etc.) and other appurtenances requiring plumbing, together with required utility connections. The schematic will include, where applicable, clean-outs, water hammer arrestors, vents through roof, trap primers, valves, backflow preventers, pumps, and expansion loops.

Drainage Systems

- Riser diagrams for drainage systems shall indicate location (floor level and room number) for each component. Provide unique sequential node numbers for each component starting at the most remote inlet/outlet and proceeding to a junction, sump/tank, or connection to the site supply system. Each branch connected to a junction shall have its own unique sequence of node numbers. Each junction shall have a node number at each inlet and outlet to the junction.
- For roof storm drain systems, each drain shall indicate its horizontally projected roof area (square feet) served. At each junction in the storm drainage system, indicate for each branch, the total accumulated horizontally projected roof area served.
- For sanitary drain-waste-vent systems, each drain shall indicate its Drainage Fixture Units (DFU) and where applicable, its flow rate. At each junction in the drainage system, indicate for each branch the total accumulated DFU. Each vent piping section shall indicate its developed length. Indicate at each junction in the vent system, for each branch, the total accumulated developed length (the sum of all the individual section developed lengths back to the most remote drain) and the total accumulated DFU connected to the drainage system served by that vent.
- Provide sequential tabular entries for each branch and main, listing node numbers (corresponding to the system riser diagram), location, component description, pipe size, material, and DFU. Use a spreadsheet, to be approved by DC Water, for these calculations.
- Note calculation requirements for system components under "Technical Guidelines" of this section.

Supply and Pumped Systems

- Riser diagrams for supply systems and pumped systems (including recirculation systems) shall indicate location (floor level and room number) for each component. Provide unique sequential node numbers for each component starting at the most remote inlet/outlet and proceeding to a junction, pump, or connection to the site supply system. Each branch connected to a junction shall have its own unique sequence of node numbers. Each junction shall have a node number at each inlet and outlet to the junction. The pressure loss for each branch connected to a junction shall balance to within 10 percent of the pressure loss to that point in the system.
- Provide sequential tabular entries for each branch and main, listing node numbers (corresponding to the system riser diagram), location, component description, pipe size, material, flow, length, velocity, and friction loss coefficient or equivalent length for fittings. Use a spreadsheet, to be approved by DC Water, for these calculations.
- Provide catalog cut sheets showing the flow vs. pressure loss relationship for each component (straight pipe sections, fittings, equipment, valves, devices, etc.). Provide the required supply pressure at design flow for any equipment or device. This would include but not be limited to pressure requirements to avoid net positive suction head (NPSH) issues and minimum pressure requirements (both positive and negative) for operation of equipment, fixtures and devices.
- System head curve showing losses and pump curves.

- Note calculation requirements for system components under "Technical Guidelines" of this section.
- Parameters - Consider pipe as ten years in service.

Locate general notes in the upper right-hand corner of drawings. Include fixture numbers for all fixtures. Numbers must correspond to the fixture schedule. Connection sizes to fixtures must correspond to the plumbing fixture schedule. Indicate all pipe sizes in inches (nominal). Vertical pipes, stacks and risers will be numbered and will correspond with plans.

6.2.2 Details

Use DC Water Standard Details, throughout the design in all drawings, figures, and report text descriptions, when applicable. If a standard detail needs to be modified to suit the condition, modification may be done only upon prior authorization by the Authority.

6.2.3 Calculation Requirements

See Section 6.2.1, General, for general requirements for the submittal of calculations. Specifically, provide computations for all systems and equipment required under this section including but not limited to sanitary, cold water, hot water, hot water recirculating, compressed air, gas and vacuum systems, water heaters, air compressors, vacuum pumps, sump pumps, sewage ejectors, circulating pumps, fire pumps, jockey pumps, booster pumps, and pressure regulating and temperature regulating valves.

6.3 TECHNICAL GUIDELINES

Certain criteria related to the systems covered in this section appear elsewhere in this Volume 2 - Facilities Design. In particular, refer to Section 5, Mechanical Process, for design criteria relating to chemical piping and equipment and hangers and supports; and individual DP conceptual design reports for additional requirements and specific criteria.

- All designs shall meet or exceed all applicable codes and regulations including Occupational Safety and Health Act (OSHA) [29 Code of Federal Regulations (CFR)] requirements.
- Conform to the requirements contained in DC Water Drafting Standards (CAD) Manual and all other volumes of the Design Criteria Manual and obtain appropriate standard details and standard specifications from DC Water.
- Consider future expansion in all designs and equipment layouts.
- Follow good engineering practice, as described in American Society of Plumbing Engineers (ASPE) criteria, for systems and conditions not covered in this section.
- Consider both capital and operation and maintenance (O&M) costs in system design and equipment selection.
- Arrange all equipment for ready accessibility for maintenance, repairs and replacement (e.g., maintenance personnel should be able to remove coils and motors without moving other equipment).
- Identify equipment considered critical to sustained system operation or which malfunction thereof could cause system damage or compromise worker health and safety. For such equipment so deemed critical, provide standby equipment or redundancy to allow essential system operation during periods of equipment malfunction or maintenance and to allow alternate operation to extend the useful life of the critical equipment.
- Check all equipment for performance at all operating conditions.
- The PDE shall prepare the project asset classification table and include all required plumbing

equipment assets, descriptions, and the equipment Tag identifications.
- All plumbing equipment and valves 1-inch and larger, shall be identified on the drawings with the Tag identification, and shall be consistent with other discipline drawings.
- Specifications shall require the contractor to provide and install the equipment and valve identification Tags in addition to the manufacturers' nameplates for all equipment. Such information shall be submitted by the contractor for review and approval.

6.3.1 Design Considerations

Key aspects of each plumbing system design must be coordinated with architectural, structural, mechanical process, electrical, instrumentation and heating, ventilation, and air conditioning (HVAC) designers. The design engineer must:

- Coordinate with the architect for the location of valves requiring access panels.
- Coordinate with the architect the provisions for compliance with the Americans with Disabilities Act (ADA).
- Coordinate the size and location of piping chase requirements with the architect to avoid structural members and to ensure piping concealment.
- Coordinate the location of all large pipes with the structural engineer to determine if the structure is sufficient to support the load.
- Coordinate routing of piping with the mechanical, electrical, instrumentation and HVAC engineers to ensure that piping can be installed with process piping and ductwork in the confines provided.
- Coordinate floor and roof drain locations with the architect and structural engineer for proper placement in relation to valleys and low points.
- Coordinate with the architect to ensure adequate ceiling heights in equipment rooms and to ensure door sizes that allow for piping and equipment clearances.
- Coordinate with the Architect to ensure adequate clearance between vent discharges and opening into the building.

Coordinate with the HVAC engineer to ensure adequate clearance between vent discharges and air intakes. Show expansion loops or expansion joints and anchor points on piping requiring expansion compensation; coordinate with the structural engineer. Select accessible locations for points where service lines enter the buildings; coordinate entrance points with the civil engineer, architect, and plant personnel. Coordinate with the site engineer for connection to site supply and drainage systems. Confirm that these utilities have adequate capacity for the additional loads. In particular, confirm that there is adequate flow and pressure at that flow for fire suppression and domestic water systems (including emergency showers and eye washes). Arrange equipment so that there will be a minimum of 3'-0" on two sides between all other major equipment and structures. Locate all equipment on 6-inch high concrete housekeeping pads. All connections to equipment will be made with unions or flanges.

Design and route piping in a manner that will facilitate supporting the piping system. Allow for thermal expansion, flexibility, and an economical pipe support system. In areas, having hung ceilings, install all piping above the hung ceilings.

Provide section isolation valves for partial shutdown during maintenance and repairs.

For pipe penetrations through exterior walls and floors below grade, for floor slabs on grade, or for watertight non-fire rated penetrations, provide sleeves with mechanical elastomeric seals and stainless steel hardware (link seals). For fire-rated barriers, seal both ends of penetrations through fire rated assemblies to maintain fire resistive integrity with UL listed fill, void, or cavity material. Provide gastight seals where required, including through barriers separating classified and unclassified areas. The sleeve must be large enough to accommodate differential movement between the pipe and the structure as well as flanges, hubs, or similar connections. In new construction, sleeves in floor slabs and below grade exterior walls will include a minimum 2-inch high water stop annular ring. In existing concrete, provide core drilled holes grouted with non-shrink grout, smooth and round in lieu of pipe sleeves.

To simplify specifying, purchasing, installation, and maintenance of equipment, provide packaged equipment to the greatest extent possible. Other design considerations are organized below by category.

6.3.1.1 Drainage

- Connect roof and area drain piping to storm drains wherever possible, otherwise discharge in compliance with code.
- Connect floor drain piping to sanitary sewage system.
- Separate interior roof drain piping from the sanitary system inside the building.
- Insulate roof drain piping in areas with very high humidity, or where required to protect adjoining finished surfaces from condensation water damage.
- Do not run piping in electrical and/or control rooms. Do not run directly over Motor Control Centers (MCC).
- Protect all sewer and storm drainage systems against the probability of backflow.
- Provide floor drains in all pump rooms and process equipment areas where water could be present.
- Provide gutters at all exterior walls below grade and at all wet well and tank walls.
- Design all floor slopes to floor drains and gutters; floors will slope at minimum 1/8 inch per foot and gutters will slope at 1/8 inch per foot.
- Provide sump pumps or sewage ejectors, as appropriate, for all drainage piping that cannot be connected to a sanitary sewer by gravity.
- Provide simplex sump pumps for inflows that are not constant.
- Provide duplex sump pumps for inflows that are constant; e.g., drains from pump seal water systems, automatic strainer backwash, and analyzers.
- Provide sump pump and sewage ejector discharge piping with a check valve and isolation valve; locate the valves in the horizontal and as close to the pump discharge as possible; locate the isolation valve after the check valve; provide a lever and weights or springs for check valves 3 inches and larger.
- Provide oil separators in areas where oil leakage may contaminate the floor drainage system.
- Isolate areas with chemical equipment from other areas by curbs; slope floor of the curbed areas to chemical-resistant sump pump installations dedicated to the curbed areas. Locate the sump within the curbed area but accessible from outside the curbed area on at least one side. Size the curbed area to hold the volume of the largest vessel in the curbed area without overflow. Make provisions for pump discharge into trucks in case of tank failure. Do not provide floor drains within diked areas.
- Provide an independent acid waste drainage and venting system in laboratories and other uses where corrosive wastes outside of the range of pH 6.0 to 9.0 will be handled. Neutralize acid waste to a pH of approximately 7.0 before discharging to channels or exterior as appropriate.

6.3.1.2 Water Service

- Provide sufficient wall or yard hydrants for watering of outdoor landscape and cleaning of facility walkways, roadways and outdoor equipment. Make provision to avoid or prevent the use of these hydrants for supplying a process system.

- Provide pressure-reducing valves where water pressure exceeds 80 psi.
- Supply drinking water fountains adjacent to toilet rooms, in eating areas and within 100 feet of office areas, with a minimum of one on each office or work floor.
- Provide in-line water booster pumps to supply increased water pressure for dilution water to chemical equipment.

6.3.1.3 Sanitary Facilities

- Provide handicapped accessible sanitary fixtures where required.
- Provide a floor-mounted mop receptor with a drain and removal strainer plate in each janitor's closet; provide service sinks where space limitations do not permit floor receptors.
- Do not allow exposed sanitary sewer lines and water lines over any food preparation areas including cold storage and dish washing areas and laboratories.
- Provide garbage-can washing facilities.
- Provide floor drains in toilet rooms that have two or more water closets/urinals and in drying areas.
- Provide garbage disposals in lunchroom sinks.

6.3.1.4 Safety

- Sleeve all concealed gas lines within partitions, walls, ceilings, plenums, and chases.
- Provide symbol coding on all piping systems.
- Keep drinking fountains clear of traffic aisles.
- Provide hose stations supplied by the PSW system at areas requiring wash down, i.e., pipe galleries, pump rooms, and all process areas. Hose stations shall be in locations and of quantity necessary to reach all areas with a maximum 50-foot hose. Hose station pipe size shall be appropriate to the service.
- Provide emergency shower and/or eyewash units at chemical fill stations, chemical handling areas, and sludge discharge facilities. All units shall be plumbed type, except self-contained eye wash stations are permitted. Provide dust covers on all eyewash units. Provide frost proof units for all exterior installations and installations within unheated building enclosures. Frost-proof units shall not depend on electric heat tracing, and shall include independent frost-proof shower and eyewash valves. Exterior units installed adjacent to heated buildings may be wall mounted with valve operator extensions from heated spaces for freeze protection, such that valves may be operated from the exterior location of the unit. All units shall be provided with a flow/switch alarm that sends a signal to the plant wide Process Control System for remote safety alarm indication and a local strobe/horn alarm unit for exterior units only, unless otherwise directed.
- Provide 70 degree F tempered water for all deluge showers and eyewash fountains, except those in galleries/tunnels which may be compliant with ANSI Z358.1 with 60 degree F minimum tempered water.
- Provide a tempered water recirculating system for systems serving frost proof units and systems with runs exceeding 50 feet.

6.3.1.5 Energy Use

Provide return-circulating hot water in all buildings that are two or more stories in height and in one-story buildings where horizontal runs exceed 50 feet. The circulation rate must limit the water temperature drop to 10 degrees F in the system. Provide fiberglass insulation on all cold and hot water piping within buildings. This includes potable cold water, hot water, and hot water recirculating; 70 degrees F tempered water, and tempered water recirculating where space temperatures are maintained at 60 degrees F or less (e.g., galleries/tunnels); horizontal rain leaders, and bodies of roof drains. Provide a vapor barrier jacket on all insulation on cold piping. See section titled "Insulation and Heat Tracing" below for additional requirements.

Provide storage tank type water heaters to deliver 140 degrees F potable hot water to mixing valves as well as dishwashers, lab ware washers and other equipment requiring hot water of 140 degrees F or more. Where not integral to equipment, use booster heaters to provide hot water for equipment requiring water in excess of 140 degrees F. Mixing valves shall be used to deliver maximum 120 degrees F hot water to plumbing fixtures unless lower temperatures are directed by the Plumbing Code. Mixing valves meeting ANSI Z358.1 with temperature override protection and cold water bypass shall be used to deliver 70 degrees F tempered water to plumbed emergency eye wash stations and/or showers. Do not supply high water use fixtures (like showers, service sinks, dishwashers or other food preparation fixtures) from the same hot water source as those serving emergency eye wash stations and/or showers. Size hot water heaters serving emergency fixtures to maintain 70 degree F hot water to the emergency fixtures for the entire discharge period required by ANSI Z358.1. Assume that all other fixtures connected to the hot water system are flowing at full capacity and that less than 80 percent of any hot water tank capacity is available before its temperature degrades. If the hot water demand is small, tankless type water heaters may be used. Provide energy efficient water heaters, such as gas-fired condensing type water heaters, wherever possible. Alternate energy sources, such as solar power and waste heat if available, should be considered. The water heater should be located as close as practical to the hot water demand.

6.3.1.6 Miscellaneous

- Provide insulating flanges, couplings and unions wherever nonferrous and ferrous metal piping are connected and wherever cathodically protected ferrous pipes enter buildings or galleries.
- Provide blow-down tanks or blow-down separators for all steam boiler blow-down connections.

6.3.2 Plumbing Systems

6.3.2.1 Piping Applications and Materials

Do not locate any pipes carrying liquids, or subject to condensation, within an electrical control room or over electrical rooms or equipment, except as required for fire protection sprinklers when required by code.

Provide wash water stations at any roof mounted equipment to allow cleaning of equipment to reduce risk of histoplasmosis.

See Tables 2-6-1 and 2-6-2 for plumbing systems materials; and 2-6-3 for floor drains descriptions. Where more than one material is shown for a given service, the choice may depend on size, cost, whether the pipe is exposed or buried, and other factors. The tables are design guides only and are not intended to be used "as is" for the design documents. The PDE shall be responsible for selecting the material and preparing schedules that will be included in the design drawings. The PDE shall ensure that the use of the design guides is in conformance with the applicable codes and the regulatory requirements.

Table 2-6-1. Plumbing Services, Pipe Codes, Materials

PIPING MATERIAL CODES	
Code	**Piping Material**
ARCI	Acid resistant cast iron
CI	Cast iron
CISP	Cast-iron soil pipe
CLCI	Cement-lined cast iron
CLDI	Cement-lined ductile iron
CPVC	Chlorinated Polyvinyl Chloride
CU	Copper
DI	Ductile iron
DWV	DWV copper
GALVS	Galvanized steel
PP	Polypropylene
PVC	Polyvinyl chloride
SST	Stainless steel
STL	Steel

Table 2-6-1. Plumbing Services, Pipe Codes, and Materials (continued)

LEGEND AND PIPE MATERIALS		
Service	**Code**	**Materials**
Acid-Resistant Drain	ARD	ARCI, PP, PVC
Acid-Resistant Vent	ARV	ARCI, PP, PVC
Air, Laboratory	ALB	CU*
Air, Plant Utility	UA	CU*, STL
Cold Water (Potable), City Water	CW	CLDI, CU*
Deionized Water, Distilled Water	DIW	PVC
Drain	D	CISP, DWV
Fire Protection	FP	CLCI, CLDI, STL
Hot Water (Domestic)	HW	CU*
Propane Gas (Liquefied Petroleum Gas)	LPG	STL
Roof Drain	RD	CISP, DWV, CLDI
Sanitary Sewer (Gravity)	S	CISP, DWV
Sump Pump Discharge	SPD	CLDI
Vacuum (Laboratory)	VAC	CU*
Vent	V	CISP, DWV

Note: For process service water and seal water, refer to Section 5 – Mechanical Process, of this Design Manual Volume 2.

* Do not use copper piping in areas subject to H_2S exposure, such as in Preliminary and Primary Treatment areas

Table 2-6-2. Plumbing Materials List

System	Material - Pipe Or Tube	Fittings	Joints
1. Drainage Systems			
Hubless CI Piping	CISP, service wt., no-hub	CISP, service wt., no-hub end	No hub, with neoprene sealing sleeve and heavy duty stainless steel clamps
Hub and Spigot CI	CISP, service wt., hub and spigot ends	CISP, service wt., hub and spigot ends	Hub and spigot, rubber gasket or lead and oakum
Type DWV	Tube: Wrought CU See Note 4	Wrought CU, Type DWV soldered joint ends	95-5 soldered Joints
Sanitary drain-waste-vents within buildings, above slab • 1½ -inch and smaller • 2-inch through 6-inch • 8-inch and larger	PVC Hubless CI Hub & spigot CI		
Sanitary drain-waste-vents within buildings, under slab buried • 2-inch and larger	Hub & spigot CI		
Roof drains, within buildings, above slab • 3-inch through 6-inch • 8-inch through 15-inch • 16-inch and larger • special architectural treatment	Hubless CI Hub and spigot CI DI Type DWV CU. See Note 4		Mechanical
Roof drains, within buildings, under slab, buried • 3-inch through 15-inch • 16-inch and larger	Hub and spigot CI DI		Mechanical
Roof drains, RD-1, applications	CI, dome-top with gravel stop (J.R. Smith 1010) for all roofs		
Secondary (emergency) roof drains, RD-1 (where required by code)	CI, dome-top with gravel stop (J.R. Smith 1800)		

Table 2-6-2. Plumbing Materials List (continued)

System	Material - Pipe Or Tube	Fittings	Joints
2. Acid-Resistant Drainage Systems			
Polyvinylidene (PVDF) or Polypropylene (PP) Systems	PVDF or PP, Sch. 40	PVDF or PP, Sch 40, Socket type	Above slab Fusion welded, stainless steel mechanical joint clamps, or flanged joints. Buried Fusion welded
Acid-Resistant CI Piping	High silicon CI, hubless ends		Hubless, mechanical
Acid-Resistant Drain Locations and types • Between floor and ceiling lines • In furred ceilings • In ground	PVDF or PP PVDF, PP or acid-resistant CI PVDF, PP or acid-resistant CI		
Acid -Resistant Drainage Vents	Match fittings to the attached system.		
Neutralization/Dilution Tank	PP or chemical stoneware tank charged with limestone between acid waste system and sanitary waste piping.		
Gasoline and Sand Trap	See Note 2		
Grease Interception	See Note 3		
3. Gutter Drains			
	Std. CI bell fitted with hub strainer		

Notes:

1. Neutralize and dilute acid wastes in the tank to protect sanitary drainage piping.
   Provide gasoline and sand trap between all drainage piping in garage and maintenance areas and the sanitary sewer.
2. Provide grease interceptors for the drainage system serving any kitchen or cafeteria equipment that will introduce any grease into the drainage system.
3. Traps on gutter drains to be addressed on a case-by-case basis.
4. Do not use copper piping in areas subject to H2S exposure, such as in Preliminary and Primary Treatment areas.

Table 2-6-3. Floor Drains

Floor Drain No.	Application	Description
FD-1	General purpose finished area or shower drain; not for process areas	J.R. Smith 2010-A-B
FD-2	General purpose process areas; general washdown or rainfall	Heavy duty, round, tractor grate, indoor or outdoor; J.R. Smith 2120
FD-3	General purpose process areas, general washdown of scum or sludge areas	Heavy duty, round, tractor grate; J.R. Smith 2140
FD-4	Funnel type for low-flow equipment drains	Round, tractor grate, 6-inch round funnel; J.R. Smith 2140 w/3581
FD-5	Floor sink type for high-flow equipment drains,	12-inch round, 2 grate; J.R. Smith 3060
FD-6	Trench drain, slotted rectangular tractor grate, truckways	J.R. Smith 2710
FD-7	General purpose, laboratory and chemical areas	Acid-resistant, round, polypropylene construction; Enfield F4000
Hub Strainers	Gallery gutter drains, soil pipe grates	Tyler 547

Note: In process areas, use large floor sink type, stainless or enameled cast iron drains without traps. Vent end line and turn discharge end down into sump to below water surface for “line trap”. Traps on individual drains in sludge areas embedded in base slabs shall not be used. For new sludge areas, consider trench drains.

6.3.2.2 Water Systems

Plumbing water systems consist of potable and non-potable systems. Potable water systems consist of cold water, hot water, hot water recirculation, tempered water (70 degrees F) and tempered recirculation water systems. Non-potable water systems consist of PSW, hot service water, and seal water systems and are included in Section 5 - Mechanical Process. No hose bibs shall be on the potable water systems except where required to drain potable water systems and equipment. Where non-potable water is not available, hose bibbs for exterior landscaping or washdown, shall be served through a reduced pressure zone backflow preventer.

Potable water systems will connect to the city water supply system for the site and will service all plumbing fixtures and equipment that will not contaminate the water system by any backflow of liquids or other substances that are harmful for human consumption.

Non-potable water systems will connect to the potable water systems through approved reduced-pressure zone backflow preventers and will service selected process equipment, washdown hose stations, and other equipment that would contaminate the potable water supply. Seal water will be provided from seal water units that will be of size and capacity appropriate to the pumps to which they are connected. The service water system will supply the units.

Provide a strainer upstream of water meters, backflow preventers, check valves, control valves, and similar accessories. All exterior wall hydrants shall have integral vacuum breaker conforming to American Society of Sanitary Engineering (ASSE) 1019; and all interior spigots shall have vacuum breakers conforming to ASSE 1011. Label all pipes in accordance with District of Columbia (DC) Plumbing Code 608.8. Install labels and flow direction arrows in 5-feet intervals, with colors dark blue with white lettering for potable, and yellow with black lettering for non-potable.

6.3.2.3 Valves

See Table 2-6-4 for valve selections. See Section 5 – Mechanical Process for valve numbering guidelines.

Table 2-6-4. Valves

Type	Size	Model and/or Ends	Body Material
Gate	2" and smaller 2½" and larger	Screwed, union bonnet, rising stem Flanged, OS&Y	Bronze IBBM
Globe	2" and smaller 2½" and larger	Screwed, union bonnet, rising stem Flanged, OS&Y	Bronze IBBM
Check	2" and smaller 2½" and larger	Screwed, swing type Flanged, swing type, outside lever and weight or spring for sump, pump and sewage ejector discharge	Bronze IBBM
Plug	2" and smaller 2½" and larger	Screwed Flanged	Iron Iron

6.3.2.4 Hose Valves

See Table 2-6-5 for hose valve selections.

Table 2-6-5. Hose Valves

Application	Use	Description
HG-1	3/4-inch hose gate valve for all washdown applications; for use with service water indoors	Garden hose thread, 11-1/2 threads per inch; Jenkins 372N
WH-A	Wall hydrant, for use with service water outdoors	3/4-inch inlet and outlet nonfreezing type, garden hose thread, 11-1/2 threads per inch; J.R. Smith 5610

6.3.2.5 Hoses and Nozzles

Specify adjustable hose nozzles for each hose.

6.3.2.6 Hose Racks

Provide a hose rack for each hose gate. Provide each hose rack with 50 feet of 3/4-inch hose. Use wall-mounted, stanchion-mounted, or handrail-mounted hose racks according to needs.

6.3.2.7 Nozzle Flows and Pressures

Design water distribution systems to provide a flow of 28 to 36 gpm at 50 to 80 psig for 3/4-inch wash down water nozzles using a 50-foot hose. Requirements for service water are provided in the mechanical section of this design manual, (Section 5).

6.3.2.8 Insulation and Heat Tracing

In general, design plumbing piping with freeze protection assuming facility is out of service and no process heat is present. However, verify this criterion with DC Water for each project, whether located at Blue Plains or off-site. Minimum insulation thickness for plumbing piping will be 1-inch fiberglass. The insulation will comply with the following federal specification: HH-1-558B (Form D, type III, Class 12).

Pipe covering will have a maximum flame-spread rating of 25 and a maximum smoke development rating of 50, in accordance with Federal Standard No. 00136B.

All insulation will be neatly covered with pasted-on, re-wettable glass fiber cloth jacket, pre-sized, with paintable surface.

Protect insulated pipe within 5 feet of floor by sheet aluminum jacket, minimum 0.016-inch thick.

All valves and fittings will be insulated and covered with preformed fitting covers. The following piping will be insulated and electrically heat traced:

- Exposed exterior piping containing liquid subject to freezing.

- Buried exterior piping containing liquid subject to freezing to a minimum of 6 inches below the frost line.

Heat-traced piping must meet the following criteria:

- Minimum design outdoor temperature: 0 degrees F
- Maximum design wind velocity: 50 mph

Allowance should be made for additional feet of piping to be heat-traced where valves and fittings are located in the piping.

6.3.2.9 Hot Water Systems

Provide hot water for all fixtures and equipment requiring hot water. In general, water heaters having an outlet temperature of 140 degrees F will provide hot water. Provide hot water booster heaters to increase the water temperature from 140 degrees F to 180 degrees F where required (e.g., dishwashers).

Provide field adjusted thermostatic or mixing shower valves set for maximum 120 degrees F water temperature.

Provide water that is tempered to 70 degrees F for all emergency eyewash/showers. Tempering will be accomplished by blending 140 degrees F hot water and cold water with a thermostatic mixing valve, similar to a Powers No. 430 regulator. Use a 15-minute emergency eyewash/showers demand rate to size the hot water heater to which the tempered water system is connected. Apply a diversity factor when three or more emergency fixtures serving the same hazard on the same floor level are on one hot water heating system.

For water heaters with less than 120-gallon capacity, use glass-lined steel, vertical water storage heaters of the commercial/industrial type, depending on burner size desired and energy budget requirements. For heaters with greater than 120-gallon capacity, use glass-lined or cement-lined steel, vertical or horizontal water storage heaters of the commercial or industrial type. If feasible based on life cycle costs, consider using a demand type tankless water heater.

6.3.2.10 Clean-Outs

Table 2-6-6. Clean Outs

Application	Use	Description
FCO-1	Finished floor clean-out	Round, nickel bronze top and screwed plug inside; J.R. Smith 4028
FCO-2	Unfinished floor clean-out	Round, cast-iron tractor cover and screwed plug inside; J.R. Smith 4248
WCO	Wall clean-out for finished wall application to concealed drain	Stainless shallow cover with countersunk plug; J.R. Smith 4472

6.3.2.11 Backflow Prevention

Protect potable water lines inside the buildings from contamination. Provide reduced pressure zone backflow preventers in piping connected to potable water lines and supplying to the HVAC equipment, chemical solution equipment and other potential sources of contamination. Backflow preventers and appurtenant drains shall be located above finished ground level to avoid submergence, or above finished floor elevation, in accordance with the DC Water Cross Connection Control Policy Manual (available on www.dcwater.com) Do not locate backflow preventers in any room or area subject to flooding even if that room or area is above grade.

Refer to the DC Water Cross Connection Control Policy Manual backflow prevention requirements. Specify that each reduced-pressure zone-type backflow preventer assembly shall conform to requirements of the ASSE 1013, consisting of two spring-loaded check valves; spring-loaded, diaphragm-actuated, a reduced pressure zone with drain, differential-pressure relief valve; two shutoff valves; and necessary test cocks and test kit. Consult with DC Water's Compliance Program to determine which, if any, manufacturer's models are preferred, or compatible with existing facilities, or for which DC Water maintains an inventory of parts. Backflow prevention assemblies shall be located in a manner providing easy access to accommodate regular periodic inspections and testing, and have appropriate test cocks and valves for regular periodic testing.

6.3.2.12 Plumbing Fixtures

The architectural drawings will indicate the number and locations of plumbing fixtures for various types of facilities. Fixtures and toilet accessories such as towel bars, mirrors, and soap dispensers will be part of the architectural work. Provide utility sinks in main mechanical equipment rooms, general repair shops, and paint shops. Plumbing fixtures will be in accordance with all applicable codes.

6.3.2.13 Plumbing Schedules

On the plumbing drawings, include a plumbing schedule showing the following connections to each plumbing fixture, as applicable:

- Cold water service size
- Hot water service size
- Waste connection size
- Vent connection size
- Special service connection size

6.3.3 Fire Protection Systems

Automatic fire suppression systems will be designed in accordance with state and local building codes, District of Columbia fire code, and all applicable NFPA codes, including but not limited to, NFPA 72 *National Fire Alarm Code,* NFPA 10 *Portable Fire Extinguishers,* NFPA 75 *Protection of Information Technology Equipment,* NFPA 2001 *Clean Agent Fire Extinguishing Systems,* and NFPA 70 *National Electrical Code.* Fire protection shall also be predicated on the insurance requirements established by the Authority. The guidelines described in this section apply to automatic fire suppression systems.

All structures shall be completely protected by sprinkler system. Exceptions to this requirement are pipe galleries, electrical rooms, control rooms, and computer areas. Pipe galleries will not be provided with fire suppression systems insofar as other code compliant design approaches are possible, e.g., sufficient egress.

Electrical Rooms

The plumbing PDE shall coordinate design of fire protection systems with the project architect and electrical designer. NFPA 13 states that sprinkler protection shall be required in electrical equipment rooms, unless all of the following conditions are met:

- The room is dedicated to electrical equipment only.
- Only dry-type electrical equipment is used.
- Equipment is installed in a 2-hour fire-rated enclosure including protection for penetrations.
- No combustible storage is permitted in the room.

Check with the local fire department for their requirements. Electrical rooms shall be equipped with smoke detectors. Where sprinklers are installed, hoods or shields installed to protect important electrical equipment from sprinkler discharge shall be non-combustible. Consider using pre-shaped flat tiles to cover conduits and cable trays for fire protection of electrical cables and equipment. Requirements for fire protection of special high-voltage equipment, circuit breaker panels, and transformers, etc., are found in NFPA 70.

Regulatory mandates notwithstanding, preference is to avoid application of water on an electrical fire. Consider using a multipurpose fire extinguisher. When an electrical room must have sprinkler by code, typically provide a fixed-temperature heat detector for the room, and a manual pull station in close proximity, separately zoned at the fire alarm control panel, to alert occupants of fire at an early stage. Sprinklers should be 212- or 286-degree temperature rated to avoid sprinkler discharge in the event of a high (closed room) temperature increase. Provide head guard protection for the sprinklers to avoid accidental discharge.

Control Rooms and Computer Areas

Control rooms and computer areas shall be provided with a gaseous-based automatic fire suppression system meeting all applicable codes. The primary function is to provide protection for sensitive and valuable assets within the enclosure. While an automatic carbon dioxide (CO_2) flooding system will stop any fire, avoid the sole use of CO_2 due to lethality in confined spaces and equipment damage due to toxicity and conductivity. Consider using a clean agent fire suppression system, such as Inergen, FM-200, or Sapphire as a safer alternative. Inergen is a blend of argon, nitrogen, and CO_2 that extinguishes a fire by safely lowering oxygen content below the level necessary for continuation of combustion. Calculate the room volume to determine exactly how much agent (or percent of $C0_2$ gas) will be required for (normally) ten minutes of total flooding. In addition to high system cost, the downside of clean agent systems for these applications is the stringent requirement of intact enclosures with doors shut and external ventilation completely sealed prior to agent discharge.

If the room volume is less than 800 cubic feet, and ceiling height not exceeding 12 feet, a single self-contained “Cease Fire” overhead fire extinguishing system unit may be considered. Formerly referred to as “halon balls,” these EPA- and FM-approved cylinders are designed for single-room protection, activate automatically, and flood the room with a non-toxic blended powder and gas agent or Halon 1301 (the halon type which is still environmentally safe). They are rechargeable and require no piping. This type of protection is endorsed in NFPA 101.

The PDE shall research alternative systems for each DP and coordinate the requirements with the local fire department throughout the design process i.e., from conceptual stage to final completion stage. The PDE will provide design criteria, piping details, and specifications for all automatic fire suppression systems. Final design of automatic fire suppression systems will be provided by a qualified contractor and his licensed fire protection professional engineer or National Institute for Certification in Engineering Technologies (NICET) Level III or IV designer certified in the type of systems to be designed. Water-based sprinkler systems shall include exterior fire department connections, tamper and flow switches, and in-line test connections.

Standpipe Systems

Provide standpipe systems whether or not required by the Building Code. Where not required by code, comply with the following minimum requirements:

- Coordinate with DC Water regarding whether fire hose stations and/or fire hose valves are desired at each building egress, each stairway landing, on building roofs, or in galleries. DC Water has no firefighting capacity, does not train employees to handle fire hoses, and has removed all 1.5-inch fire hoses previously installed in facilities. The DC Fire and Emergency Medical Services Department (FEMS) has indicated it would not use any existing DC Water equipment in a fire response. NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* restricts Class II systems for use by trained industrial fire brigades.
- Determine whether a wet or dry standpipe will be required to meet code and insurance requirements.
- Coordinate with the site utilities designer to determine if any modifications of existing water distribution infrastructure may be required for adequate flow capacity and pressure for proposed standpipe systems.
- Verify that no fire pump shall be required provided that the standpipes are capable of a minimum 250 gpm at 65 psi to the topmost floor in buildings equipped throughout with an automatic sprinkler system, or a minimum of 500 gpm at 65 psi to the topmost floor in all other buildings, from the lowest level of fire department vehicle access.
- Avoid the need for fire pumps as much as possible.

Building Roofs

Any building roof that has equipment located on it shall have a freeze protected fire water connection. Verify requirements of the building code, the local fire department, and DC Water regarding requirements for any hose stations, valves, and valve sizes. Valves should be located within 150 feet reach by hose around all rooftop equipment. Provide multiple fire hose valves where required.

Hydrants shall be located not more than 50 feet from fire department connections. Outside the Blue Plains AWTP area, hydrants shall be provided in accordance with Volume 3 – Infrastructure Design.

The types of fire protection to be considered include:

- Wet-pipe, dry-pipe, deluge, and/or pre-action sprinkler systems
- Indoor hose cabinets (subject to verification)
- Dry chemical extinguishers

- Wet chemical extinguishers
- Yard hydrants
- Clean agent fire suppression systems (gaseous)

The protection of yard and storage areas will depend on the nature and types of materials stored in nearby buildings.

During concept finalization stage of the design process, consult with local fire departments and the Authority fire underwriters to be sure that their requirements and suggestions are addressed in the design. Pre-final design submittals will be submitted by DC Water for third party plan reviews for fire protection.

6.3.4 Fuel Oil Systems

6.3.4.1 Fuel Dispensing System

The following standards apply to gasoline and diesel oil storage and dispensing systems for motor vehicles, construction equipment, street sweepers, and portable fuel cans.

Provide separate gasoline and diesel oil dispensing systems for garage/maintenance facilities. Because gasoline is a NFPA 30 class I flammable liquid with a vapor pressure over 1.6 psia, the underground storage system must include a vapor recovery system. Diesel oil is a class II or Class IIIA combustible liquid with a vapor pressure less than 1.5 psia and does not require a vapor recovery system. Provide separate storage and dispensing systems for each grade or type of fuel to be dispensed. Follow design recommendations in the ASPE Data Book Volume II to the greatest extent possible.

Fuel dispensers will be the commercially available type, with a self-contained electric motor and pumping unit, or the remote pumping type, where the pump and motor are located in the storage tank. Flow rates will be a minimum of 10 gpm. Each dispenser must be metered, and be fitted with fume suppression and recovery equipment that meets all applicable codes.

6.3.4.2 Fuel Storage

Fuel will be stored in underground, double-wall, horizontal tanks made of fiberglass-reinforced plastic (FRP). The total amount of storage capacity in each dispensing system will be approximately twice the capacity of all vehicle fuel tanks, by grade or type of fuel. However, the minimum storage capacity for any grade or type of fuel will be 5,000 gallons.

Locate the tanks so that the truck or transport making the product delivery shall need a minimum amount of maneuvering. Avoid designs that require vehicles to back up. The driveway grade should be such that the truck will drain properly.

If the tanks are installed below the groundwater table or if they may become buoyant as a result of a rise in the water table, they must be anchored. The tanks must not be in contact with or embedded in concrete and should be located an adequate distance from adjacent structures that might impose loads on the tank walls.

6.3.4.3 Liquid Fuel Piping

Use standard-weight black iron pipe for fuel piping. Pump manufacturers' recommendations for pipe size should be considered. Gasoline piping will be approximately 18 inches below grade at the pump island. Vent piping will be at least 12 inches below grade at the terminal end and slope uniformly toward the tank without sags or traps in the pipe in which liquid can collect.

Provide strainers, check valves, swing joints, flexible connectors, fill connections, sounding line, and adapters, as required for proper system operation. Enclose fill connections in concrete boxes with removable covers. Provide corrosion protection for the piping system as required.

6.3.5 Compressed Air System

The compressed air system, if needed, shall consist of a duplex-tank-mounted, reciprocating-air compressor unit of the air-cooled, lubricated, non-oil-free, package type. Each compressor will be a 125-psi unit of suitable capacity to satisfy the system demand. The system will include all pipe, fittings, valves, hoses, couplings, filters, air-drying component pressure regulators, and connections to equipment requiring compressed air. The air-drying equipment may have to be of extraordinary precision and deserves special attention during design. Air receivers will be American Society of Mechanical Engineers (ASME)-rated. Use standard-weight black steel with threaded, malleable iron fittings for pipe. Use globe-type valves. Certain applications, e.g., instrumentation, may require dry air for proper operation. Provide desiccant type dryers or refrigerant type dryers with non-corrosive coated coils for these applications. Any compressed air system producing dried air shall be provided with a moisture indicating system.

6.3.6 Laboratory

Sinks, cupsinks, hoods, faucets, traps, and outlets will be provided with the laboratory furniture and equipment in addition to an acid waste and vent piping system, including acid neutralizing sump for the laboratory. Provide potable hot and cold water for the sinks and equipment, tempered water (70 degrees F) for emergency shower and eyewash units, and gas piping for the laboratory outlets. The gases will include compressed air, vacuum, and bottle gas. The laboratory air compressor and vacuum pump will be included with the laboratory equipment.

6.3.7 Fuel Gas Systems

A 16-inch main conveys a supply of natural gas to the Blue Plains AWTP, is used for process as well as other heating requirements. Propane gas is used in the laboratory. All gas piping systems shall be designed to conform to the applicable local and national codes. The propane gas containers shall be secured on concrete pads and provided with weather hoods. Gas piping will be black steel pipe with wrought-iron threaded fittings. Valves will be plug cocks for gas service.

6.4 MAINTAINABILITY CONSIDERATIONS

All floor gratings and drains shall be constructed of materials suitable to resist corrosion from chemicals likely to be in the area.

Floor penetrations in floors above the lowest floor level are to have a concrete curb or stainless steel sleeve at least 8-inchs high to prevent liquid on the floor from running down the floor penetration.

Provide securely-mounted equipment guards for couplings, belts, chain drives, extended shafts, and exposed moving parts.

Provide, to the maximum extent practical, similar pieces of equipment furnished by the same manufacturer to maintain uniformity.

The minimum clear space around equipment shall be as required by applicable codes, recognized industry standards of good practice, or 3 feet, whichever is greater. Maintenance access requirements, especially on large equipment, shall be taken into account when establishing the layout. Maintenance access shall consider the need to completely remove each piece of equipment at some future time.

Arrange equipment and piping to prevent tripping hazards.

Equipment that must have periodic service is to be located at a convenient height.

Allow walking access to all process equipment without having to climb over or crawl under pipes, electrical conduits, or other obstructions.

Provide convenient access to adjustment points, test points, and filling and draining points on all equipment.

Arrange equipment so that access to malfunctioning equipment does not require the disassembly of adjacent equipment.

Ensure that ample clearance is provided in hazardous areas for personnel encumbered by protective equipment.

Maintain a minimum of 10-feet vertical clearance from the floor to the centerline for all piping that may impact equipment access. Piping that would limit personnel access shall have a minimum of 7’-6” vertical clearance above the floor. Ductwork and piping that drops to low levels around 5’-5” to 6’-4” for short stretches of less than 15 feet of length, shall be painted red during those stretches, to warn people of head bumping hazard.

Pumps and other equipment and associated pipes and fittings are to be orientated so maintenance workers are not drenched when the equipment is opened.

All wetted equipment (pumps, control valves, etc.) shall have valve configuration to allow isolation and removal of equipment.

If control valves or instruments have bypass lines to allow removal of device, the bypass line is to have two isolation valves, one on each end of the bypass line. Connection from each isolation valve to the bypass line is to be flanged to allow removal of the bypass section if desired.

Locate floor drains in upper rooms so that drainage piping passing through lower rooms shall not be above chemical tanks, or electrical equipment.

Leave adequate clearance at pipe flanges, unions, couplings, and valves to facilitate disassembly of piping.

Allow ample space for access to and maintenance of valve operators. Provide adequate clearances for rising stem and valves in all positions.

Include drain and vacuum relief connections to allow pipes to be drained.

All liquid cooling lines shall have a visible means to easily confirm flow.

All bolts used in piping flange connections are to have positive means to prevent loosening of the bolts in service.

Any piping section that does interfere with the removal or service of equipment shall be capable of being isolated by valves, then drained, and removed in convenient pieces.

All underground piping shall have clean out connections to allow removal of blockages.

All piping shall be routed to avoid interference with the removal or service of equipment.

All manual valves shall have identification labels or tags attached that are readable and legible from the nearest operating work surface. The labels shall be corrosion resistant and/or ultraviolet resistant based on the location of the valve. Provide numbers and colors in accordance with DC Water requirements.

All air and gas piping shall be sloped to a low point and a valved drain provided.

For all pressurized piping (not including gravity drains), branches from supply headers shall be provided with a valve within 12 inches of the branch connection to allow isolation of the branch.

Sump pumping stations shall be located in all below grade areas. Sumps and pumps shall be located and configured to allow for convenient maintenance of both sump and pumps.

Strategically place manual valves such that dead legs are minimized. Provide manual air relief on dead legs and high points in the pipelines and pipe the air release to the nearest drain.

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DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY
(DC Water)

"SERVING THE PUBLIC - PROTECTING THE ENVIRONMENT"

PROJECT
DESIGN MANUAL
VOLUME 2 - FACILITIES DESIGN

SECTION 7 - HEATING, VENTILATION AND AIR CONDITIONING

August 2018

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AUTHORIZATION FORM

Revision Number	Date	Content
Draft	9/18/2010	Project Design Manual Volume 2 - Facilities Design Section 7 - Heating, Ventilation and Air Conditioning
Draft	3/30/2012	Project Design Manual Volume 2 - Facilities Design Section 7 - Heating, Ventilation and Air Conditioning
Draft	9/16/2014	Project Design Manual Volume 2 - Facilities Design Section 7 - Heating, Ventilation and Air Conditioning
Draft	12/30/2014	Project Design Manual Volume 2 - Facilities Design Section 7 - Heating, Ventilation and Air Conditioning
Draft	12/31/2015	Project Design Manual Volume 2 - Facilities Design Section 7 - Heating, Ventilation and Air Conditioning
August 2018	08/02/2018	Section 7 - Heating, Ventilation and Air Conditioning

This 2018 version was authorized by:

12/20/2018

Denise Edwards PE, Supervisor, Electrical and Mechanical Design — Date

SECTION 7 HEATING, VENTILATION, AND AIR CONDITIONING LOG OF REVISIONS (Revisions from 2010 version)		
Paragraph	**Brief Description of Revision**	**Comments / Date**
Global	Deleted dates for specific standards/codes and referred to the "latest version".	
7.3 TECHNICAL GUIDELINES	Added reference to Energy Savings Plan. Added requirement for HVAC design workshop with DC Water	
7.3.1 Design Conditions	Clarified outdoor design conditions, and referenced ASHRAE 55 and NFPA for indoor design criteria.	
7.3.3 Piping Systems	7.3.3.1 Added details for use of glycol for freeze protection	
7.3.4.2	Duct Systems – Materials. Updated acceptable duct work materials options.	
7.3.4.7	Hangers and Supports – Added preferred epoxy adhesive type anchors for equip/ducts subject to vibration	
7.3.5 Heating Systems	- Deleted diesel and No. 2 fuel oil backups for heating and hot water boilers - Clarified heating coil provisions for make-up air - If pump speeds > 1,750 rpm are needed for high heads, DC Water approval is required. - Added provision for coatings for coolant lines & components, & approval by DC Water Facilities.	
7.3.6 Ventilation Systems	7.3.6.1 DC Water Facilities to approve the type and arrangement of proposed equipment.	
7.3.7 Air Conditioning Systems	7.3.7.2 Added coating requirements for pressurized coolant lines and components	
7.3.8 Energy Recovery Systems	7.3.8.1 Added provision for access and inspections for preventive maintenance	
7.3.9 Control Systems	7.3.9.1 Added name of preferred brand of automatic controls for systems operated 24- hours without supervision	
7.3.10 Operations and Maintenance	Added new Para. 7.3.10 to address O&M, costs, training, spare parts, warranties, etc.	
7.3.11 Equipment Asset Tag Identifications	Added requirements for equipment asset classification, and Tag IDs, and contractor provision of ID tags and Maximo numbers.	
Acronyms & Abbreviations	Added AHU, NEBB, NFPA, and PCS	05/30/2014
7.1	Added inter-discipline coordination items	06/04/2014
7.3	Added direction to specify O&M training requirements.	05/30/2014

7.3	Addressed use of HVAC Integrator	05/30/2014
7.3.2	Added National Environmental Balancing Bureau	05/30/2014
7.3.3.1	Required safety warnings for low headroom; Clarify pressure-regulating valves and control valves; Pipe drains to be according to pipe size and length	05/30/2014
7.3.3.2	Added criteria for piping in corrosive applications	06/04/2014
7.3.3.5	Changed expansion tanks from diaphragm to bladder type; Provide automatic air vent at air separators; Provide strainers upstream of all control valves	05/30/2014
7.3.3.6	Provide SST or PVC insulation jackets in corrosive areas	06/04/2014
7.3.4.1	Limitations on use of flexible duct; Address ductwork located with reduced headroom; Avoid ductwork condensation over electrical room & equipment	05/30/2014
Table 2-7-1	Change refrigerant piping to stainless steel	05/30/2014
7.3.4.5	Parallel blade dampers in AHU mixing boxes	05/30/2014
7.3.4.6	Added reference to energy code	05/30/2014
7.3.5.2	-Deleted cast iron sectional type boiler requirement, to allow other types including energy efficient boilers. -Added hot water boiler location criteria. -Units to be sized for heat transfer capacity inclusive of the applied protective coating on coils	06/04/2014
7.3.6.1	Added H_2S scrubbers and positive pressure required in rooms with PCS equipment	05/30/2014
7.3.7.1	Catch pan and drain for cooling coil condensate	05/30/2014
7.3.7.2	Cooling lines to have visible flow indication	05/30/2014
7.3.8.2	Clarified glycol solution is propylene glycol	05/30/2014
7.3.9.1	BAS/BMS connection to be with Honeywell BAC-Net open sources	
7.4	Added criteria to facilitate maintainability.	06/04/2014
Acronyms & Abbreviations	Added AWTP, SCADA, DC Water, SCH, ASTM, DCU, RIO, OWS, BAS, and BMS. Added ACH, AFU, CFM, MUAU, Pa, RTU	09/19/2014 10/14/2015
7.1	Coordinate HVAC design with other design disciplines	12/21/2015
7.2.3	Calculations submittal rqmts for piping and duct systems	10/14/2015
7.3	- Do not locate AFUs in ceilings, but floor-mounted or outside. - Isolation valves and dampers for all HVAC equipment.	10/14/2015 10/14/2015

7.3	- Requirements for operational redundancy, secondary power, PCS monitoring, and capacity for portable equip. - Backup shall not require emergency generator.	12/21/2015 12/21/2015
7.3.1	-Revised HVAC design conditions per ASHRAE climate data. - Account for infiltration load but avoid overdesign.	10/14/2015 12/21/2015
7.3.2	Added NFPA 45 and NFPA 850	10/14/2015
7.3.3.1	Added criteria for backflow prevention. Referenced DC Water Cross-Connection Control Policy Manual	10/14/2015 12/21/2015
7.3.3.2	Requirements for corrosion protection for all air stream coils. Do not use CSST gas supply pipe, due to safety issues.	10/14/2015 12/30/2015
7.3.4.1	-Added design requirements for duct systems. -Provide dirt legs in ducts to protect fans.	10/14/2015
Table 2-7-1	Deleted fuel oil. Added Natural Gas piping and valves.	10/14/2015
7.3.4.2	Insulate roof mounted and other exterior ducts	10/14/2015
7.3.4.3	Added reference to ASHRAE fitting database	10/14/2015
7.3.4.5	Duct systems in hazardous areas & noise-sensitive areas	10/14/2015
7.3.4.7	Duct support rqmts; Ref. to SMACNA standards & seismic rqmts	10/14/2015
7.3.5.1	Heating and hot water system requirements. Separate process and domestic hot water systems.	10/14/2015
7.3.5.2	- Multi-stage systems; heating coils coatings & warranties - Locate thermostats at operator eye-level. - Check for available HVAC equip extended warranties.	10/14/2015 11/17/2015
7.3.5.3	Layout of unit heaters & heat exchanger pumps	10/14/2015
7.3.6.1	Criteria for ventilation air feeds and return locations, and for corrosive atmospheres.	10/14/2015
7.3.6.2	Equipment sizing conservatism factor and duct leakage allowance; ventilation equipment warranties	10/14/2015
7.3.7.1	Added AC design conditions for humidity and temperature	10/14/2015
7.3.7.2	Check for AC equipment extended warranties	10/14/2015
7.3.8.1	Switch-over procedures for energy recovery systems	10/14/2015
7.3.8.2	Energy recovery equipment sizing. Energy savings calculation method. Design for degraded heat transfer.	10/14/2015
7.3.9	HVAC control systems requirements	10/14/2015
7.1	-stated preference for HVAC equip manufactured by Trane or Carrier. -Coordinate with the DC Water Mechanical Shop for review to make sure all required items are included in the HVAC design.	08/02/2018

7.3.7.1	Provide heat-gain calculations for meeting required cooling tonnage for electrical equipment served.	08/02/2018
7.3.9	BAC-Net controller to be integrated and tested by a controls contractor	08/02/2018
7.4	Roof-mount installations to meet safety rqmts. Safety rails on roof to be coord w/ roof mfgr to maintain roof warranty.	08/02/2018

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SECTION 7 - HEATING, VENTILATION AND AIR CONDITIONING TABLE OF CONTENTS

LIST OF TABLES

ACRONYMNS AND ABBREVIATIONS

ACH	air changes per hour
AHU	air handling unit
AFU	air filtration units
AMCA	Air Moving and Conditioning Association
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASTM	American Society for Testing and Materials
AWTP	Advanced Wastewater Treatment Plant
BAS	Building Automation System
BMS	Building Management Systems
BTU-in/hr-ft^2	British thermal units – inches per hour – square feet
CAD	computer-aided design
cfm	cubic feet per minute
CH_4	methane
CSST	corrugated stainless steel tubing
CW	chilled water
DC Water	District of Columbia Water and Sewer Authority
DCU	distributed control unit
Deg	degree
DP	design packages
FM	Factory Mutual
fpm	feet per minute
fps	feet per second
FRP	fiberglass reinforced plastic
H_2S	hydrogen sulfide
HVAC	heating, ventilation and air conditioning
HW	hot water
IBC	International Building Code
ICC-ES	International Code Council Evaluation Service
kW	kilowatt
mph	miles per hour
MUAU	makeup air units
NEBB	National Environmental Balancing Bureau
NFPA	National Fire Protection Association
NG	natural gas
NPSA	net positive suction head
O&M	operation and maintenance
OSHA	Occupational Safety and Health Act
OWS	Operator Work Station
Pa	Pascal
PCS	Process Control System
PTFE	polytetrafluoroethylene / Teflon
PVC	polyvinyl chloride
RG	refrigerant
RIO	remote input/output
RTU	Roof Top Units
SCADA	Supervisory Control and Data Acquisition
SCH	Schedule
SEER	seasonal energy efficiency ratio
SMACNA	Sheet Metal and Air Conditioning Contractors
UL	Underwriters Laboratories

PROJECT DESIGN MANUAL
VOLUME 2 – FACILITIES DESIGN

7. HEATING, VENTILATION AND AIR CONDITIONING

7.1 GENERAL REQUIREMENTS

The requirements outlined in this section are general and apply to all design packages (DPs). Specific heating, ventilation, and air conditioning (HVAC) requirements for each DP are contained within the individual DP conceptual design reports and will supplement the requirements and guidelines outlined in this section.

Coordinate HVAC design with other design disciplines including, but not limited to:

- Architectural, for building thermal envelope parameters, fire, smoke and access separation requirements, space requirements for HVAC equipment, and louver sizes/performance parameters.
- Structural engineering, for HVAC equipment weights, and large floor and roof opening sizes and locations.
- Process engineering, for equipment heat dissipation and make-up air requirement for blowers and compressors. For mechanical process requirements, see Section 5, Mechanical Process.
- Plumbing engineering, for HVAC drainage requirements, cold water make-up requirements, and HVAC fuel gas requirements.
- Electrical engineering regarding space pressurization to satisfy electrical classification, electrical equipment heat dissipation, HVAC power requirements, HVAC signal connections to Supervisory Control and Data Acquisition (SCADA), and HVAC controls trade limits.

DC Water has a stated preference for equipment manufactured by Trane, Inc. or Carrier Corporation since they are found locally and have parts available.

The PDE shall have the program manager to invite the DC Water Mechanical Shop to the HVAC design workshop, and present the HVAC design for DC Water review to make sure all required items are included in the design.

7.2 FORMATS

7.2.1 Flow Diagrams

Provide flow or process diagrams for HVAC systems. Flow diagrams must be clear and show all equipment, ductwork, piping, dampers, and valves. Label all ductwork and piping. Label all equipment with proper tag numbers. Show all instrument and control devices with tag numbers. Demonstrate a fully balanced system.

7.2.2 Standard Details

Use DC Water Standard Details throughout the design in all drawings, figures, and report text descriptions, when applicable. If a standard detail needs to be modified to suit the condition, DC Water must provide authorization prior to any modifications.

7.2.3 Calculation Requirements

See Section 1, General, of this Volume, for general calculation requirements. Additionally, conform to the following requirements:

- Provide psychometric chart for air conditioning process.
- Provide pressure loss calculations for piping and duct in accordance with American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Fundamentals Handbook and the following parameters.
- Provide a single-line drawing showing all components of the system under consideration in the design and construction drawing sets. Provide a copy of the drawing with the calculations and update it for each design submittal. The drawing shall conform to the following requirements or equivalent method pre-approved by DC Water. Drawing shall indicate location (floor level and room number) for each component. Provide unique sequential node numbers for each component (straight pipe or duct section, fitting, equipment, valves, devices, etc.) starting at the most remote inlet/outlet and proceeding to a junction, pump, or fan. Each branch connected to a junction shall have its own unique sequence of node numbers. Each junction shall have a node number at each inlet and outlet to the junction. The pressure loss for each branch connected to a junction shall balance to within 10 percent of total loss of the higher of the branches with balancing valves/dampers completely open. The higher value should be carried forward in the calculations.
- Include sequential tabular entries, for each branch and main, listing node numbers corresponding to the system drawing, location, component description, pipe or duct size, material, flow, length, velocity, and friction loss coefficient or equivalent length for fittings.
- Provide catalog cut sheets from at least three manufacturers showing the flow vs. pressure loss relationship for each component (straight pipe or duct section, fitting, equipment, valves, dampers, devices, etc.). Provide the required supply pressure at design flow for any equipment or device.
- Calculations must demonstrate compliance with the more stringent criteria of ASHRAE handbooks and criteria stated herein under "Technical Guidelines".
- For manual or spreadsheet calculations for piping and duct systems, submit proposed format, including assumptions and formulas, for DC Water approval. For computer software calculations, refer to Section 1.3.4 Computer Calculations in Section 1 of the Design Manual.
- Specifications shall require that any changes made during construction be shown on the as-built or record drawings supplemented with revised single-line drawings and calculations performed by a Professional Engineer.

Piping Systems - Required Elements:

- Calculations shall account for required and available net positive suction head (NPSH) and minimum pressure requirements (both positive and negative) for operation of equipment and devices.
- Consider pipe as ten years in service, and adjust for fluid characteristic when glycol is used.
- Provide system head curve showing losses and pump curves.

Duct Systems - Required Elements:

- Base fan sizing on 110% of the required air flow to account for duct leakage. On larger systems and those with large plenums consider increasing this duct leakage rate.
- Sequential tabular entries shall include available ASHRAE fitting numbers in the description, plus size, length, section airflow, airflow velocity, pressure, accumulated pressure loss, pressure loss

coefficient, fitting loss, and inlet/outlet losses etc.
- A plot of system curve, overlaid on the fan performance curve for the selected fan.

7.2.4 Design Criteria Documentation for Future Reference

Document the design conditions for each space on tables in spreadsheet format so that the information is available to those who may occupy or visit the space well after the design and construction are complete. Information required includes, but is not limited to:

- Name of space
- Design temperatures
- Ventilation
- Relative humidity
- Noise
- Equipment description and operational strategy (e.g., two fans in continuous operation, one stand-by fan)

7.3 TECHNICAL GUIDELINES

This section presents general requirements and design criteria for HVAC and related systems.

- All designs shall meet or exceed all applicable codes and regulations including Occupational Safety and Health Act (OSHA) requirements, and including, but not limited to, those listed in paragraph 7.3.2.
- Conform to the requirements contained in DC Water Drafting Standards (CAD) Manual and all other applicable volumes of the Project Design Manual.
- Consider future expansion in all designs and equipment layouts.
- Comply with criteria in accordance with ASHRAE standards, including systems and conditions not covered in this section.
- Consider both capital and operation and maintenance (O&M) costs in system design and equipment selection.
- Arrange all equipment for ready accessibility for maintenance, repairs and replacement, e.g., maintenance personnel should be able to remove coils, tube bundles and motors, without moving other equipment. **Air Filtration Units (AFU) shall not be located in a ceiling, but shall either be floor mounted with cartridge filters or located outside with bulk media.**
- Provide Isolation valves upstream and downstream of all equipment including but not limited to pumps, control valves, coils, heat exchangers, boilers, etc. This applies to all equipment whose non-operation or removal would allow short circuiting of the flow. Locate strainers, check valves and flex coupling in between isolation valves. Arrange piping and valves so that each piece of equipment as referenced above can be completely isolated from the system without affecting the remainder of the system (see redundancy requirements later in this manual).
- Provide Isolation dampers upstream and downstream of all equipment including but not limited to fans (both supply and exhaust), air handling units (AHUs), makeup air units (MUAU) (whether connected to duct or not), roof top units (RTUs) (whether connected to duct or not), AFU, scrubbers etc. This applies to any equipment whose non-operation or removal would allow short circuiting of the flow. Locate filters, backflow dampers and flex coupling in between isolation dampers. Arrange ductwork and dampers so that each piece of equipment as referenced above can be completely isolated from the system without affecting the remainder of the system (see redundancy requirements

later in this manual). As part of the design process, consider the economic feasibility of using a separate dedicated system instead of relying on the dampers. Low leak isolation dampers shall have leakage no greater than 4 cfm per square foot at 4-inch water column pressure differential.

- Provide redundant operational capacity for HVAC systems providing: air changes used to downgrade the classification of an area within a building or a whole building; supply to Electrical rooms and control rooms; service to below grade areas including but not limited to tunnels and basements; service to OSHA-defined confined spaces; and service to process areas ≥ 3000 sq ft, and to chemical use/storage areas ≥ 200 sq ft.
- At Blue Plains, HVAC is typically not tied into the Process Control System (PCS); however, if HVAC air changes are used to lower the classification of an area within a building or the whole building, then the air flow is required to be monitored by PCS and redundancy of the air system is required, and an alarm is required at a constantly manned location if air flow stops or is reduced.
- For HVAC in critical areas, and where air changes are used to lower the classification of an area within a building or the whole building, provide secondary feed or backup power to the critical installed HVAC equipment. At Blue Plains Advanced Wastewater Treatment Plant (AWTP), such backup power shall not depend on an emergency generator. Provide capability to connect portable HVAC equipment matching the same size as the installed equipment, including supply and exhaust/return capacity.
- Redundant operational capacity shall allow essential system operation during periods of equipment malfunction or maintenance, shall allow alternating equipment operation to extend the useful life of the equipment, and shall be capable of maintaining all design values (air flow, temperature, humidity, etc.) during a design day with the largest single piece of equipment isolated from the system. Examples of redundant systems are an air system with two 100 percent AHUs or a heat exchanger system with three 50 percent units or four 34% parallel pumps.
- Check all equipment for performance at all operating conditions.
- Specify proper testing procedures, for equipment and systems. Include acceptance criteria and requirements for a balanced air and water system in the specification.
- Specify training requirements for O&M of the equipment and systems.
- Selection of equipment shall be in accordance with the DC Water Energy Savings Plan

During the design process, designers shall attend a separate workshop on HVAC design with DC Water and present detailed design, process, operations, control concepts, maintenance requirements, and preliminary estimates of maintenance costs for all HVAC equipment. During the workshop, discuss with DC Water and determine if a designated HVAC integrator is desired to be provided by the construction contractor. The HVAC system integrator would be responsible to coordinate and calibrate the operations of the HVAC components and controls subsystems to ensure that those subsystems function together. If DC Water decides to require an HVAC integrator, then determine required credentials and whether such credentials shall be submitted as part of the construction bid package or submitted for approval by DC Water after contract award.

Certain criteria related to the systems covered in this section appear elsewhere in the Project Design Manual. In particular, refer to Volume 2, Section, Mechanical Process, for design criteria relating to chemical piping, equipment, and hangers and supports; and individual DP conceptual design reports for additional requirements and specific criteria.

7.3.1 HVAC Design Conditions

Design HVAC systems to meet the following outdoor design conditions:

Temperatures (per ASHRAE climate data)		
Winter	0°F	
Summer	Office and administrative areas: 1.0% - 92°F (dry bulb) - 76°F (wet bulb)	Process areas using outside air for cooling: 100°F (dry bulb) 81°F (wet bulb)

Wind Speed (per ASHRAE climate data)	
Average	11 mph (Summer) 11 mph (Winter)
Prevailing Direction	S (Summer) NNW (Winter)

All electrical rooms shall be air conditioned to a maximum indoor temperature of 85 degree Fahrenheit assuming an outside air temperature of 100-degree F dry bulb/ 81-degree F wet bulb.

Flow rate for ventilation cooling (using outside air only) shall be based on a maximum temperature rise of 5-degree F.

In process areas excluding control rooms, break rooms, conference rooms, restrooms/ locker rooms and other normally occupied areas, the indoor winter design temperature shall be 55-degree F, unless directed otherwise by DC Water.

Blue Plains may experience outdoor temperatures from zero to over 100 degrees F, and winds over 50mph (43 knots). Some buildings may have significant infiltration load. For cases where wide bay doors are left open for extended periods, and since most HVAC computer calculations do not account for these high infiltration loads, consider the economic feasibility of upsizing equipment where indoor design temperatures are 55 degrees F and outdoor temperatures are predominantly above 18 degrees F. However, do not over design for large doors left open, as HVAC design should be based on doors normally closed.

ASHRAE 55, *Environmental Conditions for Human Occupancy*, and National Fire Protection Association (NFPA) provide indoor design criteria that shall be used for DC Water projects unless stated otherwise in this manual.

7.3.2 Codes and Standards

It is the Project Design Engineer's (PDE's) responsibility to confirm the appropriate applicable codes, standards, and regulations to be used for each project, including but not limited to the latest versions of the following codes and standards:

- Air Moving and Conditioning Association (AMCA), Park Ridge, Illinois
- American Conference of Governmental Industrial Hygienists. *Industrial Ventilation: A Manual of Recommended Practices*
- American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE)/ American National Standards Institute (ANSI)/ASHRAE Standard 62.1. *Ventilation for Acceptable Indoor Air Quality*
- American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc (ASHRAE). *Handbook Series*
- Associated Air Balance Council, Washington, D.C.
- International Building Code and District of Columbia Building Code Supplements
- International Code Council, International Mechanical Code
- Manufacturers' Standardization Society of the Valves and Fittings Industry, Falls Church, Virginia
- National Environmental Balancing Bureau (NEBB), Gaithersburg, Maryland
- National Fire Protection Association (NFPA). *Codes and Standards*
    - NFPA 45 *Fire Protection for Laboratories Using Chemicals*
    - NFPA 820 *Fire Protection in Wastewater Treatment and Collection Facilities*
    - NFPA 850 *Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations*
- Sheet Metal and Air Conditioning Contractors National Association (SMACNA). *HVAC Duct Construction Standards - Metal and Flexible*

7.3.3 Piping Systems

7.3.3.1 Piping Design Considerations

Design and route piping in a manner that will facilitate supporting the piping system. Design piping to provide for thermal expansion, flexibility, and an economical pipe system.

Piping connections into piping systems of different service ratings will conform to the specifications of the higher service rating up to and including the first isolation valve. Use unions or flanges to make all connections to equipment. No vertical or horizontal loads shall be applied to the equipment in a static state as a result of the layout and support system. For wall penetrations, provide mechanical elastomeric seal (link seal) for wall sleeves. Provide gas-tight seals where required. The sleeve must be large enough to accommodate flanges or other connections.

All connections to the city water system shall be through a “Reduced Pressure Zone Backflow Preventer.” Refer to the DC Water Cross-Connection Control Policy Manual. A double check backflow preventer is not acceptable. The backflow preventer and the discharge from the reduced pressure zone shall be above finished floor level and above the flood level. Do not locate the backflow preventer below grade or in an area subject to flooding.

Make piping runs as short and direct as possible. Do not run piping through electrical rooms or above any electrical equipment, motors, or motor control centers. Arrange piping to provide for access to equipment and valves to facilitate both normal maintenance of the equipment and removal of the equipment if needed for maintenance and inspection.

Provide the following minimum headroom clearances:

Process areas, galleries, and buildings	8'-0"
General Yard areas	12'-0"
Main access roads	15'-0"

Specific requirements of the facility and/or equipment will dictate the clearance requirements. Provide higher clearances where required. If circumstances require reduced headroom which presents a safety hazard, provide appropriate permanent safety warnings.

Provide bypass piping with manual globe valves for all pressure regulating valves. Three-way control valves should have balancing valve in bypass line. See section 7.3 Technical Guidelines above for additional isolation and redundancy requirements. Locate all frequently operated valves, instruments, control valves, relief valves, or other equipment such that it is conveniently accessible from grade, finished floor, or operating platform. All relief valves will be hard-piped to a floor drain and discharge through an air gap above the flood rim of the drain. Provide an extension stem or chain wheel operator for valves located 6'-6" above the operating level. Chains will clear the operating level by a minimum of 3'-6".

Provide all low points with a drain and hose connection, sized as appropriate for the size and length of pipe being drained but in no case less than 3/4-inch size, and design piping systems to provide complete drainage of piping and equipment. Provide all high points of lines with a manual valve, vent, nipple, and threaded cap, all sized as appropriate for the size and length of pipe being vented but in no case less than 3/4-inch size.

Where required for freeze protection, 30 percent propylene glycol solution with corrosion inhibitors shall be used. The solution shall not be clear, but shall have dye characteristics to facilitate inspections for leaks in the system. Fill stations shall be provided for addition of the solution, and stations shall provide protection of the solution against external contamination. The propylene glycol solution specified shall be compatible with all hydronic components in system including but not limited to boilers, terminal units, pumps, and heat exchangers. A nameplate shall be posted for easy access and reference of the system, including propylene glycol ratio, flow, etc. Heat transfer capacities and flow rates specified shall accommodate the presence of propylene glycol solution heat transfer medium.

The HVAC designer will coordinate the design of direct buried underground heat distribution piping with the geotechnical engineer to ensure adequate drainage and to prevent water damage to piping or insulation.

Provide piping schedules on the construction drawings.

7.3.3.2 Piping Construction Materials

The construction materials for the various HVAC piping systems are shown in Table 2-7-1. Provide dielectric unions and flanges at joining of dissimilar piping materials. For all DC Water facilities, all coils used in air streams shall be protected with a factory-applied corrosion-resistant coating on both interior and exterior surfaces (e.g., unit heaters, fan coil units, air handling unit-heating and cooling, convectors, cabinet heaters and air conditioning evaporators and air-cooled condensers). Coatings shall be BlyGold PoluAl XT or approved equal. Coating applicator must be manufacturer certified or qualified. **Coating submittal must be reviewed by DC Water Facilities HVAC personnel for final approval prior to shipping to the project site.**

Because of potential susceptibility to nearby lightning strikes and a number of potentially related explosions and fires, do not use corrugated stainless steel tubing (CSST pipe) for gas supply lines. The NFPA, the International Building Code (IBC), and several fire protection research organizations have published technical literature addressing CSST safety issues. This restriction does not apply to flexible stainless steel gas appliance connectors.

For areas subject to corrosive atmospheres and in corrosive soil, all piping shall have suitable surface preparation and paint or coating including the pipe surfaces of insulated piping (beneath the insulation). In lieu of painting or coating, series 300 stainless steel pipe may be used where appropriate and allowed by code. For areas with corrosive atmospheres and in corrosive soil, all pipe insulation jackets shall be of suitable material for the needed corrosion resistance and the jackets sealed air tight. For areas with corrosive atmospheres, all pipe hangers, rods, fasteners, supports, and building attachments shall have DC Water approved paint or coating or be of series 300 stainless steel.

7.3.3.3 Piping Design Criteria

The velocity for hot and chilled water piping is as follows:

Minimum	2 fps
Desirable	5 fps
Maximum	8 fps

The maximum allowable pressure loss is 4 feet of water per 100 feet of pipe.

For steam, condensate, and gas piping, follow the guidelines given by ASHRAE handbooks.

The velocity for refrigerant piping is as follows:

Type of Line	Minimum Velocity (fpm)	Maximum Velocity (fpm)
Suction Line		3,500
Horizontal	500	
Vertical	1,000	
Hot Gas Line		3,500
Horizontal	500	
Vertical	1,000	
Liquid Line	N/A	300

7.3.3.4 Piping Pressure-Loss Calculations

See paragraphs 7.1 and 7.2.

7.3.3.5 Piping Valves and Appurtenances

The valve types to be used for the various HVAC piping systems are shown in Table 2-7-1. Use swing check valves in a horizontal position only. Use bladder-type expansion tanks on all closed-loop piping systems. Locate expansion tanks on the suction side of the pump. Provide automatic air vent at air separator for all systems and place air separator at hottest water point in piping system. Install Y-type strainers with 40-mesh screens in all pump suction lines, and upstream of all critical control valves, and provide a manual blow-off valve. Balancing valves, if used as shut-off valves, shall have a memory device to return to original balance point. See paragraph 7.3 Technical Guidelines above for additional isolation and redundancy requirements

7.3.3.6 Piping Insulation and Heat Tracing

Minimum insulation thicknesses for HVAC system piping will be as shown in Table 2-7-1. The minimum insulation thermal conductivity will be:

- 0.25 Btu-in/hr-ft^2- degrees F at 75 degrees F

All valves and fittings will be insulated and covered with preformed fitting covers. Vapor barrier jackets are required on all chilled water and insulated refrigerant lines. The following piping will be insulated and heat-traced:

- Exposed exterior piping containing liquid subject to freezing
- Buried piping which is installed above the frost line

Use the following criteria for design of heat-traced piping:

- Minimum design outdoor temperature: 0 degrees F
- Maximum design wind velocity: 50 mph

Allowance should be made for additional feet of piping to be heat-traced where valves and fittings are located in the piping. Provide aluminum jacket protection for pipe insulation exposed to mechanical damage. Provide minimum 0.020-inch-thick stainless steel jacket protection or minimum 30 mils polyvinyl chloride (PVC) jacket protection in areas subject to corrosive atmosphere. Choice of material shall be as appropriate for the atmosphere. Provide jacketing seal continuously applied to all joints in the jacket for an air-tight seal.

7.3.4 Duct Systems

7.3.4.1 Duct Design Considerations

Design and route duct systems in a manner that will facilitate proper support. Arrange systems to provide access to dampers for maintenance and removal or replacement. See paragraph 7.3 Technical Guidelines above for additional isolation and redundancy requirements.

Use of flexible duct shall be limited to 3-feet maximum per supply air diffuser branch duct, pulled taut with no kinks and no more than one 90-degree turn equivalent. Flexible duct shall not be permitted elsewhere.

Use round duct wherever possible. When using rectangular duct, the duct aspect ratio should not exceed 4:1 except where necessary, but in no case more than 6:1.

Use the minimum number of fittings possible. Include volume dampers at all branches from main trunks and at any other locations, as required for system balancing. Use nonmetallic flexible connections for all connections to equipment.

Include a minimum of three duct-diameters straight duct at fan inlets and outlets. If this is not possible, use an inlet box for fan inlets. Where elbows must be used at fan inlets, they will have a minimum radius-to-diameter ratio of 2.5. At other duct locations, use elbows with a radius-to-diameter ratio of not less than 1.5. Where space does not permit, provide turning vanes.

Provide pitot tube traverse flow measurement stations for all fans in hazardous areas. Ventilation systems serving hazardous areas classified under the provisions of Article 500 of NFPA 70 shall incorporate fans fabricated in accordance with AMCA Type A or Type B spark-resistant construction.

All mechanically ventilated spaces (areas) governed by NFPA 820 shall be served by both supply and exhaust fans. The project drawings shall clearly state the space's electrical classification (per NFPA 820 and NFPA 70), the minimum air changes per hour (ACH) and the associated air flow rate in cfm to maintain that classification. Ventilation rates shall be based on air changes per hour and shall be calculated based on the maximum aggregate volume, under normal operating conditions, of the space to be ventilated. Air changes per hour shall be based on 100 percent outside supply air, which shall be exhausted.

In general, Dual ventilation rates in accordance with NFPA 820 for NFPA 70, Class I, Division 1 and Division 2 areas are not allowed due to concerns about maintaining combustible gas detectors and accurately determining when a space is occupied. The reduced air flow rate would significantly impair the ability of completely scavenging all portions of the spaces to prevent short-circuiting and to promote the effective removal of both heavier- and lighter-than-air gases and vapors. Hourly personnel will enter most spaces requiring the design ventilation rate and for more than half of the year the supply temperature will be above 50F again requiring the higher ventilation rate. These conditions significantly reduce the benefits of a dual ventilation system and when coupled with the added cost and complexity of a dual ventilation rate system make it a poor option.

Spaces of different classification shall be physically separated by a gastight partition between the two spaces (whether adjacent or nonadjacent), with no means of gas communication between the spaces. Personnel entry to the separate spaces is by individual, grade-level exterior access ports with no physical connection between the two. The gastight partitions required to separate spaces of different classification shall be clearly shown on the drawings. Ventilation systems shall not transfer air between unclassified interior spaces and classified interior spaces. Ducts shall not cross interior boundaries between areas of different classification. Refer to NFPA 820 including Appendix A for additional information on separation requirements.

Ventilation systems serving unclassified areas adjacent to classified areas shall maintain a differential pressure relative to ambient air pressure of 25 Pa (0.1 in. water column) under all operating conditions. Ventilation systems serving classified areas shall maintain a differential pressure relative to ambient air pressure of −25 Pa (−0.1 in. water column) under all operating conditions.

Ventilation systems for hazardous areas that are designed to operate intermittently or only when the space is occupied shall not be permitted to be used for the purpose of downgrading the electrical classification of areas. Ventilation systems serving areas governed by NFPA 820 shall receive power from electrical equipment that receives power from a primary power source and that also has the means to accept power from alternate power sources. Minimum requirements for the means to accept the alternate source of power shall include connectors that are designed to connect to devices such as standby generators, portable generators, uninterruptible power supplies, and so forth. Automatic or manual switching to a permanent alternate source of power shall also be permitted. Power failure of the primary source shall be alarmed.

Contract drawings shall clearly locate means of alternate source of power for HVAC equipment, staging area for portable generator (if required), and access to each connection point.

Table 2-7-1. HVAC PIPE MATERIALS AND APPURTENANCES

System Designation		Piping			Insulation		Valving			Remarks
System	**Service**	**Material**	**Schedule/ Class**	**Joint Type**	**Type**	**Pipe Size/ Thickness (Inches)**	**Block**	**Check**	**Throttling**	
CW	Chilled Water	Carbon steel	SCH. 40	≤ 2.5" Screwed > 3" Welded	Fiberglass or elastomeric closed cell	<= 1"/ 0.5"> 1" / 1"	Gate	Swing	Globe	
NG	Natural Gas	Carbon steel	SCH 40	≤ 2.5" Screwed > 3" Welded	--	______	Ball or plug	--	______	Buried Pipe: ASTM D2513 PE Pipe, 100 psig working pressure, max 11.5 SDR, fusion-welded joints.
HW	Hot water	Carbon steel	SCH. 40	≤ 2.5" Screwed > 3" Welded	Fiberglass or elastomeric closed cell	<= 1"/ 0.5">1" / 1"	Gate or ball	Swing	Globe	
RG	Refrigerant	Stainless Steel, seamless	ASTM A312, Type 316	welded	Polyurethane foam or elastomeric closed cell	<= 1"/ 0.5"> 1" / 1"	---	---	---	

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The minimum duct clearance to any wall, floor, or ceiling will be 2'-0".

Minimum headroom clearances for ducts are as follows:

Process areas, galleries, and buildings	8'-0"
General yard areas	12'-0"
Main access roads	15'-0"

Ductwork shall be located as much as possible to avoid obstructions or interference to operations staff and maintenance personnel. Ductwork that suddenly drops to less than 6’ 8” (standard door height) above finished floor for short stretches of less than 15 feet in length shall have safety flagging or highly visible paint colors to warn personnel of headspace hazard.

Ductwork which is subject to condensation shall not be located over electrical rooms or equipment. Provide all low points of duct carrying moist air (i.e., odor control system duct) with 3/4-inch nonmetallic PVC drain valves. In all exhaust systems where any air inlet to the system is in an area warmer than any portion of the ductwork up to and including the fan (or system exhausting moist air or subject to condensation), protect the fan with a dirt leg and drain. The dirt leg shall be ½ the diameter of the duct up to 12” diameter, 6” for up to 24” ductwork, and 8” for larger duct. The dirt legs shall be located as close as possible to the fan suction in order to collect all potential condensate without entering the fan scroll. In addition, provide dirt legs at all locations where the ductwork is subjected to a rise or drop. The dirt legs shall be located at the low point (base of rise or drop) of the ductwork. Drain valves shall be hard-piped to a floor drain or sump and discharge through an air gap above the flood rim of the drain. For duct that carries exhaust air from kitchen hoods or any other area where grease is present, use welded seams and provide fire suppression sprinkler systems as required by NFPA. Design system in accordance with NFPA 96.

Use sound traps or acoustical duct liner to minimize equipment noise in sensitive areas such as administration and office areas. Ducts must be adequately reinforced to prevent pulsations and noise caused by duct pressure changes.

7.3.4.2 Duct Construction Materials

Design duct systems to withstand the maximum pressure (positive or negative) that may be imposed by any fan in the system. System pressure classification and duct construction will be in accordance with the following, as applicable:

- Latest edition of applicable SMACNA standards
- National Bureau of Standards, PS 15-69
- NFPA-91, Reinforced Thermosetting Plastic Ducts

The preferred material of duct construction for non-corrosive and non-moist air applications is filament wound fiberglass reinforced plastic (FRP). Approval by Factory Mutual (FM) and Industrial Risk Insurance is required. Acceptable alternatives, if approved by DC Water, may include aluminum or 316 stainless steel, for use in the following areas:

- Administration areas, offices, and conference rooms where no corrosive air, moisture or contaminants are expected in the duct.

- Electrical rooms where the majority of the air is recirculated and no corrosive air or contaminants are expected in the duct.

In odor control systems, and applications where high temperatures or corrosive gases may be present, FRP is acceptable, subject to fire-rating requirements, and Hastelloy™ is a good option. However, polytetrafluoroethylene (PTFE/Teflon) lined 316 stainless steel is considered the best option, based on its durability, low coefficient of friction, and resistance to corrosion, high temperatures, chemicals, and odors. PTFE can also be used with aluminum and steel alloys. **Do not use zinc-coated steel (galvanized) duct under any circumstances.**

7.3.4.3 Duct Design Criteria

The equal friction or static regain method shall be used to size the duct. Maximum friction drop will be equal to 0.15 inches water column per 100 feet of duct. Maximum duct velocities shall be as follows:

Area	Maximum Duct Velocity (fpm)
Administration, laboratories, offices, and lunch rooms	1,500
Pump stations, galleries, process areas, maintenance areas, and warehouses	1,800

Use duct roughness factors and fitting friction-loss coefficients in accordance with the full ASHRAE fitting database (note that the fittings listed in the handbooks are abbreviated and incomplete; use the full ASHRAE fitting database), SMACNA guidelines or manufacturer's data. Base friction-loss values for louvers, coils, and other equipment on manufacturers' data. Include a copy of such data in the design calculations.

7.3.4.4 Duct Pressure-Loss Calculations

See Section 7.2.3, Calculation Requirements, of this section.

7.3.4.5 Duct Dampers and Appurtenances

Dampers will be constructed of the same material as the ducts in which they are installed. All dampers will be AMCA-certified.

Locate all frequently operated dampers conveniently accessible from finished floor or an operating platform. Provide all dampers with a position indicator visible from the operating level. All dampers except balance dampers shall be automatically operated by electric actuators. Design electric actuators to power open and power close the damper. Except for installation in an Engine/Generator Room, **do not use spring returns.** Locate the control station at the operating level and within sight of the damper position indicator. Use parallel blade dampers for applications requiring two-position control and in air handling unit mixing boxes. Use opposed blade dampers for applications requiring modulating control. All dampers shall be low leakage type.

Fire dampers must be provided in the ductwork to stop the spread of fire from one fire zone to another. Provide fire dampers and access panels in accordance with NFPA and local building codes.

Convergent transitions will slope 30 degrees; divergent transitions will slope 15 degrees.

Whenever the duct system is conveying dirt-laden or grease-laden air, provide sufficient access doors to allow cleaning and inspection of entire duct system. Provide fire protection sprinklers as required by NFPA and local codes. To facilitate servicing, provide access doors at filters, heating and cooling coils, and dampers.

At air inlets and outlets, air distribution shall be uniform. Coordinate the location of air distribution devices with the architectural features of the space, the equipment layout, the lighting layout and the sprinkler layout. For heat removal from spaces such as electrical rooms, locate air inlets above and as close to heat-producing equipment as possible. Air shall be introduced into and exhausted from hazardous areas in a manner that will encourage scavenging of all portions of the spaces to prevent short-circuiting and to promote the effective removal of both heavier- and lighter-than-air gases and vapors, such as hydrogen sulfide (H_2S) and methane (CH_4).

Whenever possible, terminals should be located over areas less sensitive to noise, such as corridors, storage rooms, etc. Quiet air terminals facilitate the location of terminals over unoccupied space as with these units larger zones are possible resulting in fewer terminals, reduced first cost, and improved energy efficiency.

- The use of lined duct work or manufacturers' attenuators downstream of air terminals can help attenuate higher frequency discharge sound. Flexible duct (used with moderation) is also an excellent attenuation element.
- Sound may be reduced when appropriate fan speed controllers are used to reduce fan rpm rather than using mechanical devices to restrict airflow. This form of motor control is often more energy efficient.
- The air terminal and the return air grille location should be separated as far as possible. Radiated sound can travel directly from the terminal through the return air grille without the benefit of ceiling attenuation.
- Designing systems to operate at low supply air static pressure can reduce the generated sound levels, provide more energy efficient operation, and allow the central fan to be downsized.
- Sharp edges and transitions in the duct design should be minimized to reduce turbulent airflow and its resulting sound contribution.
- Maximum velocity through system components will be as follows:

Component	Maximum Velocity (fpm)
Intake louvers	600 through free area
Exhaust louvers	800 through free area
Heating coils	600
Cooling coils	500
Dehumidifying coils	450

7.3.4.6 Duct Insulation

Comply with the following or with local advanced energy code, if applicable, whichever is more stringent:

Insulation is required on the following ducts:

- Ducts carrying cooled air for air conditioning applications.
- Return air ducts in ceiling plenums of air conditioned spaces.
- Ducts where moist air being carried by a duct could condense if the duct passes through cool spaces.
- Boiler breeching, flue, and smoke pipe connections.
- Ducts conveying air at temperatures above 100 degrees F.
- Outside air ducts up to the air handling unit or mixing box.
- Any roof mounted ducts and other ducts located outdoors.

Provide insulation thickness as follows:

- Ducts: 1½ inches fiberglass with aluminum foil jacket vapor barrier (maximum thermal conductivity = 0.20 Btu-in/hr-ft^2 at 75 degrees F).
- Board type insulation is preferred. Blanket type insulation is acceptable with approval of joint seal technique by the engineer.
- Boiler breeching, flue, and smoke pipe: 2 inches fiberglass up to 350 degrees F, 2 inches calcium silicate above 350 degrees F.

7.3.4.7 Duct Hangers and Supports

Duct hangers and supports shall comply with applicable SMACNA standards, and seismic requirements. Provide adequate support to control movement and support the weight of the duct system. Design hangers to permit freedom of movement of the duct system within the range of expansion forces expected. Where connected to equipment, including isolation dampers, valves, etc., the ductwork or piping shall be independently supported with no weight supported by the equipment and in such a manner that the equipment may be removed for service without the need for temporary support of the ductwork or piping.

Support ducts at intervals required by the SMACNA construction methods and pressure class being used. In no event will support spacing exceed manufacturers' recommendations.

In concrete construction, place inserts in the forms for use with duct hangers. For lightweight ducts or field modification, concrete anchors may be used. Generally, epoxy adhesive anchors are preferred where vibrations are expected. For installation of manufactured anchors in existing structures, the designs shall be based on the accepted values in the specific product's International Code Council Evaluation Service (ICC-ES) Reports. Provide calculations to DC Water for review. Specify that pull testing must be performed on the anchors after installation.

For structural steel, beam clamps of forged or cast construction may be used. The use of threaded inserts is prohibited.

Support vertical risers by angle iron attached transversely to the duct work. Provide additional reinforcing at the point where the riser support attaches to the duct.

Where coils, fans, dampers, or other inline equipment are installed in ductwork, they shall be independently supported by the structure and not by the duct system. The adjacent ducts will be independently supported to allow removal of the equipment without the need for temporary support of the ducts.

Do not use threaded rods for hanger rods. Specify materials to prevent corrosion caused by contact of dissimilar materials. Use stainless steel fasteners and bolts for all hanger supports. Where trapeze hangers are used, design rods as if the entire load is on one rod. Rods shall be stainless steel. Hanger trapeze shall be angle iron.

7.3.5 Heating Systems

7.3.5.1 Heating Design Considerations

Base equipment sizing on detailed heat-loss calculations for each area, following procedures outlined in the ASHRAE Fundamentals Handbook. Accurate determinations of wall and roof "U" values will be made from architectural specifications and drawings.

For new heating systems, use natural gas fired hot water boilers to account for transmission, infiltration, ventilation, domestic hot water, and any process heat loads. If available and if deemed feasible, consider the potential use of steam or high temperature condenser water for heat source. See section 7.3 Technical Guidelines for additional isolation and redundancy requirements. Dual fuel burners need not be specified. Do not design for diesel fuel or No. 2 heating oil back up at the Blue Plains AWTP. For final equipment sizing, add a safety factor of 10 percent to the total load. This safety factor should be applied to the calculated load plus the 10% duct leakage factor. Gas fired make-up air unit can be considered in some applications. Electric heat can also be used in some locations where natural gas is not available.

With DC Water approval, considerations may include radiation heaters for small localized areas or other appropriate applications.

Provide hot water where required for process loads and plumbing load if required. Do not connect hot water process loads to the domestic hot water system. When plant service water is not available or is of insufficient quality the makeup for a process hot water system may be provided from the domestic (City) cold water system through an approved "Reduced Pressure Zone Backflow Preventer". Any closed-loop hot water system shall include an expansion tank and pressure relief valves to prevent over pressurization and back flow into the domestic (city) water system. Design of hot water lines must be coordinated with the mechanical process engineer and plumbing engineer.

For distribution piping system, reverse return system is preferred over direct-return system.

To tie-in an existing hot water or steam heating system, it is necessary to assess the existing capacity for the additional load or the modified load. It is also necessary to evaluate the current conditions of the existing system and propose replacement of the system, if necessary.

7.3.5.2 Heating Equipment Selection

Hot water unit heaters are used for galleries, warehouses, maintenance areas, mechanical rooms, pump stations, grit facilities, and screening facilities. They should be designed for a 50 degrees F air temperature rise. When heating is intermittent, the unit heater capacity must be 25 percent greater than design heat loss to allow for quick recovery.

Use electric unit heaters for electrical rooms. Use convectors and fin tube radiation for conference rooms, control rooms, lunchrooms, offices, laboratories, locker rooms, and toilet rooms. Small restrooms out in the process area may use electric unit heaters, electric baseboard heaters, or radiant heaters. Provide enclosures for all convectors and fin tube radiation. These units will be controlled with automatic, thermostatically controlled radiator valves and sensor-mounted on the valve or at a remote location. **All thermostats shall be located at approximate operator eye-level.**

Size heating capacity of AHUs to provide a discharge air temperature equal to the higher of 75 degrees F or the space indoor design temperature at the winter airflow condition. If hot water heating coils are provided in 100 percent makeup AHUs provide face and bypass dampers for temperature control and freeze protection. The maximum airside velocity is 600 fpm. Provide an adjustable freezestat set at 40 degrees F in the discharge air duct to shut off the fan and close the outside air damper. All heating coils shall have factory-applied corrosion-resistant coating as stated below.

When electric heating coils are used, multi-stage heater must be specified. One stage for 2.5 kW and smaller; two stages for greater than 2.5 to less than or equal to 7.5 kW; three stages for greater than 7.5 kW and less than or equal to 20 kW; and four stages for all system greater than 20 kW. In occupied (non-process) areas, the entire range between energizing the first stage and the last stage of a system shall be less than 4 degrees Fahrenheit and all stages shall be energized at a temperature no lower than two degrees below space set point temperature (design room temperature). In process areas, the entire range between energizing the first stage and the last stage of a system shall be less than 10 degrees Fahrenheit and all stages shall be energized at a temperature no lower than four degrees below space set point temperature. The dead band between energizing a stage and de-energizing a stage shall be between 1.0 and 1.5 degrees Fahrenheit.

Select centrifugal pumps so that the pump will operate at between 60 percent and 120 percent of the pump's best efficiency point. Select pump motors so that the horsepower requirements of the pump from shutoff to free discharge do not exceed the motor nameplate rating. Motors operating in the service factor under any conditions are unacceptable. Pump motors will have speeds of 1,200 rpm or 1,750 rpm. If speeds higher than 1,750 rpm are needed to provide high heads for condensate return or boiler feed water pumps, then consult DC Water for approval.

Generally, pumps operating at 60 gpm and less with motors 3 Hp and smaller may be inline pumps supported by the piping system. Larger inline pumps must be supported independently. Pumps operating at more than 60 gpm should be base-mounted pumps. See section 7.3 Technical Guidelines for additional isolation and redundancy requirements.

Hot water boilers should be of energy efficient design and not located in spaces with corrosive atmospheres or other spaces where the atmosphere is detrimental to the boiler's combustion process. Design boilers to operate on natural gas. Do not design for diesel fuel or No. 2 fuel oil. Boilers and burners must comply with NFPA, Underwriters Laboratories (UL), and FM requirements. Where propylene glycol is used for freeze protection, use correction factors in equipment sizing to account for lower thermal conductivity and increased viscosity.

All HVAC units, AHUs, finned tube coils, and heating-cooling coils shall have protective coating and shall be sized such that their heat transfer capacity meets the specified design value with the coating applied. **Do not use zinc-coated steel (galvanized) under any circumstances.** HVAC units shall use ASHRAE HFC R-410A refrigerant. All pressurized coolant HVAC copper lines and components shall be epoxy, phenolic or polyurethane dip-coated or factory applied to protect from corrosion primarily caused by sulphur emissions. Units, lines and components must be factory coated prior to delivery and protected during site storage. Coatings shall be BlyGold PoluAl XT or approved equal. Coating applicator must be manufacturer certified or qualified. **Coating submittal must be reviewed by DC Water Facilities HVAC personnel for final approval prior to shipping to project site.**

All refrigerant circuit casings and cabinets and all exposed metal surfaces including the external and interior casings/cabinets shall be coated with Devoe Devran 224HS high-build epoxy and Devoe Devthane 379UVA. **Do not use zinc-coated steel (galvanized) under any circumstances.**

The PDE shall check with manufacturers of all HVAC units proposed for a project, to determine the available options and costs of extended warranties, and specify the longest available manufacturer's extended warranty either required or approved by DC Water.

7.3.5.3 Heating Equipment Layout

Arrange equipment so that there is a minimum of 3'-0" clearance from any other equipment or structure. Locate all equipment on a 6-inch-high housekeeping pad. Any equipment anchors must penetrate the pad.

Hot water unit heaters will be suspended or hung from a wall bracket using the mounting height recommended by the manufacturer. Locate units at points of greatest heat loss and to blanket outside doorways and provide coverage for exposed window areas.

Units should be arranged to blow toward or along exposed walls, preferably striking the wall at a slight angle so that the heated air exerts a wiping effect along the wall. Heater shall be located so that the flow and direction from one heater is reinforced by the air flow from adjacent heaters. All other units required to supply the building heating requirements should be spaced uniformly in the remainder of the area. Units should not be located close to any obstruction that will impede the full and natural air delivery of the unit. Provide isolation valves, vents and drains for each unit. For finned tube heating coils, adequate room must be provided to pull the coil out for repair or replacement. Provide isolation valves at the inlet and outlet of the coil.

For heat exchangers, provide space for removal and replacement of plates or tubes. Provide isolation valves at inlets and outlets of the heat exchanger. Locate temperature gages and pressure taps at all inlet and outlet lines.

Pumps should generally be independently supported and provided with flexible connections on pump suction and discharge. However, if approved by DC Water, pumps operating at 60 gpm and less (motors 3 Hp and smaller) may be inline pumps supported by the piping system. Larger inline pumps must be supported independently. For pumps operating at more than 60 gpm, base-mounted pumps are preferred. Flexible couplings shall not be used to correct the alignment and no loads can be transferred across the flexible coupling. No load shall be transferred across valves or dampers from piping or ductwork system. See 7.3 Technical Guidelines for additional isolation and redundancy requirements.

Provide five pipe diameters of straight piping at the pump suction. If this is not possible, use a suction diffuser. Equip pump suction lines with an isolation valve. Provide pump discharge piping with a check valve, a thermometer, a sight flow indicator, and an isolation valve. Locate isolation valves after the check valve. Locate pressure gages at the suction and discharge of all pumps. Provide air release valves where needed.

Ventilation Systems

7.3.5.4 Ventilation Design Considerations

The type and arrangement of equipment shall be approved by DC Water Facilities for each specific application. In the absence of direction otherwise, in general, makeup air for all areas will be tempered by heating with heating coils. Motors in all fans and air handlers must be isolated from the air stream. See paragraph 7.3 Technical Guidelines above for additional isolation and redundancy requirements. Use equipment with two-speed motors to provide operational flexibility where required. Where transfer grilles and/or ducts are used, consider the transmission of noise through these openings.

Air shall be introduced into and exhausted from hazardous areas in a manner that will encourage scavenging of all portions of the spaces to prevent short-circuiting and to promote the effective removal of both heavier- and lighter-than-air gases and vapors, such H_2S and CH_4. See section 7.3.4 for additional ventilation requirements. Do not connect kitchen hood, fume hood, toilet room, locker room, and boiler room exhaust systems to any other building exhaust system. Do not connect ventilation systems serving hazardous areas to systems serving non-hazardous areas. Where ventilation is used for heat removal from spaces such as motor rooms or electrical rooms, air will be supplied near the floor level and exhausted at higher levels. Locate exhaust- or return-air inlets as near the source of heat as possible.

In paint shops, provide mechanical exhaust systems for year-round operation. Design the systems to achieve an air velocity of not less than 125 feet per minute across the face of the spray booth. All equipment will be explosion-proof. Makeup air will be filtered and heated.

Hydrogen sulfide scrubbers and positive pressure shall be provided for all rooms containing PCS equipment including distributed control units (DCUs), remote input/outputs (RIOs), and Operator Work Stations (OWSs). In control rooms or any other areas where non-water-based fire suppression systems are used, provide exhaust systems. Provide pre-discharge alarms in the space and a visual indication, in accordance with NFPA, that a discharge has occurred at all entrances to the space. Alarms shall register both inside and outside the enclosed space to advise staff not to enter, and shall register in the PCS. In addition, provide all ducts to and from the space with automatic dampers that will close before the release of the fire suppressant. Additional guidelines are listed in the applicable NFPA standards**.**

In laboratories, provide ventilation in accordance with the design criteria. In addition, provide tempered supply air and exhaust air as required for fume hoods. Systems serving different laboratories within the same building must be kept separate. There may be a requirement of positive pressure with respect to ambient, and negative pressure with respect to adjacent spaces in the building. (See NFPA 45 Standard on Fire Protection for Laboratories Using Chemicals)**.** In boiler room, openings on ductwork for combustion air must comply with the requirements in National Fuel Gas Code (NFPA 54).

7.3.5.5 Ventilation Equipment Selection

Fans for all equipment shall be sized to allow for 10 percent duct leakage. Note that the heating and cooling capacity of the unit shall take into account this 110 percent air flow plus an additional 10 percent safety factor. Air flows and pressures must be corrected to standard conditions for fan selection. See paragraph 7.3 Technical Guidelines above for additional isolation and redundancy requirements.

Air handling units are used for supply air to all areas. Provide adequate space for inspection, maintenance, and removal of all components including heating and cooling coils. Provide filtration for all units. To minimize face velocity, use angular-type filters. Use 2-inch throwaway-type media with minimum ASHRAE dust-spot efficiency of 30 percent. Use UL-listed Class 1 filters. Use centrifugal fans for odor control system fans, and exhaust air systems, such as pump stations, with large airflow requirements. Wherever the service permits, use fans with backwardly inclined blades. Use radial-bladed fans for severe dust conditions.

Use inline centrifugal and axial fans for return air in air conditioning systems and supply air fans. For general exhaust ventilation, use roof or wall-mounted centrifugal exhausters.

If a control room or office is located in an odorous area, a duct mounted air purification unit can be considered to be used in the air stream. The air purification unit will use activated alumina impregnated with potassium permanganate in dry pellet form and activated carbon as the media.

Provide vibration-isolating bases for all floor-mounted fans. For all suspended fans, provide vibration-isolating hanging systems.

The PDE shall check with manufacturers of all HVAC units proposed for a project, to determine the available options and costs of extended warranties, and specify the longest available manufacturer's extended warranty either required or approved by DC Water.

7.3.6 Air Conditioning Systems

7.3.6.1 Air Conditioning Design Considerations

Provide air conditioning for electrical rooms, offices, conference rooms, control rooms, locker rooms, and other areas as deemed appropriate or as directed. Following the procedures outlined in the ASHRAE handbooks, base all equipment and system sizing on detailed heat-gain calculations and the following considerations:

- Heat gain thorough transmission
- Solar gain
- Heat-producing devices
- Heat gain from people, both sensible and latent
- Heat gain from outdoor air used for ventilation
- Fan motor heat gain

Area	Design Criteria
Office and administrative areas, laboratories, break rooms	Humidity: 45 to 55% Temperature: 70 Deg F (Winter) 78 Deg F (Summer)
Pump stations, galleries, maintenance, warehouses, process areas	Humidity: N/A Temperature: 55 Deg F (Winter) 104 Deg F (Summer)
Electrical room	Humidity: 40% Temperature: 55 Deg F (Winter) 84 Deg F (Summer)

Heat from heat-producing devices is particularly important in electrical rooms, laboratories, boiler rooms, process areas, turbine rooms and rooms with pump/ motor sets. Every effort must be made to calculate the heat gain from all equipment in the room. Detailed heat-release data from the electrical engineer or equipment manufacturers should be used for all calculations. A system heat-gain calculation shall accompany each design to assure the specified equipment meets the cooling tonnage for the electrical equipment to be served. Provide catalog cut sheets clearly showing this information and state in the construction documents that this is the basis of design. Clearly state in the specifications that if the construction contractor provides equipment with higher heat losses then he must increase the cooling capacity of the system at no additional cost to the Authority.

Where air conditioning loads are comprised primarily of transmission, solar, and people heat gains, such as in operations and administration buildings, use a computerized energy analysis program to perform calculations. The program will calculate system loads using ASHRAE's modified bin method of analysis or a similar method that takes the diversity of loads into account. For all air conditioning systems, show the process clearly on a psychrometric chart. Include this chart in the computations. For all process areas including control and electrical rooms, assume 24/7 operation with no diversity for internal loads. See paragraph 7.3 Technical Guidelines above for additional isolation and redundancy requirements.

All cooling coils in finished spaces shall have a separate stainless steel catch pan covering the entire underside of the equipment. The catch pan shall have drain lines to carry leaked condensate for proper disposal.

7.3.6.2 Air Conditioning Equipment Selection

Air Conditioning units shall have a seasonal energy efficiency ratio (SEER) rating of 13. Units shall use ASHRAE HFC R-410A refrigerant. Use packaged room-conditioning units for small air conditioning loads, generally 10 tons or less, in remote areas. See paragraph 7.3 Technical Guidelines above for additional isolation and redundancy requirements.

Use split system air conditioners for loads up to 35 tons, where it is possible to locate the condensing unit fairly close to the direct expansion cooling coil (evaporator). Use air-cooled chillers for loads of 35 tons or more. Air-cooled chillers are used in conjunction with chilled water coils in AHUs and fan coil units. Locate chilled water pumps for these systems in the buildings being serviced. See paragraph 7.3 Technical Guidelines above for additional isolation and redundancy requirements.

Locate all equipment with a minimum of 3' 0" clearance to any other equipment or structure. Provide sufficient space for coil removal for equipment with coils. Locate all equipment on 6-inch-high housekeeping pads.

Cooling and condenser coils will be coated with a corrosion-resistant coating.

<u>All liquid cooling lines shall have a visible means to easily confirm flow. ALL pressurized coolant HVAC copper lines and components shall be epoxy, phenolic or polyurethane dip-coated or factory applied to protect from corrosion primarily caused by sulphur emissions</u>. Units, lines and components shall be factory coated prior to delivery and protected during site storage. Coatings shall be BlyGold PoluAl XT or approved equal. Coating applicator shall be manufacturer certified or qualified. Coating submittal must be reviewed by DC Water Facilities HVAC personnel for final approval.

All refrigerant circuit casings and cabinets and all exposed metal surfaces including the external and interior casings/cabinets shall be coated with Devoe Devran 224HS high-build epoxy and Devoe Devthane 379UVA.

The PDE shall check with manufacturers of all HVAC units proposed for a project, to determine the available options and costs of extended warranties, and specify the longest available manufacturer's extended warranty either required or approved by DC Water.

7.3.7 Energy Recovery Systems

This section describes the application of air-to-air energy recovery systems used for recovering energy from exhaust air streams and using the energy to offset a portion of the energy required for heating supply air. Specifically, rotary wheel exchangers, fixed-plate exchangers, and run-around systems are covered. Alternative methods of heat recovery may be considered. Additional information can be found in the ASHRAE handbook series and SMACNA publications.

7.3.7.1 Energy Recovery Design Considerations

Consider energy recovery systems for all systems that offer a potential for energy savings through energy recovery. The decision to use energy recovery equipment will be based on economic analysis of the proposed system. Energy savings, capital cost, and O&M costs must be considered. The economic analysis shall consider local design conditions, operating schedules, indoor design conditions, increase operating cost, and maintenance costs. The analysis shall indicate payback period and capital expenditure required over base design.

Provide detailed procedures for switch over from pre-heating the incoming air during periods when heating is required to pre-cooling or bypassing the air during warmer periods. Define any transition periods between heating and cooling when the recovery unit is ineffective. There will be significant periods during the year, mainly in the spring and fall when the unit will change from pre-heating to pre-cooling multiple times in a 24 to 48-hour period. For this system to be effective that change over must be automatic.

Exhaust air streams frequently contain particulates and/or corrosive gases. Filtration must be provided on both air streams to prevent the fouling of equipment by particulate matter. Follow the recommendations of the equipment manufacturer. Similarly, the materials that are in contact with the exhaust air stream must be capable of withstanding the corrosive effects of any vapor and gases present.

The exhaust air will have a relative humidity high enough that upon cooling, moisture (possibly corrosive) will condense. For all energy recovery systems, the design must provide for drainage of this condensate to a floor drain.

In areas with mechanical cooling, total energy recovery devices can be used to advantage. During the winter months, energy can be recovered by transferring sensible heat from the exhaust air stream to the supply air stream. During the summer months, both sensible and latent (humidity) heat can be transferred, thus pre-cooling and pre-dehumidifying the supply air. The summer operation will only work if some form of mechanical cooling is also used say for AC supply to an office but will not work in an area with heating only. For example, in the case of the dry well for the pump station the pump motors will always be adding heat to the room. If the only means of removing this heat is ventilation air (no mechanical cooling) then the exhaust from the room will be at a higher temperature (normally about 10 degrees F - 15 degrees F higher than the incoming air. In this case, even with outside air temperatures of 90F or more the supply will be pre-heated not pre-cooled.

Winter performance of the energy recovery system should be carefully evaluated to ensure that frosting will not occur under any conditions. Where frosting is possible, controls must be included to prevent this problem. Under all modes of operation, the system shall meet or exceed the minimum ventilation rate and maintain design heating, cooling and humidification/de-humidification values. See paragraph 7.3 Technical Guidelines above for additional isolation and redundancy requirements. When these systems work, they can significantly reduce energy costs but they are prone to failure and typically have a shorter life span than other HVAC equipment. Therefore, energy recovery systems should not be used to reduce the capacity of the non-heat recovery components of the heating and cooling system. The energy savings will continue to accrue as long as the energy recovery system functions correctly.

Points of inspections shall be provided to facilitate preventive and predictive maintenance of equipment. HVAC Meters related with process areas shall be installed and shall be easy to read and access.

7.3.7.2 Energy Recovery Equipment Selection

The performance of energy recovery equipment is usually expressed in terms of its effectiveness in transferring sensible, latent, or total heat. The effectiveness (e) of the equipment is defined as follows:

$$e = \frac{\text{actual transfer for the given equipment}}{\text{maximum possible transfer between the airstreams}}$$

Typical effectiveness ranges for energy recovery equipment are as follows:

Equipment	Effectiveness Range
Rotary wheel exchangers	0.75 - 0.85
Fixed plate exchangers	0.40 - 0.80
Run-around systems	0.40 - 0.60

In addition to an economic analysis, the following calculations are required for energy recovery systems:

- Detailed calculations of energy savings due to the proposed system; calculations must be done using the ASHRAE bin method of analysis. The degree-day method is not acceptable, as ASHRAE states that the degree-day method should only be used when all conditions remain constant as outdoor temperature varies.
- A plot of the system operation on a psychrometric chart.
- Manufacturers' data or computerized selection indicating actual equipment effectiveness under design conditions; if the equipment effectiveness varies with temperature, this information must be provided and considered in the energy recovery calculations.
- Air at the Blue Plains site contains many contaminants which foul and corrode the heat transfer surfaces. It is realistic to assume that effectiveness will degrade significantly when sizing the heating and cooling equipment. Provide manufacturers’ data to support long term effectiveness.

Use rotary wheel exchangers for energy recovery between air streams where total recovery (sensible plus latent) is desired. The pores of rotary wheel exchangers allow a small amount of the exhaust stream to be carried into the supply stream. If this is not acceptable, a purge section may be added to reduce cross contamination to near one percent. Wheels will be driven by a variable-speed drive connected to the wheel by a chain or belt. Provide controls to vary the wheel speed to maintain a fixed supply or discharge temperature as required to prevent frosting. Velocities will be between 400 fpm and 900 fpm.

Use fixed-plate exchangers for energy recovery between air streams where only sensible heat recovery is desired or where no cross contamination of air streams can be allowed. The design must provide for drainage of condensate to a floor drain.

Use run-around systems for energy recovery between air streams where exhaust and supply ducts are widely separated. Run-around systems use two or more finned-tube heat exchangers connected by piping. Propylene glycol is circulated in the piping to transfer heat from the exhaust air stream to the supply air stream. Careful attention must be paid to coil selection, circulating liquid flow rate, and the heat loss/gain in both legs of the interconnecting piping. A computerized optimization is required to obtain the maximum effectiveness from this type of system. Operation at off-design conditions must be examined.

Avoid excessive pressure drop across heat recovery equipment as an energy concern.

7.3.7.3 Energy Recovery Equipment Layout

Access should be provided for cleaning and/or use of wash down equipment so that any contaminants that may build up can be removed. Where possible, counter-flow arrangements should be used for maximum effectiveness. Provide bypass ducts around rotary wheel exchangers and fixed-plate exchangers. Bypasses may be internal or external. Frosting of energy recovery equipment can be prevented by bypassing a portion of the supply air around the equipment. See section 7.3 Technical Guidelines above for additional isolation and redundancy requirements.

Air streams must be in close proximity to rotary wheel exchangers. Wheels should be mounted in the vertical plane (to provide horizontal airflow). Air streams must also be in close proximity to fixed-plate exchangers. Systems are generally made up from standard modules offered by manufacturers. Use plenums to connect ductwork to the number of modules required for a given airflow.

For run-around systems, air streams can be widely separated. Several exhaust or supply air streams may be included in a single loop. Follow guidelines elsewhere in this manual on finned tube heating coils, piping, and duct systems.

7.3.8 Control Systems

Control systems should be as simple as possible while providing all necessary functions for proper control. Use electric or electronic/direct digital (DDC) control systems. The recommended control system supplier/manufacturer shall be well established with over ten (10) years of experience in installation, equipment integration, testing and maintenance support.

To maintain desired room conditions, the capacity of equipment will be controlled automatically according to the load. The control system will anticipate demand and provide automatic compensation so that system capacity will change according to load. To reduce operating expenses, design control systems to prevent overheating and overcooling.

Control methods include the following:

- Manual controls - Used for room-type heating or cooling equipment where loads do not vary widely and for equipment requiring seasonal adjustment such as switchover from winter to summer conditions.
- Semiautomatic operation (that is, manual start with automatic capacity control) - Used for most systems.

- Automatic control systems – Used where equipment is to operate on a 24-hour basis without supervision. Building Automation System (BAS) / Building Management System (BMS) shall:
  - be latest version of Honeywell Tridium or equal;
  - be operated by software application compatible with BAC-Net open-open source;
  - be connected to the DC Water Facilities Web-based control system for monitoring;
  - include redundancy for all key components;
  - have back-up with uninterruptible power supply for minimum four (4) hours run time; and
  - be computer integrated and tested by a controls contractor

Use two-position controls for limit or safety control and for small, simple systems that cannot be adapted to modulating control, such as small room units, unit heaters, and radiators. Use modulating controls for varying equipment capacity in response to load changes and for simultaneous control of more than one variable.

Provide freezestats downstream of all water and steam coils. All outside air dampers will be interlocked with their respective fans. For freeze protection, use one of the following methods to prevent freezing of coils where large amounts of makeup air are required:

- Face and bypass dampers - Locate a sufficient distance from downstream coils or use air blender to prevent stratification.
- Recirculation pump - To maintain a minimum coil tube velocity of 3 fps.
- Glycol loop with separate heat exchanger, pump and expansion tank.

Economizer controls must not be used on air conditioning systems for electric rooms. Consider economizer controls for other areas if they are cost-effective.

7.3.9 Operations and Maintenance

Considerations for O&M of equipment designs shall be documented, including, but not necessarily limited to:

- Compatibility with existing facilities and equipment
- Conformance with DC Water Energy Savings Plan
- Equipment testing protocols
- Estimated operating costs
- Estimated maintenance costs
- Recommended operator training
- Recommended or proposed spare parts
- Availability of local suppliers
- Availability of local service representatives
- Available warranties.

The above considerations shall be presented, discussed, and addressed in the HVAC design workshop to be conducted with DC Water.

7.3.10 Equipment Asset Tag Identifications

The PDE shall prepare the project asset classification table and include all required HVAC equipment assets, descriptions, and the equipment Tag identifications. All HVAC equipment shall be identified on the drawings with the Tag identifications, and shall be consistent with other discipline drawings. Project specifications shall require the construction contractor to provide and install the identification Tags and the Maximo identifications in addition to the manufacturers' nameplates for all equipment. Such information shall be submitted by the contractor for review and approval.

7.4 MAINTAINABILITY CONSIDERATIONS

Any enclosed space with refrigeration units shall have a refrigerant alarm system to prevent suffocation in the event of a large refrigerant leak. Alarms shall register both inside and outside the enclosed space to advise staff not to enter, and shall register in the PCS.

Floor penetrations in floors above the lowest floor level are to have a concrete curb or stainless steel sleeve at least 8-inches high to prevent liquid on the floor from running down the floor penetration.

Any cooling coil assembly subject to condensate formation shall have a separate stainless steel catch pan covering the entire underside of the equipment. The catch pan shall have drain lines to carry leaked condensate for proper disposal.

Any roof that has equipment located on it must have a provision to allow removal of the equipment using commonly available material handling equipment (i.e., a truck mounted crane). The use of a load lifting helicopter is not allowed.

All roof-mounted equipment installations shall include safety provisions as required for fall protection from roof perimeter. All handrail or guardrail installations on a roof shall be coordinated with the roof manufacturer to keep any applicable roof warranty intact.

Provide securely-mounted equipment guards for couplings, belts, chain drives, extended shafts, and exposed moving parts.

Provide, to the maximum extent practical, similar pieces of equipment furnished by the same manufacturer to maintain uniformity.

The minimum clear space around equipment shall be as required by applicable codes, recognized industry standards of good practice, or 3 feet, whichever is greater. Maintenance access requirements, especially on large equipment, shall be considered when establishing the layout. Maintenance access shall consider the need to completely remove each piece of equipment at some future time.

Arrange equipment and piping to prevent tripping hazards.

Equipment that must have periodic service is to be located at a convenient height.

Allow walking access to all process equipment without having to climb over or crawl under pipes, electrical conduits, or other obstructions.

Provide convenient access to adjustment points, test points, and filling and draining points on all equipment.

Arrange equipment so that access to malfunctioning equipment does not require the disassembly of adjacent equipment.

Ensure that ample clearance is provided in hazardous areas for personnel encumbered by protective equipment.

Water lines or ductwork subject to condensation shall not be run over electrical rooms or equipment.

No pipes carrying liquid can be located within an electrical room or control room.

Maintain a minimum of 10' vertical clearance from the floor to the centerline for all piping that may impact equipment access. Piping that would limit personnel access shall have a minimum of 7'-6" vertical clearance above the floor.

Ductwork and piping that drops below 6'-8" clearance for short stretches of less than 15' of length, shall be painted red during those stretches, to warn people of head bumping hazard.

Pumps and other equipment and associated pipes and fittings are to be orientated so maintenance workers are not drenched when the equipment is opened.

All wetted equipment (pumps, control valves, etc.) shall have valve configuration to allow isolation and removal of equipment.

If control valves or instruments have bypass lines to allow removal of device, the bypass line is to have two isolation valves, one on each end of the bypass line. Connection from each isolation valve to the bypass line is to be flanged to allow removal of the bypass section if desired.

Leave adequate clearance at pipe flanges, unions, couplings, and valves to facilitate disassembly of piping.

Allow ample space for access to and maintenance of valve operators. Provide adequate clearances for rising stem and valves in all positions.

Include drain and vacuum relief connections to allow pipes to be drained.

All liquid cooling lines shall have a visible means to easily confirm flow.

All bolts used in piping flange connections are to have positive means to prevent loosening of the bolts in service.

Any piping section that does interfere with the removal or service of equipment shall be capable of being isolated by valves, then drained, and removed in convenient pieces.

All piping shall be routed to avoid interference with the removal or service of equipment.

All manual valves shall have identification labels or tags attached that are readable and legible from the nearest operating work surface. The labels shall be corrosion resistant and/or ultraviolet resistant based on the location of the valve. Provide numbers and colors in accordance with DC Water requirements.

For all pressurized piping (not including gravity drains), branches from supply headers shall be provided with a valve within 12 inches of the branch connection to allow isolation of the branch.

Noise readings must be taken and recorded for all newly installed equipment to demonstrate compliance with applicable codes and standards.

Hour meters shall be provided with all rotating equipment to allow for monitoring of run times.

Strategically place manual valves such that dead legs are minimized. Provide manual air relief on dead legs and high points in the pipelines and pipe the air release to the nearest drain.

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DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY
(DC Water)

"SERVING THE PUBLIC - PROTECTING THE ENVIRONMENT"

PROJECT
DESIGN MANUAL
VOLUME 2 - FACILITIES DESIGN

SECTION 8A – INSTRUMENTATION AND PROCESS CONTROL

August 2018

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AUTHORIZATION FORM

Revision Number	Date	Content
Draft 2	6/19/98	Project Design Manual Volume 2 - Facilities Design Section 8 – Instrumentation
Draft 3	04/29/2005	Section 8 – Instrumentation
Draft 4	09/01/2010	Section 8 – Instrumentation and Process Control
Draft 4, Rev1	09/01/2010	TOC update
Draft 5	04/18/2012	Updated 8.4.1 to comply CSI 50 Div format
Rev 5	03/01/2013	Updated per Log of Revisions, March 2013 edition
Rev 6 and 7	08 & 09/2013	Updated as indicated in Log of Revisions
Rev 8	05/2014	Updated as shown in Log of Revisions
Rev 9	05/2015	Updated as shown in Log of Revisions
Rev 10	10/2015	Updated as shown in Log of Revisions
Rev 11	01/2018	Updated as shown in Log of Revisions
Rev 12	08/2018	Updated as shown in Log of Revisions

This 2018 version was authorized by:

9/25/18

Duncan Mukira PE, Supervisor, Control Systems Section Date

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SECTION 8A, INSTRUMENTATION AND PROCESS CONTROL LOG OF REVISIONS (Revisions made after the 1999 version)		
Paragraph	**Brief Description of Revision**	**Comments**
*Global	-Changed ‘DC WASA’/ ’WASA’ to “DC Water” -Changed ‘EPMC’ to “PM” -Changed ‘Long Term Control Plan’ to “Clean Rivers Project” -Deleted dates for specific standards/codes and referred to the “latest version”. -Deleted reference to Vol. 5 Standard Details; replaced w/ “Obtain Standard Details from DETS”	
8A.1 General	Added: Processes and systems at the remote Water and Sewer pumping stations will be controlled and monitored through the Supervisory Control and Data Acquisition (SCADA) system.	Rev 5 02/28/2012
8A.3.3	Deleted: and all instrument functions performed by the PCS.	Rev 5 02/28/2012
8A.3.3	Added: Control signals shall correspond to electrical wiring ………. common line shall be avoided.	Rev 5 02/28/2012
8A.3.5	Added: Care shall be taken to especially lines between panels for control portions.	Rev 5 02/28/2012
8A.4.1	Added: Instrument schedules shall identify instrument, required optional equipment, and signal interface type as a minimum.	Rev 5 02/28/2012
8A.4.1	Added: Schedules shall identify including power source/requirements as a minimum.	Rev 5 02/28/2012
8.A.4.2	Added: Indicate historian requirements for each historical data system. Indicate alarming requirements and priorities. Indicate action from PCS and local controllers after a power outage or loss of control signals	Rev 5 02/28/2012
8A.4.5	Added: I/O lists for the SCADA system shall meet the requirements for the SCADA system.	Rev 5 02/28/2012
8A.6.2	Added: This equipment grouping shall correspond to the	Rev 5 02/28/2012
8A.6.4	Added: and Naming Conventions.	Rev 5 02/28/2012
8A.6.4.2	Added: RIO Cabinet – 24”W x24”D x78”H. Front and rear access.	Rev 5 02/28/2012
8A.6.4.3	Added: Naming Conventions. Ovation equipment names shall be unique and bas. (Network), UPS (Uninterruptible Power Supply), etc.	Rev 5 02/28/2012
8A.6.5.3	Added: Common wiring between signals is not allowed.	Rev 5 02/28/2012

SECTION 8A, INSTRUMENTATION AND PROCESS CONTROL LOG OF REVISIONS (Revisions made after the 1999 version)		
Paragraph	**Brief Description of Revision**	**Comments**
8A.6.6.2.1	Added: Link Controller.	Rev 5 02/28/2012
8A.6.10.1	Added: For variable speed driven equipment monitor speed input/output. For motors over 25 hp that operate continuously, monitor motor current or power (watts).	Rev 5 02/28/2012
8A.6.10.5	Added: Where cost effective, it is desired to utilize a Field Devices.	Rev 5 02/28/2012
8A.6.10.7	Added: In general, control outputs to driven equipment 50 hp budgetary constraints.	Rev 5 02/28/2012
8A.6.11.2	Added: For differential pressure devices used in flow applications, when done within PCS.	Rev 5 02/28/2012
8A.6.12	Added: Equipment shall be located above flood levels for the plant. Construction - the requirements of this section.	Rev 5 02/28/2012
8A.6.14	Modified: Provide 4 hour backup minimum for DCU and Control room areas, provide 4 hour backup minimum for RIO units.	Rev 5 02/28/2012
Appendix A	Updated. (Formerly Attachment 2-8-1.)	Rev 5 02/28/2012
Appendix C	Updated. (Formerly Attachment 2-8-2).	Rev 5 02/28/2012
8A.4.1	Updated to CSI Div. 50 format.	Rev 5 04/19/2012
8A.6.14	Added Water and Sewer Pumping Stations to Reliable Power requirements.	Rev 5 05/17/2012
8A.6.14	Added ATS and UPS monitoring points.	Rev 5 08/29/2012
8A.6.6	Added no Fieldbus or other bus technologies.	Rev 5 10/03/2012
Appendix A	Updated. (Formerly Attachment 2-8-1.)	Rev 5 12/27/2012
8A.6.10.1	Updated to add current and power monitoring for all VFDs.	Rev 5 02/21/2013
Table C-2	Added Table C-2 PCS Standard I/O.	Rev 5 02/21/2013
Appendix C	Updated Loop Numbering table per TDPS & ECF loop numbering guide, dated 6/18/2013	Rev 6 08/05/2013
8A.4	Updated the reference for preparation of project specs.	Rev 6 08/05/2013
8A.4.1	Updated specification section numbers 40 94 33, 40 95 13.13, 40 97 15, 40 97 30, and 40 97 33.	Rev 6 08/05/2013
8A.4.5	Added requirement for existing points to be included on I/O list when system modification and retesting are required.	Rev 7 08/23/2013
8A.6.2	Added requirement for upper case, standardization of alarm contacts, deleted Fieldbus as a Signal Type and added PCS as an OV Interface Type.	Rev 7 08/23/2013

SECTION 8A, INSTRUMENTATION AND PROCESS CONTROL LOG OF REVISIONS (Revisions made after the 1999 version)		
Paragraph	**Brief Description of Revision**	**Comments**
8A.6.10.1	Clarified "status" and added requirement for torque/overload monitoring of gates and valves.	Rev 7 08/23/2013
8A.6.11.1	Added requirement for sun shields.	Rev 7 08/23/2013
Appendix B	Revised Sample I/O List with additional fields	Rev 7 08/25/2013
Table C-2	Corrected ISA Prefixes	Rev 7 09/16/2013
Appendix D	Updated Sample Loop Drawings and added Pt to Pt Drawing	Rev 7 08/29/2013
8A.6.2.C	Revised Pname description	Rev 7 09/13/2013
8A.6.10.6	Revised Power Monitoring requirement, added MCCs	Rev 7 09/13/2013
8A.6.19.2	Revised Loop drawing requirement	Rev 7 09/13/2013
8A.4.1	Added System Integrator requirements under spec section 409000. Added Subsections	Rev 7 09/13/2013
Table C-2	Added ISA Prefixes	Rev 7 09/16/2013
8A.6.4	Added requirement for PCS cabinets on plinth installations	Rev 7 09/16/2013
8A.3.4	Deleted PMT from serial communication	Rev 8 05/08/2014
8A.6.2	Updated and Added items N, O, P & Q	Rev 8 05/08/2014
8A.6.6	Added "and if DCU is not available within Ethernet cable permitted length."	Rev 8 05/08/2014
8A.6.10.3	Added Requirement of HVAC monitoring	Rev 8 05/08/2014
8A.6.10.6	Updated PMT Ethernet connection requirement	Rev 8 05/08/2014
8A.6.10.7	Added "NO VFD speed controls at the local equipment, unless directed by DC Water."	Rev 8 05/08/2014
8A.6.12	Deleted Tables 2-8-1 & Table 2-8-2 and addressed requirements for rooms containing control equipment and air quality environments. Referenced ISA standard	Rev 8 05/08/2014
8A.6.19	Added requirement for instrument installation details	Rev 8 05/08/2014
Appendix B	Revised Sample I/O list	Rev 8 05/08/2014
List of Acronyms and Abbreviations	Added DP, IEEE, AI, AO, OV, LOC, L/R, OMAP. Deleted FBGateway.	Rev 8 05/08/2014
8A.4.1	Revised specs arrangement per CSI 2015 update	Rev 9 05/19/2015
8A.6.3	PDE shall verify network availability, capacity, and any need for expandability	Rev 9 05/19/2015
8A.6.6 & 8A.6.7	Added requirements for Ethernet Link Controllers	Rev 10/14/2015
8A.3.3	Added requirements for Pnames and surge suppressors in P&ID	Rev 12/26/2017
8A.6.6 & 8A.6.7	Modified requirements for Ethernet Link Controllers	Rev 12/18/2017
8A.6.10.6	Revised power monitoring requirement	Rev 12/18/2017

SECTION 8A, INSTRUMENTATION AND PROCESS CONTROL LOG OF REVISIONS (Revisions made after the 1999 version)		
Paragraph	**Brief Description of Revision**	**Comments**
8A.6.11.1	Added requirement of disconnect switches near instruments	Rev 12/18/2017
8A.6.12	Added requirement for electrical room monitoring	Rev 12/18/2017
8A.6.18	Modified Pre-loop check requirement, added PCS network and communication testing	Rev 12/26/2017
Appendix B	Revised Sample IO list	Rev 12/18/2017
Appendix D	Updated Sample Loop Drawings and Pt to Pt Drawing	Rev 12/18/2017
Appendix A	Updated HVAC & Environmental alarms priorities	Rev. 01/18/2018
8A.5.3 & 8A.5.4	Changed ‘90% Design’ to ‘Pre-Final Design’ and changed ‘Pre-Final’ to ‘Back Check Submittal’ both in accordance with the January 2018 PDM Volume 1.	Rev. 05-24-2018
Appendix B	Replaced Sample IO List with two new pages	Rev. 05-24-2018
8A. 6.10.1	Added vibration monitoring for pumps 15-75 hp.	Rev. 08-01-2018

SECTION 8 - INSTRUMENTATION AND PROCESS CONTROL
TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

ACRONYMNS AND ABBREVIATIONS

AI	analog input
ANSI	American National Standards Institute
AO	analog output
API	American Petroleum Institute
ATS	automatic transfer switch
AWG	American Wire Gauge
AWTP	Advanced Wastewater Treatment Plant
CAD	computer-aided design
CFR	Concept Finalization Report
CSI	Construction Specification Institute
DC Water	District of Columbia Water and Sewer Authority
DETS	Department of Engineering and Technical Services
DCU	distributed control unit
DI	discrete input
DO	discrete output
DP	Design Package
DSLF	Dry Sludge Loading Facility
DTA	data transfer area
ELC	Ethernet link controller
EPM	Emerson Process Management
HI	human interface
HVAC	heating, ventilation, and air conditioning
I&C	Instrumentation and Controls
IEEE	Institute of Electrical and Electronics Engineers
I/O	input/output
IP	internet protocol
ISA	International Society of Automation
LC	link controller
LOC	location
L/R	local/remote
MCC	motor control center
NET	network
NEMA	National Electrical Manufacturers Association
O&M	operation and maintenance
OEM	original equipment manufacturer
OIT	operator interface terminal
OMAP	Operations & Maintenance Assistance Program
ORP	oxidation reduction potential
OWS	Operator Work Station
OV	Ovation (system)
P&ID	Process and Instrumentation Drawing
PCD	process control description
PCS	Process Control System
PLC	Programmable Logic Controller
PDE	Project Design Engineer
PMT	power monitoring transmitter
RIO	remote input/output
RTD	resistance thermal device
SCADA	Supervisory Control and Data Acquisition
THHN	Thermoplastic High Heat-resistant Nylon-coated
THWN	Thermoplastic Heat and Water-resistant Nylon-coated
UPS	uninterruptible power supply
VFD	variable frequency drive
VLAN	virtual local area network
WCLT	Witnessed Combined Loop Test
XHHW	cross-linked polyethylene high heat-resistant water-resistant

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PROJECT DESIGN MANUAL
VOLUME 2 – FACILITIES DESIGN

8A. INSTRUMENTATION AND PROCESS CONTROL

This section 8A describes technical requirements for the instrumentation and process control design for District of Columbia Water and Sewer Authority (DC Water) facilities at the Blue Plains Advanced Wastewater Treatment Plant (AWTP). A separate Section 8B SCADA Design Guidelines describes technical requirements for the instrumentation and process control design for DC Water facilities outside of the Blue Plains Advanced Wastewater Treatment Plant. The section outlines design criteria and provides guidelines for the preparation of drawings, specifications, and contract documents. This section includes requirements that integrate the requirements for control and monitoring of all equipment and processes across all typical design and construction divisions.

8A.1 GENERAL

The requirements outlined in this section apply to all design packages (DP).

Specific requirements for each DP are contained within the individual conceptual design report, which may supplement the requirements outlined in this section. Where the conceptual design deviates from this manual the Project Design Engineer (PDE) should ask DC Water for guidance.

The PDE must obtain approval in writing to deviate from the standards and requirements presented in this manual. It is not acceptable to assume design reviewers will pick up on deviations hidden in the detailed design or electrical schematics. Design reviews are focused more on conceptual requirements.

The PDE shall review existing equipment or processes that are being modified for conformance with these standards and requirements and design modifications/replacement as required to bring them into conformance with these standards. Deviations from this policy due to cost or other concerns shall be specifically discussed with DC Water.

Each DP will be checked against this section and the DP conceptual design report for compliance, and the package will not be considered complete or acceptable unless it meets the requirements outlined in these documents.

All instrumentation, processes, and equipment shall be designed and coordinated to provide for accurate and reliable control and monitoring of all processes and facilities. The instrument and control system design has to cross all division boundaries to ensure that all equipment, regardless of which division it is specified, operates as an integrated system for DC Water.

Processes and systems at the wastewater treatment plant will be controlled and monitored through the Process Control System (PCS).

Processes and systems at the remote Water and Sewer pumping stations will be controlled and monitored through the Supervisory Control and Data Acquisition (SCADA) system as described in design manual Section 8B, SCADA Design Guidelines.

Provide local controls at individual pieces of equipment and backup controls as required for maintenance, for operation when the control system is temporarily unavailable, or as directed by DC Water.

8A.2 INTERFACE TO THE EXISTING PROCESS CONTROL SYSTEM (PCS)

The existing process control system was provided by Emerson Process Management (EPM) utilizing their Ovation, Microsoft Windows based platform. DC Water has entered into a sole source agreement with EPM for furnishing equipment and services pertaining to the Ovation system of equipment. Design documents shall carefully identify the equipment and services to be provided by Emerson from the remainder of the contract. In general, the equipment and services for each upgrade contract will be part of the construction contract. However, there may be applications where it is beneficial for DC Water to purchase the equipment for installation by the upgrade contractor.

Coordinate all modifications to the existing PCS with DC Water's PCS Program Manager during the design process. Note that all equipment point names have to be unique across the Ovation system. The PCS Program Manager is responsible for coordinating and assigning all loop numbers for the plant and loop numbers shall be requested by the PDE as systems are laid out or defined during design. The PCS program manager is keeping track of all spares and modifications to the PCS system across the upgrade contracts and will help clarify PCS layout, termination, and coordination requirements.

In addition, programming will be provided by a combination of DC Water, the PCS Program Manager, and Emerson Process Management. This division of responsibilities will need to be coordinated and defined as part of each upgrade contract.

8A.3 REQUIRED DRAWINGS AND FORMATS

Refer to the concept design report before beginning the detailed design. The detailed design must reflect the intentions of the concept design and Concept Finalization Report (CFR).

8A.3.1 I&C Drawing Arrangement

Present instrumentation and controls (I&C) drawings in a logical manner, following the process trains. Use the following sequence for types of drawings:

- Legend, symbols, and general notes.
- Piping and instrumentation drawings.
- Communication and Network Drawings.
- Panel layouts with panel schedules.
- Panel schematics and wiring diagrams.
- Typical mounting details.
- Floor plan layouts for control centers, PCS equipment, and termination cabinets. Plans for distributed control units (DCUs) and termination cabinets shall be coordinated by the PDE with DC Water's PCS program manager. (Coordinate whether to show as part of I&C drawings or electrical drawings.)

8A.3.2 Drawing Coordination

The physical location of instruments is shown on the drawings prepared by the other design disciplines. Locate equipment as indicated below:

- Mechanical - Locate all field instruments, show interface to mechanical piping (pipe taps, insertion meters, etc.).

- Structural - Locate instruments on:
  - Flumes.
  - Weirs.
  - Stilling wells.
  - Special equipment access railings.
  - Antennas including antenna base and guy wire fittings and considering wind-loading factor.
- Electrical
  - Locate all equipment that requires electrical power supply connection.
  - Locate all equipment requiring signal or communications interconnection.
- Architectural - Locate control panels and enclosures on floor plan layouts.

Care must be taken to specify or detail the field mounting location of all instruments, remote-mounted controls and indicators or displays so that equipment can be easily maintained and operated. Details or coded notes should be used to define the location and orientation of controls and indicators so that they can be safely accessed and read. For example, if motor-operated valves are required to be mounted 10 feet in the air or over water-filled basins, valve/gate actuator controls and indicators must be located such that the valve can be operated from the floor or operating deck. Indicators or displays should face the operator and be located so that they can be easily read without need of ladder or scaffolding etc.

8A.3.3 Process and Instrumentation Drawings

The detailed design will produce process and instrumentation drawings (P&IDs) for construction bidding documents. The P&IDs are required to show all piping, valves, equipment, instruments, controls, all input/output (I/O) points with their Pnames, surge suppressors and all required interlocks.

Present all tankage, piping, and equipment in an arrangement similar to that of the actual facility. Show all functions, including those in the PCS. Because the P&ID details both the field equipment functions and those included in the PCS, the P&IDs must be separated into three horizontal sections. The bottom section details all process equipment and field instrumentation; the middle section details the instrument functions located in local control panels and motor controllers; and the top section details the inputs and outputs for the PCS. This format is necessary to facilitate the interface between the PCS and other design/construction packages. The legend of symbols used in computer-aided design (CAD) was derived from the International Society of Automation publication ISA-S5.1, Instrumentation Symbols and Identification. The symbols have been modified based on DC Water requirements. Refer to CAD standards for further details.

The P&ID drawings shall show all control signals and equipment across disciplines including hardwired interlocks and panels from which signals originate, routed, or terminate. Control signals shall correspond to electrical wiring such that number, type, and routing can be determined and verified. Signals shall be separated or labeled such that termination on one end can be traced to the other end, grouping of signals into a common line shall be avoided.

8A.3.4 Network and Communication Drawings

Network and communication drawings shall show all communication network interfaces between all devices and systems. This would include:

- Ethernet communications.
- All serial communications to devices such as Programmable Logic Controllers (PLCs), etc.
- Communication with Fieldbus networked instruments and devices.
- All connections between PCS equipment.

All network switches and interfaces shall designate the cabinet/panel for which they will be located, cabling requirements (cat 5, fiber, RS485, etc.). Drawings shall show all required setup parameters for communication to devices such as internet protocol (IP) address, Node numbers, etc.

8A.3.5 Electrical Schematics (Ladder Diagrams)

Electrical schematics shall be laid out by equipment or system being controlled. Schematics shall show all interrelated signals and controls that are wired into a control circuit on one schematic. Separate schematic per panel where the intent cannot be determined on one schematic is not acceptable. Schematics shall clearly identify the location of all connections that are remote from the “base” starter or control panel location. The “base” starter or control panel location shall be clearly identified as part of the title block notes. Typical schematics shall list all equipment for which schematic applies. Contacts and interfaces to PCS shall be clearly identified with the ISA designation and description that match the I/O list. Care shall be taken to especially match set/reset designation in the I/O list with the schematics.

Schematics shall be electrically complete and show completed circuits within each schematic even if the schematic spans multiple panels. It is not acceptable to show “continuation” lines between panels for control portions.

8A.3.6 Panel Layouts

Show a front view of all control panels to be provided with all instruments and nameplates shown. Front view shall be drawn to scale. Provide each instrument and nameplate with individual identification numbers and a schedule detailing the instrument tag number. List the exact engraving of the nameplate adjacent to the panel. Include the annunciator window engraving in a separate schedule. Provide a panel title, and list the depth, height, width, and door location below the title. Identify the construction material and the National Electrical Manufacturers Rating (NEMA) rating. Coordinate with panel schedules.

8A.3.7 Control and Equipment Room Layouts

PDEs will provide room layouts for PCS equipment provided under their design package. Use the architectural room layout with doors and windows identified. These drawings indicate the proposed layout of all equipment including furniture and chairs. Leave clearance for doors and access to equipment.

Each PDE shall develop room layouts for termination cabinets, if used, and all control panel and furniture locations that include monitoring of the processes included in the design package.

8A.4 REQUIRED SPECIFICATIONS AND FORMATS

The PDE shall prepare specifications in accordance with DC Water standards. The PDE shall develop specifications that meet the requirements of this document and the design intent of the designer. DC Water guideline specifications only indicate portions of the overall requirements for a project and are generic in nature. The guideline specs do not include all the technical/coordination requirements that would be specific to one project. The designer is required to review and submit modifications to the guideline specs to incorporate all design requirements, latest technical requirements, and coordinate the specifications and drawings across the project.

Prior to design, the PDE shall coordinate with DC Water to verify what guideline specifications may exist and obtain copies of the latest versions available. If additional specifications are required for a project, refer to the DC Water Guideline Specification Masters General Instructions (latest edition) for instructions and format requirements for preparing project specifications.

8A.4.1 Specification Arrangement

Project specifications for instrumentation and process control shall be arranged by content groups, with section numbers and titles generally in accordance with the latest version of the Construction Specification Institute (CSI) MasterFormat Numbers and Titles. Alternate section numbers (interpolated from CSI numbers) and titles are permissible but the PDE shall request confirmation and comply with DC Water's latest specifications general instructions. In general, the project specifications will include the following content groups with each group containing individual sections as needed for the project:

- Process Control General Provisions (I/O list, process control descriptions, etc.)
- Computer System Hardware and Ancillaries (servers, workstations, displays, printers, etc.)
- Control System Equipment (DPC systems, PLCs, etc.)
- Network and Communication Equipment (switches, routers, cabling, wireless, etc.)
- Control System Equipment Panels and Racks (free-standing or wall-mounted panels, racks, etc.)
- Process Control Software (programming, configuration, logic, etc.)
- Packaged Control Systems (safety systems, fire and gas monitoring systems, etc.)
- Instrumentation for Process Systems
    - Flow Measurement
    - Level Measurement
    - Pressure, Strain, and Force Measurement
    - Temperature Measurement
    - Process Liquid Analytical Measurement
    - Process Gas Analytical Measurement
    - Position and Motion Measurement
    - Panel Mounted Instruments
    - Miscellaneous Instruments (calibration, valves, fittings, signal converters, etc.)
- Commissioning of Process Systems
- Primary Control Devices (control valves, controllers, actuators, regulators, VFDs, etc.)

Within the above listed content groups, each specification section shall generally include, but not be limited to, the following:

- Descriptions
  - Description of the work to be provided by the instrument supplier, including overall coordination responsibilities for all controls, wiring, and loop drawings across all divisions within the contract.
  - Process control descriptions.
  - Network system architecture definition.

- Technical requirements:
  - For console, panel and enclosure construction including wiring.
  - For miscellaneous panel components such as indicating lights, relays, selector switches, power supplies, terminal strips, and environmental controls.
  - For process control networks, defining media, communication transport and protocols; this applies to Ethernet networks as well as serial and Fieldbus networks.
  - For network components such as switches, routers, media converters, protocol converters, adapters, connectors and cabling.
  - For field mounted sensors, transmitters and other process measuring instruments.
  - For final control devices, including control valves, regulating valves, relief valves, actuators, positioners, and related control devices.
  - For variable frequency drives, process variable converters, pressure regulators and other self-contained or integrated control devices.

- Quality assurance:
  - Reference standards; supplier qualifications, responsibilities, and services; submittal requirements; and quality control requirements.

- Schedules:
  - Equipment schedules for each control device specified, identifying control signal requirements (analog position or discrete open/close), availability of position status signals, tag and loop name, valve type and applicable specification reference, networking capability, required optional equipment, and signal interface type as a minimum.
  - Instrumentation schedules for each instrument specified, identifying instrument range for future build out, calibrated range for initial installation, set/reset values to match the I/O list for discrete contacts, tag and loop name, instrument type and applicable specification reference, required optional equipment, and signal interface type as a minimum.
  - PCS I/O Schedules including both hardwired points and points transmitted via PLCs and other third-party equipment and/or networks.
  - Schedules for panels and enclosures, identifying tag names and descriptions to match across disciplines, all optional equipment needed for each panel, room/area environment where panels are being located, enclosure type, and nameplate requirements including power source/requirements as a minimum.
  - Schedules for network devices required to connect with the existing PCS network, identifying PCS equipment tag names and descriptions to match across disciplines, all optional equipment needed for each network hub, room/area environment where network components are being located. Include nameplate requirements including power source/requirements as a minimum.

  - Schedules for process control auxiliary devices required to connect to the existing PCS, identifying equipment tag names and descriptions to match across disciplines, as well as optional equipment needed for each room/area environment where devices are being located. Include nameplate requirements including power source/requirements as a minimum.

- Emerson Process Management:

  - Identify and specify requirements for the equipment, work, and services that are part of the DC Water separately negotiated pricing for work by Emerson Process Management. Note this portion of the total work must be clarified within each applicable section and coordinated as a separate bid item in the contract.

  - System configuration requirements including qualifications, responsibilities and scope of work, including: supply all instrumentation, field elements, control panels, etc.; coordinate all submittals; certify installations; conduct monthly meetings; develop loop drawings; and perform Witness Combined Loop Test (WCLT). Should have more than 5 years' experience, have an office within 250 miles of project site, and should have done projects of similar size.

- Other:

  - Delivery, storage and handling, and protection during storage
  - Installation, calibration, start-up, testing, training, and cleaning requirements.
  - Special tools, test equipment and consumables requirements.
  - Mounting and installation requirements, positioning for viewing access and maintenance.

8A.4.2 Process Control Descriptions

The process control description section of the CFR and subsequent specifications, when used in conjunction with the P&IDs identifies the control philosophy.

The PDEs shall prepare Process Control Descriptions for all systems/equipment furnished in each design package as well as any equipment/processes that are existing that are being modified as part of the project.

The Process Control Description (PCD) will be the means of communicating the methods of control to technical and non-technical people and supplement the P&IDs. The document will be created during the CFR and will be modified with each submittal to reflect any changes or additions to the control system. The document will be an aid to design review and will form a basis to understand the PDE's control design intent.

The PCS programmer will use and modify the PCD to enhance their documentation and the document will form the basis for the Operations Manual. The document will be organized and include information so it can be stored and retrieved based on the control loop number and System.

Control Strategies shall be arranged by system and subsystems and shall be coordinated with the "system test grouping" definition for testing as well as the I/O list. The "system test group" shall be as required for all the equipment within the test group to be operated automatically.

Control Strategies shall be formatted and definitively identify what is occurring in the control system, what is hardwired, and what is provided in 3rd party controls.

Contractor shall be required to submit all modifications to control strategies, schematics, and wiring during the submittal process as well as include as part of the "as-builts" and O&M manuals.

The document will include:

1. Title - Systems and/or Equipment.
2. Introduction - Brief overview of purpose.
3. Equipment Tags, description, and loop numbers that make up the system.
4. P&ID Sheet Numbers.
5. PCD narrative at each hierarchical level of control as:
    - At the device.
    - At the motor control center (MCC) or the variable frequency drive (VFD).
    - At the local panels.
    - At PCS.

The narrative would describe (at all levels including PCS):

- All automatic and manual functions.
- All safety interlocks.
- Interlocks to other process equipment.
- Calculations and formulas.
- Continuous control.
- Sequential control.
- Discrete (ladder logic) controls.
- Set points for design conditions.
- Describe all control mode options and the required process conditions for each mode.
- Describe the operator Human Interface (HI) and controls available.
- Describe HI to enable/disable control from each level of the control hierarchy.
- Define where controls are provided.
- Identify any PLC or other microprocessor control equipment.
- Describe any signals sent/received to/from other unit process controls and include the references.
- Describe the communication requirements between each level of the control hierarchy.
- Indicate historian requirements for each historical data system.
- Indicate alarming requirements and priorities.
- Indicate action from PCS and local controllers after a power outage or loss of control signals.

Describe the control requirements regardless of equipment or control supplier. These narratives are required for all systems and associated equipment.

See Appendix A "Process Control Description" for examples.

8A.4.3 Quality Control

The specifications should include the requirement for certification by the instrument manufacturer. Where possible, instruments should be certified by the manufacturer that each is installed and calibrated in conformance with both the contract specifications and the manufacturer's requirements. All certifications and calibration reports shall be submitted to DC Water and be incorporated into the operation and maintenance (O&M) manuals and commissioning reports.

8A.4.4 Instrument Schedules

This portion of the specification is attached to the end of the text section. Each individual instrument is uniquely identified by instrument type, and the exact requirements for options to be provided, service conditions, operating conditions/ranges and calibrated range are called out.

8A.4.5 Input/Output Point List

The I/O schedule is used for the computer system interface to the control system. The I/O point listing is developed in conjunction with the P&IDs. The I/O point listing permits the design engineer to keep track of the number of I/O signals at each location and will be used to determine the actual number of PCS DCUs. The I/O list identifies the signal type, function of the I/O point, energized and de-energized state for discrete points, or process range and engineering unit for analog points, the termination cabinet for each I/O point and the PLC or microprocessor that is transmitting the point for all points sent to PCS via a network connection. If an upgrade contract involves modifications to existing systems with existing I/O points, those points will require re-testing and must be included in the I/O list with a note in remarks column indicating that these are existing points. The PDE must prepare an I/O list in the most current release of Microsoft Excel with all design reviews compatible with Microsoft Office Suite. During construction, the General Contractor will be responsible to maintain and update the I/O list to document all changes, and make it available to DC Water, the PDE, or assigned representatives to periodically review the revised I/O list. See Appendix B – Sample I/O List, and detailed requirements in Paragraph 8A.6.2.

I/O lists for the SCADA system shall meet the requirements prescribed in design manual Section 8B – SCADA Design Guidelines.

8A.5 DESIGN REVIEW SUBMITTAL REQUIREMENTS

The PDE shall provide progressively more complete drawings and specifications for each review cycle. Minimum expectations for each review are indicated below. Also, see PDM Vol. 1 for requirements of progress submittals.

8A.5.1 Preliminary Design

- P&IDs - At this level it is expected that P&IDs or process schematics/flow diagrams show all the process equipment, major piping, mechanical interfaces between existing and new processes, and process field instruments required to match the Process Control Descriptions for this level. The drawings shall show all process liquid flow, solids flow, and chemical feed systems. No signal wiring, PCS interfaces, or electrical interfaces required for this submission.

- Process Control Descriptions should be organized by system and then equipment and provide enough detail for DC Water to understand the automatic operation and impact to current systems and operations.

- Equipment and primary element sizing calculations to show conformance with this section.

8A.5.2 Intermediate Design

- P&IDs shall be expanded and laid out to include all local controls, additional field instruments, expected control panels, motor controllers, and hardwired interlocks. Signals to PCS are not required to be complete on the P&IDs yet since this information can be obtained from the I/O list. Ancillary system such as sump pumps, seal water, heating, ventilation, and air conditioning (HVAC), shall be as complete as the building designs allow.

- Panel Layouts – Sketches.

- Panel Schedule – Indicate all panels anticipated and environmental requirements such as NEMA ratings, heating, air conditioning, etc.

- The I/O list should include all the points required for each piece of equipment, organization for systems and equipment to match process control descriptions, and which panel/lineup to which points are expected to be routed. The list shall indicate type and whether hardwired or digital communication. Not required would be set/reset values and analog ranges.

- Configuration/Network drawings should be provided to show all new panels/lineups and workstations and which existing network switches they will integrate.

- Updated or modified sizing calculations since the preliminary design.

8A.5.3 Pre-Final Design

- PDE considers this ready for bid with internal PDE reviews completed prior to submission to DC Water. This is expected to be at 100 percent complete with only minor comments by DC Water after review. No design/coordination between disciplines remaining. Main review at this time should be coordination with changes by electrical for wiring, schematics and interfaces. If the review shows poor or incomplete coordination with the electrical work or other divisions, or other division work is not even completed, additional pre-final submissions and reviews will be required until it is deemed by DC Water that comments are stand-alone and do not require redesign by other disciplines.

- P&IDs shall be expanded to coordinate with the other division specifications and shall show all signals to PCS and all changes since the intermediate design. The P&IDs shall be complete, and shall be coordinated across all other disciplines. Final electrical design shall be completed in coordination with the P&IDs.
- I/O list – 100% complete.
- Instrument Schedules – 100 percent complete.
- Configuration/Network Diagrams – 100 percent complete.
- Process Control Descriptions – 100 percent complete.
- Panel Layouts – 100 percent complete.

8A.5.4 Back Check Submittal

This submittal shall be considered bid-ready but not sealed. All items submitted in the pre-final design submittal shall be included in the Back Check Submittal. The PDE shall submit a Consolidated Design Review Comment Spreadsheet demonstrating that all comments received and design workshop actions/decisions have been resolved and approved. The resolution of comments from all reviews, including those of DC Water, program management consultants, and any regulatory agencies shall be included in this submittal. If there were no changes made to any specific design document, then that should be noted.

8A.5.5 Final Design/Final Bid Documents

Should only require a check against the comments from the Back-Check review.

8A.6 TECHNICAL GUIDELINES

All designs based on information contained in this section will adhere to the standard details in the DC Water CAD Manual.

8A.6.1 Standards

Instrumentation design for the DC Water projects must conform to the codes and regulations listed in this section. Reference materials may be obtained from the following professional societies:

ABBREVIATION	NAME
Fed. Spec.	Federal Specification
ANSI	American National Standards Institute
ISA	International Society of Automation
IEEE	Institute of Electrical and Electronics Engineers
API	American Petroleum Institute
NEMA	National Electrical Manufacturers Association

Use the latest editions of following reference materials on the project:

- API, RP-550, Manual of Installation of Refinery Instruments and Control Systems.
- ISA, S5.4, Instrument Loop Diagrams, Standard.
- NEMA, Enclosure Type, Standards.
- DC Water PLC Programming Guide.
- DC Water PCS Configuration Guide.

8A.6.2 Input/Output Point Listing

Each design package shall include an I/O list (see Sample I/O List – Appendix B) that contains at least the following minimum information. Additional information can and should be added to accommodate the specific requirements of the designer's design methods. Designer should complete remaining columns with help from DC Water database holder. It is intended that the I/O list show all hardwired and data link points from devices such as power monitoring transmitters (PMTs), PLCs, etc. The list is not to include internally generated PCS points, only points from external sources. Use upper case for all entries with the exception of notes.

a. System Grouping - Field that corresponds to systems definitions for testing and control strategies that tie multiple equipment items together (i.e., Pumps, feeder breaker, priming valves, and discharge valves might be a system).

b. Equipment Grouping - Field that corresponds to all points associated with a piece of equipment (i.e., a valve might have 4 points associated with it, this grouping ties them together).

c. Point name based on ISA Tag Designation and loop number. Do not use special characters or letters as suffix. See Appendix C for naming conventions.

d. Description shall be based on DC Water standard for abbreviations; descriptions have a 30 character limit. See DC Water PCS Design and Interface Guidelines - Appendix E.

e. Type Values would include:

- DI - Discrete Input.
- DO - Discrete Output.
- AI - Analog Input.
- AO – Analog Output.

f. Analog I/O Information:

- Analog Range - Calibrates signal range or 0-100 percent.
- Analog Units - mgd, gpm, gph, psi, pct, etc.
- Loop Power - Field or PCS.
- Loop Ground - Field or PCS.

g. Discrete I/O Information:

- Set Value - Value when field contact is closed (i.e., Running, High Level, Low Level, Fail, etc.). Coordinate with electrical schematics.
- Reset Value - Value when field contact is open (i.e., Stopped, Normal, etc.). Coordinate with electrical schematics.
- Standardize the use of alarm contacts [normally open/closed (NO/NC)] and provide fail safe operation both in the field and at PCS.

h. I/O Signal - Type of signal into PCS. Values would include:

- 120 VAC.
- 4-20 ma.
- Ethernet.
- Serial.

i. I/O Interface - Where field device is wired. Values might include:

- DCU name (hardwired).
- RIO name (hardwired).
- PMT name.
- PLC name.

j. Ovation (OV) Interface Type - How signal is interfaced to Ovation. Values would include:

- Local - Hardwired to DCU.
- RIO - Hardwired to RIO.
- SCADA - Scada Server Field gateway.
- LC - Link Controller Module.
- ELC - Ethernet Link Controller Module.
- PCS – Fanout Switch to PCS

k. OV Interface - Where the values enter the ovation system or gateway card is located. There would be one of three options:

- DCU Name.
- RIO Name.
- SCADA server Name.

l. Cabinet Cluster - Name of the lineup assembly that includes uninterruptible power supply (UPS) cabinets, DCU cabinets, I/O cabinets, etc. that is bolted together as an assembly. Should match names on drawings.

m. Termination Information - Values for the fields below are normally to be assigned by Emerson for new installations, but care/coordination has to occur with electrical cabling during design to minimize inter-wiring between cabinets. Evaluate level of detail for design verses specification coordination for contractor. For existing installation, this information is to be provided to designate spares to be used.

- PCS Cabinet - Name of cabinet within assembly where final PCS termination occurs.
- I/O – Location (LOC) - Module location within cabinet following Emerson guidelines for location.
- I/O - Channel - Channel on Module to which point is terminated.

n. Alarm – Add columns to show alarm priority, alarm type, and alarm descriptions.

o. Power – Indicate whether the instrument is field powered or self-powered by PCS.

p. Dwg Number – Add reference to I drawings for each I/O point.

q. Protocol – Add signal protocol where applicable, Modbus, etc.

r. Miscellaneous design/construction coordination information.

- Surge and Intrinsic Safety requirements for each loop.
- DC Water or Contractor responsibility for equipment operation or upgrade.

8A.6.3 Equipment Selection and Sizing Calculation Requirements

See Calculation Requirements in Section 1, General, of this volume. The additional requirements specific to the instrumentation discipline follow. The quality of a control system's operation depends on the proper application and sizing of the primary elements and process equipment. The PDE shall verify existing network availability and capacity for the current design project, coordinate with DC Water regarding post-project remaining capacity for future construction, and identify any need for expandability.

Size the elements properly to provide a reliable system operation over the operating range. Calculations for flow meters, control valves, variable-speed controlled equipment, chemical feed equipment, and other pertinent equipment shall be done for minimum, average, and maximum operating conditions. In addition, these calculations (min/avg/max) must be done and presented for start-up flows and conditions as well as the ultimate design flows and conditions. Specifically, equipment needs to be sized for a range that is bounded by minimum condition at start-up and maximum or peak condition at ultimate design. As much of the equipment operates in a range of minimum to average conditions, DC Water requires equipment to be sized to be economically and accurately operated in this range. Peak conditions generally occur with storm events, which are experienced less than 1 percent of the time.

The PDE shall evaluate whether to make provisions for future replacement/upgrade of the equipment (upsizing when design conditions are met), provide more units that can total up to the future peak requirements, or operate at reduced accuracy and control. The evaluation and impacts to DC Water will be specifically discussed and agreed to with DC Water. The evaluation shall include operating costs such as energy and chemical consumption when equipment is oversized and can't provide the turn-down needed for minimum conditions at start-up.

8A.6.3.1 Flow Meters

Perform standard sizing calculations for flow meters and provide design criteria. The calculations will verify Reynolds Number, differential at minimum and maximum flows, and the head loss for venturi meters. Calculate velocities at minimum and maximum flows for both start-up conditions and ultimate design conditions.

8A.6.3.2 Control Valves

Check all modulating control valves for the following criteria for both start-up conditions and ultimate design conditions, during design:

- Position at low flow (maximum required head loss).
- Position at maximum flow (minimum required head loss).
- Verification that cavitation is not present during operational range.
- Motor operator size.
- Performance when close-coupled to a venturi flow meter.

8A.6.4 PCS Equipment Layout, Sizing, and Naming Conventions

Distributed control units are the process control units of the PCS. They are intended to be the main control device in each plant area. As the main control devices they will form a single resource for almost all of the programmable monitoring and control functions in the plant. PCS provides a common database for all devices connected to it and plantwide communication for process control coordination. Equipment layout and design shall conform to Emerson Process Management document "Planning your Ovation System REF_1005".

Sizing considerations are as follows:

a. External I/O associated with a DCU from any combination of hardwired, serial, Ethernet, or other device should be limited to approximately 3,000 to 5,000 points. This includes points through RIO units connected to the DCU. The numbers above could go up or down depending on the complexity of the programming.

b. Location and sizing of Ovation lineups shall be coordinated with the DC Water PCS engineer. In general, the Ovation lineup size can be determined by the I/O quantity. Allow for access to the cabinets from all sides. Ovation lineups will consist of a number of cabinets as follows:

- UPS/Network Cabinet - 24" W x 32" D x 78"H. Front and rear access.
- DCU Cabinet - 24”W x 24"D x 78"H. Front and rear access.
- RIO Cabinet - 24"W x 24"D x 78"H. Front and rear access.
- I/O Cabinet(s) - 24"W x 24”D x 78"H. Front and rear access, number as required.
- PCS cabinets may be installed on matching NEMA rated Plinths only in special cases, especially when bottom conduit/cable entry is required. Provision should be made so that all serviceable components are accessible to average height person without ladder.

c. Naming Conventions. Ovation equipment names shall be unique and based on the Building Abbreviation followed by equipment type abbreviation and then a sequential number. For example, SPBDCU1 would be the first DCU on the Solids Processing Building. Equipment types could be DCU (Distributed Control Unit), RIO (Remote I/O), OWS (Operator Workstation), NET (Network), UPS (Uninterruptible Power Supply), etc.

d. I/O Card Modules. Although other cards are available from Emerson, below are the standard I/O card modules utilized in the PCS system:

- DI Cards - 16 inputs, isolated 120 volt AC.
- DO Cards - 16 outputs, isolated contacts rated 120 volt ac.
- AI Cards - 8 isolated inputs, 4-20 ma, configurable for loop or field power.
- AO Cards - 4 isolated outputs, 4-20 ma.

8A.6.5 Hardwired Signal Interface

Typically, computer system I/O subsystems are designed to accept certain types of signals, both analog and digital. Standard interface signals are listed below. Any other special signals must be coordinated, through DC Water, with the PDE responsible for PCS.

8A.6.5.1 Analog Inputs

The following typical analog signals may be used on the DC Water projects:

- 4 to 20 mA dc into 250 ohms.
- Resistance thermal devices (RTD).
- Thermocouples (J, K, etc.).

8A.6.5.2 Analog Outputs

Use 4 to 20 mA dc into a minimum of 750 ohms at 24 V dc.

8A.6.5.3 Digital Inputs

All digital inputs will be dry, isolated contacts, which will be wetted by the DCU. The wetting voltage will be 120 VAC. Common wiring between signals is not allowed.

8A.6.5.4 Digital Outputs

The digital outputs will be isolated contacts (Form "C") rated for 100 to 200 VA.

If contacts are required in the 5- or 10-amp range, interposing relays will have to be furnished.

8A.6.6 PCS Connection to I/O and Field Devices

The designer will have to select the most appropriate type connection based on proximity to DCU/RIO, are drivers available to match field equipment, separation/number of networks for protocols and reliability (single cable failure should not take down more than one train or facility), and point count. The following guidelines should be used in selection of connection types. Utilization of any connection other than hardwired should have a benefit/risk assessment for DC Water evaluation.

a. Hardwired. Utilize for all equipment where hardwired is available. In some cases, additional information, reliability, or cost can contribute to utilizing the other methods below.

b. Ethernet and Serial communications links:

- DCU
  - Ethernet Connections: Use 3rd Party I/O or Ethernet Link Controller (ELC) Module. Utilize for any device that requires direct communications. ELCs cannot be used for closed loop real time control applications. These must be hard-wired. It may be used for noncritical process control applications only and will require redundant ELC modules. ELCs will be utilized for power monitoring by PMTs, without requirement of redundant modules.
  - Serial Connections: Utilize serial to Ethernet converter and Ethernet module. Utilize for any device where direct communication is required.

- RIO
  - Serial: Use link controller module. Utilize for PMT devices only. Only to be utilized until Emerson can provide Ethernet modules for RIO panels and if DCU is not available within Ethernet cable permitted length.

- SCADA Servers
  - Ethernet: Utilize for any device where direct communication is required. Mainly used for connection to large external PLC networks.

c. Fieldbus and other bus technologies. Do not use Fieldbus and other bus technologies without specific permission of DC Water. It is currently evaluating the long term reliability/feasibility of fieldbus where currently installed at the plant.

8A.6.7 PCS Reliability and Layout

a. To increase reliability and allow system shutdown or maintenance, split process trains such as ODD/EVEN or EAST/WEST on different DCU or RIO units to increase reliability. This will have to be evaluated on a case by case basis during design.
b. To the greatest extent possible, points on modules shall be grouped together such that losing one card, will not take out multiple trains.

c. There shall not be a single point of failure in communications networks, including switches, such that one component will take out multiple process trains.
d. Core, root, and fan out switches shall utilize redundant hardware. Connections between these components shall be redundant with separate physical paths.
e. Fan out switches to DCUs. Connections shall be redundant, but physical path separation is not required. Cables can be in same conduit/fiber bundles.
f. Fan out switches to workstations and servers. Connections shall be redundant, but physical path separation is not required. Cables can be in same conduit/fiber bundles.
g. DCUs shall utilize redundant processors and communications.
h. RIOs shall utilize redundant communication modules.
i. Workstations and Servers shall utilize redundant Ethernet controllers.
j. Redundant ELCs must be mounted side by side on I/O branches in cabinet. When a non-redundant ELC is used, space should be left open on the branch next to it, to allow for potential future addition.

8A.6.8 PCS Configuration and Programming

All designs and programming shall accommodate the requirements in the PCS configuration and Programming guide.

8A.6.9 PLC Applications and Requirements

In order to accomplish the goal of programming mostly in PCS, PLCs should only be used in limited cases, and should only be used for basic control, such as interlocks and sequencing. Use of any PLC has to be approved by DC Water. PLC control should only be used in cases where PLC programs will not need to be changed after initial startup. Incorporating PLCs into plant design should only be done for dedicated control of a piece of equipment, and:

a. for O&M reasons is needed for manual control if a DCU is out of service, or

b. is used to replace relay interlocks in a complex piece of equipment.

c. PLCs should not perform closed or open loop PID control. The design goal is to have all PID control done in PCS.

d. All primary field (analog and digital) signals should be direct inputs to the DCU and not rerouted through the PLC. The design intent is to minimize the I/O of a PLC and to maximize the information available to PCS. This practice will also reduce DC Water's labor in maintaining the I/O databases (PLC and PCS), and the I/O hardware.

e. PLCs should only be used for dedicated control of process equipment such as centrifuges, conveyors, and influent screens where the safety interlocks are complex.

Large blowers, large pumps, variable frequency drives, and centrifuges are examples of equipment that might use PLCs in their normal control scheme. Their PLCs should be specified as part of the responsibilities of the equipment supplier. Typically, all input and output wiring to these PLCs will be internal to the equipment or have a few external signals. Where PLCs are specified, they should conform to the project standards.

All PLC's shall be specified to conform to the requirement of the "PLC Design and Interface Guidelines" in the appendix.

8A.6.10 Control and Monitoring Guidelines

This section defines general guidelines to use in determining which functions should be monitored and which should be controlled.

8A.6.10.1 General Monitoring

Provide a "RUN" status input to PCS for all motors over 1/3 hp except for HVAC equipment. Be careful to provide run status of the driven equipment and not just the motor, in cases where equipment run status and motor run status may be different. For example, if a drive belt is used to drive a piece of equipment and the belt fails, the motor will be indicated as running but the driven equipment will not be.

The following processes and equipment should be monitored:

- Major process variables such as temperature, flows, levels, and pressures.
- Status of major process equipment such as pumps, and blowers (include as a minimum both run status and availability (disconnect and/or breaker).
- Status of process variables or equipment controlled by the DCU.
- Flow, motor amperes and power (watts) for all pumps, blowers, compressors and fans 100 hp and larger.
- For variable speed driven equipment monitor speed input/output. For motors that operate continuously, monitor motor current and power (watts).
- Gas flows to be pressure, temperature, relative humidity compensated.
- Switchgear breaker status and microprocessor breaker monitor.
- Limit switches and torque/overload on valves and gates.
- Status of motors and speed of variable speed devices that are larger than 1/3 hp. Not applicable for HVAC equipment.
- Safety indicators (e.g., chlorine leak detectors).

DC Water has standardized the monitoring of protective devices to be provided for large equipment. Provide PCS monitoring of rotating assemblies for backspin, vibration (xyz), and temperature (windings and bearings) for large motors (75 hp and above) in addition to the hardwired interlocks with the equipment. For pumps of 15 – 75 hp, vibration monitoring shall be provided unless DC Water specifically agrees to waive this requirement on a case by case basis. A combination of discrete, analog, or serial communications to devices is acceptable. Analog monitoring of temperature is preferred over discrete inputs to PCS. The items above are minimum monitoring points; the PDE shall evaluate if other points are beneficial for continuous monitoring.

Alarms must also be monitored. To acknowledge and initiate a response, all emergency and alarm signal conditions must be wired into the nearest DCU for reporting to the operator. Install alarm sensors in equipment that will generate alarm signals for major process equipment problems, process variables, and controlled device failure-to-respond signals. Furnish alarm sensors in equipment to indicate pending problems (i.e., preparatory alarm), such as impending torque overload for a clarifier drive. These alarms are intended to alert the operator of pending problems. Designer to evaluate and discuss with DC Water requirements for manually resetting alarms separate from PCS and having pre-shutdown alarms sent to PCS.

8A.6.10.2 Fire Alarm Monitoring

Note PCS is not intended to monitor fire alarm systems/equipment which should be on a separate system from PCS. PCS should only monitor this type of signal where there are specific hardwired interlocks to process equipment and DC Water Operations needs to know the reason for shutdown.

8A.6.10.3 Facility HVAC

Facility systems such as HVAC are not anticipated or desired to be on PCS at this time. PCS should only monitor this type of signal where there are specific hardwired interlocks to process equipment and DC Water Operations needs to know the reason for shutdown. Exceptions could include environmental monitoring of temperature or air quality. In case the area classification has been lowered by providing air changes, air flow will be monitored and alarmed in PCS.

8A.6.10.4 Actuator Control and Monitoring

Open/Close valves should be designed for separate momentary open and close outputs from PCS.

Modulating or positioning valves should be designed to utilize isolated 4-20 ma input and output signals with PCS with backup discrete signals for monitoring full open and full close positions.

All valves should have discrete inputs to PCS for full open and full close position.

Pump discharge valves should be directly interlocked with pump and not controlled through PCS. PCS will only monitor these valves.

Design should clearly specify what is to happen to actuator on loss of control signal.

8A.6.10.5 Variable Speed Driven Equipment

Variable speed drives shall be designed with separate Hand-Off-Remote controls/switches for start/stop and local/remote switches for speed control. All speed signals shall be designed for 4ma = 0 speed and 20 ma = 100 percent speed. All variable speed drives shall be programmed with a minimum speed to prevent equipment damage regardless of control mode. Designer to specify the above and appropriate submittal requirements. Where cost effective, it is desired to utilize a communication Interface to PCS per Paragraph 8A.6.6 PCS Connection to I/O and Field Devices.

8A.6.10.6 Power Monitoring

Power monitoring shall be provided and connected to PCS on:

- 15kv feeders and mains.
- 5 k feeders and mains.
- Unit substation primary, secondary, all feeders.
- MCC, incoming and tie breakers.
- Large equipment 100 hp and above.
- For equipment 20 to 100 hp, monitor current and KW only.

Power monitor interface to PCS can either be designed for Ethernet or RS485 using Modbus RTU protocol (only if Ethernet connection is not available or approved otherwise by DC Water) with appropriate protocol per Paragraph 8A.6.6 PCS Connection to I/O and Field Devices.

Power monitors interface to PCS shall provide current and voltage on each phase [root mean square (RMS)], power factor (set up to show negative on lagging PF), KW, KWH, and KVAR for each device.

Power monitors shall provide the I/O interface for breaker position status and other alarm points such that PCS will pick up these points through the power monitor rather than have separate hardwired connections to PCS.

PCS will also monitor 5KV and above transformers for alarms such as leak detection, oil level, cooling fan operation, high temp, high/low pressure and transformer monitor fail.

Power monitors shall be completely prewired and tested during the factory test prior to shipment to the jobsite and shall be included in the factory test results submission.

Specify submittal information requirements per the PCS Interfaces section of this requirements document.

8A.6.10.7 Control and Hierarchy Guidelines

Equipment shall be designed such that control is only from one location at a time (i.e., local at driven equipment, control from PLC, control from PCS, or control from the equipment starter/control panel.

Control at driven equipment or field will always take precedence from PCS and disable PCS control.

Safety for both personnel and equipment shall have priority over PCS control.

All devices that transfer or allow control from PCS shall be monitored by PCS such that PCS knows when it has control of the equipment. In some cases, such as control of chemical metering pumps or variable speed drives, separate hand switches will need to be provided for these signals.

Control Switches shall have the designation Hand-Off-Remote or Local-Remote, if control by PCS. Do not utilize Hand-Off-Auto nomenclature.

For variable speed equipment provide separate switches for start/stop and speed. No VFD speed control is required at the driven equipment unless directed by the contract or DC Water.

In general, control outputs to driven equipment 50 hp and larger shall utilize separate momentary start and stop commands from PCS. For equipment, smaller than 50 hp the designer may utilize either maintained outputs or momentary outputs to meet process and budgetary constraints.

Provide manual and automatic controls in accordance with the guidelines below:

Manual. Provide manual control as part of the prepackage equipment or at local control/backup panels. Provide start/stop lockout pushbuttons or switch at driven equipment if local/remote (L/R) switch is remote from driven equipment. Provide an input to PCS that indicates that PCS has control of the equipment. This input must include status of all local/remote selector switches, the stop/lockout pushbutton, and status of the breaker in the MCC or switchgear which feeds the equipment. The interface to the DCU must be designed so that local controls are locked out when the L/R switch is in the remote position, and the DCU is locked out when the L/R switch is in the local position.

Automatic. Full automatic control is to be provided by the DCU and not duplicated in the field. Design device controls are to be as simple and straightforward as possible.

Design the DCU and instrumentation systems for "fail-safe" control. If a DCU fails, all outputs are to remain unchanged, allowing the flows to be hydraulically self-regulated, and thereby maintaining process stability.

8A.6.10.8 Interlocks

Protective interlocks shall be hardwired into the electric circuit of equipment. Signals from protective sensors can be either discrete (contacts) or continuous signals and will have no controllable operator interface. All protective interlocks are to be wholly independent of all location of control signals. Equipment and personnel safety signals and interlocks should be hardwired between equipment and field devices.

Any signals that will shut down or alarm equipment should also be sent to PCS so that PCS knows the specific cause of the shutdown or alarm. Common alarms should be avoided, but if required, the designer should obtain specific approval from DC Water for using a common alarm to PCS. Submit a list to DC Water that defines which equipment is latched and must be manually reset and what is not. Anything that causes shutdown should be latched.

8A.6.10.9 Local Control

Local control is accomplished at or in close proximity to a piece of equipment. Local control functions will include emergency shut-off as required by code; sufficient control for start-up, testing, maintenance and repair functions; and adequate provisions for manual operation in the absence of any higher-level control components.

Local/off/remote or start/stop control shall be provided within 25 feet of all motors. If the driven equipment is not in the same area as the motor, a stop/lockout switch shall be provided at the driven equipment. Open/close controls shall be provided in conjunction with all local/off/remote control for remotely operable valves.

Panel lights shall incorporate a two light system and red shall depict "run" or "open" flowing or energized function (assume ISA standard). Lights should only be provided for equipment whose run status cannot be verified visually, such as a submerged pump. Both the open and closed indicating lights will be lit when a motor operator valve is in travel.

8A.6.11 Field Instrumentation

Use the following standards in selecting field instruments.

8A.6.11.1 Instrument Locations

Instruments should be located in an accessible, dry location not exposed to corrosive elements. The proper location of instruments will allow a long, useful life and will greatly assist in the routine maintenance of the instruments. Refer also to Paragraph 8A.3.2 and 8A.6.19. Locate instruments such that the instrument is protected from adverse conditions and not exposed to corrosion. Avoid installations where an instrument could accidentally be submerged, damaged by passing vehicles, or dripped upon. Provide for installation of instruments in areas adjacent to normal operator travel to allow casual viewing of the local indicator to confirm proper operation. Use intrinsically safe instruments in potentially explosive environment. Control panels and cabinets shall be NEMA 4X 316 stainless steel (fiberglass for chemical resistance is appropriate). Control panels and cabinets installed in hazardous areas shall be NEMA 7 cast aluminum. Use sun shields on all instruments with digital data screens/readouts. Provide disconnect switches for instruments powered by 120vac; install disconnect switches near the instruments.

8A.6.11.2 Flow Meters

Piping and flow meter placement shall be designed to maintain a full pipe under all conditions; whenever possible, flow meters should be installed in a vertical pipe. Flow meters shall be installed in the main pipe, not in a bypass to avoid inaccuracies and additional head loss associated with tees and elbows associated with the bypass.

Use magnetic flow meters for sludge and chemical lines. Chemical lines may require the use of Coriolis flow meters in some areas due to low or pulsating flows.

Size magnetic flow meters to maintain velocity ranges high enough to prevent solids deposition and grease build-up, but not too high that grit content will cause excessive erosion. Design for a minimum velocity of 3 fps for wastewater, and 7-8 fps for sludges. Maximum velocity shall not exceed 25 fps, or less if grit contents are high. Insertion type magnetic flow meters shall not be used. The meter should be a direct current (DC) type with a 4-20mA output for input to PCS.

Use venturis for all water lines. Venturi flow meters should be installed in a horizontal pipe and provided with an auxiliary set of taps for a manometer. Venturis used in other than potable water or air service must have sealed pressure sensors.

Utilize thermal mass meters for air flow measurement on all new processes or processes being modified. Replace existing flow measurement devices on processes being modified with the new meters. Process design should include evaluation as to whether to pick up optional signals such as temperature with the air flow signals.

All flow meters wetted parts shall be compatible with fluid being measured.

For differential pressure devices used in flow applications, provide integral square root extraction at the meter for non-compressible fluids. For compressible fluids such as air, square root extraction will occur within PCS. Designer is responsible for specifying instrument specific formulas for converting differential pressure to actual flow when done within PCS.

8A.6.11.3 Level Measurement

Use ultrasonic level transmitters for chemical tank level measurement. Radar level transmitters should be used for sodium hydroxide chemical tanks. For open channel level measurement, use acoustic transmitters or submerged pressure sensors. Design level transmitters such that any transmitter faults such as loss of echo or near zone alarm conditions cause the transmitter output and any associated alarms to fail to an alarm condition. All alarms shall be transmitted to PCS and follow the alarm priorities identified in the PCS configuration guide. For example, an ultrasonic level transmitter and associated high level associated with a chemical storage tank should fail high and the high level alarm actuate on loss of echo.

Bubbler systems may be used for level measurement in indoor applications only. In the installation, include provisions for rodding out the tube through the clean out tee and for blowing out the tube with a

40-psig-air source. The tube should be fabricated of 1/2-inch 316 stainless steel tubing and cut with a v-notch at the base. The tube should extend into the wet well to a depth of 6 inches above the bottom.

For level measurement applications, where high-high or low-low level could result in equipment damage, a permit violation or endanger personnel safety, provide an independent backup, such as a float switch for the equipment, protective interlocks, and redundant alarm functions as required.

8A.6.11.4 Analytical Measurements

When installing probes in tanks, provide enough interconnecting cable to allow removal of the probe for calibration and for positioning the probe in different locations within the tank. Discuss maintenance requirements and probe mounting details with DC Water.

8A.6.11.5 Temperature Measurement

For temperature measurements, use RTDs whenever possible. All temperature elements shall be installed in wells. Provide a simple means for removal of RTD for calibration and maintenance. Convert resistance to a 4-20 mA dc signal as near to the sensor as practical. Use 4-20 mA dc local indication and input to the computer system. Provide temperature monitors in all process buildings for input to PCS.

8A.6.11.6 Pressure Measurement

Use strain gage, resonant wire or capacitance-type pressure transducers. Output signals shall be 4-20 mA dc. Provide block and bleed manifolds with manometer taps for calibration and maintenance. Wherever possible, use flange-mounted units with a large area diaphragm. Provide a flushing connection, if suitable.

8A.6.11.7 Control Valves

Most applications for modulating control valves can be performed with butterfly valves. If a tight shut-off is required on a sludge service, use a plug valve. Large control ranges may require specialty valves. Whenever possible, mount the valve at floor level, or as a minimum, provide remote-mounted electric pushbutton stations and maintenance platforms for maintenance.

8A.6.11.8 Actuators

The PDE will define which valves and gates will be motor operated, location/requirement for remote control stations, and interface to PCS. Actuators shall be designed and rated for the expected service (i.e., continuous modulating). All controls shall be accessible and viewable without climbing over anything or requiring special equipment such as harnesses or ladders.

8A.6.12 Control Areas and Environments

DC Water has very high corrosion rates in areas of the plant. The design shall include suitable protection for instruments and equipment such as:

- Place all electronic equipment inside a control room where possible.
- Conformal Coating of circuit boards.
- Sealed or encapsulated enclosures.

- Hydrogen sulfide (H_2S) scrubbers and air conditioners on sealed cabinets. Desiccants are not an alternative for purifying air.
- Tinned copper wires for control wiring.
- Equipment shall be located above flood levels for the plant.

Construction sequencing shall be specified to require that environmental controls are operational in PCS equipment areas prior to equipment arriving on site. PCS equipment shall be stored in environmentally controlled areas that meet the requirements of this section.

The control centers and PCS equipment rooms will contain computer equipment. To protect the hardware from corrosion damage due to sulfide and chloride exposure, temperature stress, and humidity-related problems, adhere to the conditions indicated in the ISA Standard 71.04-2013.

The requirements for rooms containing control equipment and room air quality requirements shall be per the latest ISA Standard for Environmental Conditions for Process Measurement and Control Systems in effect. The current ISA Standard for Environmental Conditions for Process Measurement and Control Systems is ISA Standard 71.04-2013.

Electrical rooms shall be equipped with sensors to monitor environmental conditions without requiring entry by personnel. Conditions to be monitored may include room temperature, ventilation, presence of water, and corrosive gases, etc. Conditions exceeding safe levels or desired limits shall activate local alarms at exterior of the room entrances and also send alarm signals to PCS.

8A.6.13 Power Monitoring

Use DC Water standard devices for power monitoring (obtain from DC Water Program Manager and/or DC Water Department of Engineering and Technical Services (DETS). Standard devices are compatible with PCS without additional programming.

8A.6.14 Reliable Power

At Blue Plains AWTP, all PCS equipment, including DCUs and RIOs, shall be designed with dual power feeds connected through an automatic transfer switch (ATS) and appropriate battery powered UPS. This system may either be smaller units for individual panels or large units for areas containing multiple equipment and panels. Provide 4 hour backup minimum for DCU units, RIO units and Control room areas; the UPS shall include static bypass and network management card.

At Water and Sewer Pumping Stations, power shall be supplied to the control and communications equipment including PLCs using battery powered UPS. For all new designs and when already available, design shall include dual power feeds connected through an ATS switch, for existing installations and when dual power feeds are not available, alternative power source shall be provided for maintenance bypassing. In all cases, UPS shall provide 4-hour backup minimum, include static bypass and network management card.

Coordination with electrical designer regarding dual power feeds and ATS shall be performed, as well as, consultation with owner for UPS manufacturer preferences.

The following ATS status conditions shall be monitored and alarmed in PCS:

- Source 1 Available ---- EN8XXXX

- Source 2 Available ---- EN8XXXX
- Source 1 Connected---- JMN8XXXX
- Source 2 Connected---- JMN8XXXX
- ATS Failure--------------MF8XXXX (Alarm)

The following UPS status conditions shall be monitored in PCS via Ethernet:

- Battery Volts --------------EDI8XXXX
- Input Volts ----------------EI8XXXX
- Output Amps---------------II8XXXX
- UPS Status-----------------JA8XXXX (Alarm)
- Bypass Status--------------JF8XXXX (Alarm)
- Battery Temperature------TI8XXXX
- UPS Communication Status-UPS_8XXXXCOMM

8A.6.15 Wiring

Specifications shall indicate splicing is not allowed for any type of control, signal, or communications cabling.

Optional wiring methods should evaluate wireless options where cost savings are possible.

For analog instrumentation wiring, use 19-strand,tinned copper conductors, size no. 16 American Wire Gauge (AWG) minimum with 600-volt type thermoplastic high heat-resistant nylon coated (THHN) or thermoplastic heat and water-resistant and nylon-coated (THWN) insulation.

For instrumentation power and control wiring, use 600-volt, type cross-linked polyethylene high heat-resistant water-resistant (XHHW). For conductors, use stranded copper rated not smaller than size no. 12 AWG for power wiring and not smaller than 14 AWG for control wiring.

Signal shields for a control loop shall be grounded at one location only. In general, the signal shields shall be grounded at the DCU/RIO cabinet.

See Section 9, Electrical, for additional details.

8A.6.16 Surge Protection and Interface Termination Cabinets

DC Water originally required termination cabinets for the initial process facility contracts that were designed with the PCS. DC Water has since determined that the construction contractor can wire directly to PCS equipment. A PDE may conclude that termination cabinets should be provided for a specific reason, which must be approved by DC Water. If termination cabinets are used, provide termination cabinets near the DCU. These panels must be provided with terminal strips, instrumentation power supplies for two-wire circuits, and any other interfacing equipment that would otherwise be mounted in a local control panel. For connections to and from the termination cabinets, use screw-clamp-type terminal strips capable of terminating wire between 12 and 22 AWG. Terminal strips must be neatly arranged and labeled and must be complete with supports, wire ways, and terminal jumpers.

Surge protection shall be required on any wiring that is outside the confines of a building, exposed outdoors, or are in underground duct banks. The PCS cabinets may not have space for surge protection devices and surge protection cabinets should be provided adjacent to the PCS cabinets. These can be combined with instrumentation tray cable (ITC) cabinets where required.

8A.6.17 Instrument and Control Panel Lineups

- Locate DCUs in areas, such as electrical rooms that meet the environmental guidelines of this section.
- Coordinate environmental requirements with the HVAC engineer.
- Provide two 4-inch conduits with inner duct from duct bank to data highway patch panel. Provide two 4-inch conduits with inner duct from patch panel to DCUs.
- Provide large enough openings to buildings and rooms to allow equipment access after buildings are constructed.
- Coordinate with the electrical engineer for proper power conditioning requirements.
- Coordinate with the structural and architectural engineer for raised floors in control centers.
- Coordinate with the mechanical engineer if special fire protection is required in area control centers.
- Permit future expansion by allowing for at least a 25 percent increase in space requirements, minimum of one future I/O cabinet.
- Coordinate with Electrical designer to show pull boxes or cable tray above cabinets and lineups to minimize Ovation cabinets being used as wire ways for signals routed between PCS cabinets and sections. It is not acceptable to show large conduits into PCS cabinets with the intention of routing cable within the cabinets. Specifications shall also require the contractor to coordinate cabinet I/O with conduit penetrations for each cabinet.

8A.6.18 Field Testing

DC Water in the past has had problems with piecemeal testing of "systems" where correction of a failed point resulted in wiring and termination changes for points that had already passed loop tests. In addition, there have been problems with the contractor setting up loop testing and all the equipment had not been pretested prior to the loop test. DC Water's intent is that DC Water be able to remotely control and operate the equipment through PCS immediately following the loop test and have all information needed to safely operate the equipment remotely. (i.e., you may need wet well level to be available before you can start/stop a pump remotely). The designer shall take the following into account in developing the contract documents and construction/testing sequence.

a. Specifications shall require that all equipment be calibrated; communications testing completed, and have pre-loop check completed prior to performing WCLT.

b. Pre-loop tests shall show that data is properly transferred between the field device and the PCS registers, is displayed properly on graphics and executes equipment control commands properly. Document showing the same is to be submitted with WCLT request.

c. Communications test reports shall show confirmation that PCS interfaces to PLCs, PMTs, and other electronic devices properly transfer values to the correct registers.

d. Field calibration Reports that meet the requirements under Maintenance and Calibration.

e. All new PCS Network equipment including servers, Switches, DCUs, RIOs and OWSs are tested for proper functioning/networking with existing system and seamless communication.

f. Witnessed combined loop testing shall be provided to show proper operation between field device and graphics. Graphics programming may be by "others". Witnessed Combined Loop testing shall be for complete "Systems" as defined by the contract "systems test grouping". Communications test reports, and Point-to-Point test results shall be submitted with the WCLT request. WCLT request shall include a list of I/O points to actually be tested and shall be submitted at least one week prior to requested test date. If any part of the "system test grouping" fails that requires rewiring of controls or PLC programming, then the entire "system test group" WCLT shall be retested. Specifications shall define system test grouping.

8A.6.19 Maintenance and Calibration

The continued, useful operation of a control system depends on being able to maintain and calibrate the existing equipment and instruments. Complete documentation and test connections shall be required to assist in maintenance and calibration.

Locate instruments such that routine maintenance does not require ladders or placement of personnel outside of protective handrails. As much as possible, locate transmitters inside to allow calibration during inclement weather. Gate/Valve design documents shall specifically identify where remote mounted controls and indication are required and how oriented. Designer shall provide sufficient installation location and orientation details in drawings to ensure compliance with these requirements.

Instruments should be specified to be certified by the manufacturer for being installed and calibrated in conformance with both the design specifications and the manufacturer's requirements. All certifications and calibration reports shall be submitted to DC Water and be part of the O&M manuals and as part of commissioning reports.

8A.6.19.1 Calibration Reports

Field calibration or confirmation shall be provided that show proper calibration over the full range of the instrument or equipment with values at 4ma and 20 ma or actual instrument output. Calibration reports shall show both the direct measured variable as well as corresponding process variable in process units (i.e., show differential pressure input as well as corresponding flow for differential range or actual pump speed corresponding to the 0-100 percent speed range). Calibration report shall show calculated readings as well as actual feedback and calculate the error. All flow meters using differential pressure measurement shall show anticipated dp reading to flow charts. Calibration reports for discrete points shall show action in both the rising and falling directions as well as set and reset characteristics of the instrument. All calibration reports shall be provided as part of the submittal process prior to WCLT. This will tie into the commissioning specification and construction sequencing. Specifications shall indicate minimum list of requirements that is required in loop test. Specifications shall state that all work must be completed before loop test and no changes are allowed during the loop test.

8A.6.19.2 Loop Drawings and Electrical Wiring

The contract for construction must require complete documentation of all wiring for control systems; modification of the documentation to reflect as-built conditions; and verification of the documentation in the field.

Specifications shall include requirements for complete loop drawings to be provided for all equipment. The drawings shall be complete from final field instrument to PCS equipment terminations or control panel terminations including routing through all panels on one loop drawing. See sample loop drawing requirements in attached Appendix. Provide point to point and interconnections diagrams as per sample attached in the appendix D.

A copy of the final as-built cabinet schematics and wiring diagrams shall be specified to be provided in pockets in each panel with a sign that indicates “Do Not Remove” within the panel. An electronic copy of loop drawing shall be inserted in the PCS service manuals provided by Emerson.

It is intended that all documentation be provided in a searchable, electronic format meeting the requirements for DC Water document management system and Operations & Maintenance Assistance Program (OMAP) requirements.

8A.6.19.3 Test Connections and Bypasses

All instruments that require routine calibration testing, such as pressure transmitters, will be furnished with suitable manifolds, fittings and valves such that a test gage can be easily installed without requiring the shutdown of the process or interruption of the measurement and its transmission to other process instruments. To perform routine maintenance, it should not be necessary to break any permanent piping or electrical connections.

8A.6.19.4 Pressure and Differential Pressure Transmitters

Provide all differential pressure transmitters with a minimum of a three-valve manifold to allow zeroing of the transmitter. Provide manometer taps and isolation valves for all differential pressure transmitters used for flow applications.

Provide all pressure transducers with manifold, shutoff valves and a fitting to which a pressure gage can be attached.

Provide suitable pulsation dampers and isolation seals for the test point.

8A.6.19.5 Pneumatic Control Loops

Provide all pneumatic control loops with a test air supply, a 3- to 15-psi (or suitable) air pressure regulator and gage to simulate transducer output signals into the loop. The air supply, regulator, and gage will be permanently installed adjacent to the transducer.

8A.6.19.6 Current Loops

Provide all current loops with an easily accessible point at which a signal simulator can be placed into the loop.

8A.6.19.7 Analyzers

All analyzers shall be removable from the process lines without disruption of process.

8A.7 NOMENCLATURE

See Paragraph 8A.1, General.

APPENDIX A
PROCESS CONTROL DESCRIPTION

PART 1 [SYSTEM #] ODOR CONTROL - DRY SLUDGE LOADING FACILITY (DSLF) SYSTEM Control Strategies

1.1 **[SYSTEM] Overview -** Odor Control –DSLF

A. **[English explanation of systems process goals]** The Odor Control – DSLF system is designed to remove ammonia and sulfides from the air directed towards it, and is expected to operate continuously as a condition listed in its permit to operate. It is comprised of the subsystems:
   1. Foul Air Supply
   2. Scrubber (Tower with media, sump, and makeup water)
   3. Recirculation and Spray water
   4. Chemical Feed

1.2 **[Sub-System #] -** Foul Air Supply

A. **Overview. [English explanation of sub-system process goal and how it supports the system goal]** The function of the foul air supply system is to draw foul air from various sources and to pass it through the odor scrubber. Source feed to the fan are manually dampened and not part of the PCS Odor Control Strategy.

B. **[Sub-System] Equipment Description: [List all equipment within sub-system that is connected to PCS][List loop number of equipment][State whether equipment is New, Existing, Provided under Separate Contract]**
   1. Foul Air Fan – Loop 77701**[New]**

C. **Related P&IDs [List all P&IDs sheet numbers related to this sub-system]**

D. **Associated DCU [and RIO if applicable]**

E. **Control Descriptions** – Foul Air Fan
   1. **Control Description – Local**
      a. This equipment will operate continuously. Local on and off controls are only for testing.
   2. **Control Description – Remote Panel**
      a. There is no control from remote panel (Elev 20).
   3. **Control Description – PCS Manual**
      a. The start and stop of the fan is done manually from PCS. PCS is the normal operation for this unit.
   4. **Control Description – PCS Auto**
      a. There is no PCS auto operation.

F. **DCU loss of signal - analog**
   1. Will result in DP readings going to zero and alarm.

G. **DCU loss of signal – discrete**

1. Will result in disconnect status position showing OOS and will stop fan in PCS Remote Manual mode. Manual restart of fan on re-establishing discrete signal.

H. **DCU Initialization**
1. No special instruction.

I. **Utility Power Failure**
1. No special instruction.

J. **Monitoring** – Foul Air Fan
1. **Monitoring – Local panel**
   a. Local-Off-Remote Switch
   b. Start-Stop Pushbuttons
   c. Motor and Bearing Temperatures (5) (Analog and alarms)
   d. Vibration (Analog and Alarms)
   e. On/Off Status and Drive Fault
2. **Monitoring – Remote Panel**
   a. Fan on, off, and common fault
3. **Monitoring – PCS**
   a. All I/O

K. **Interlocks** – Foul Air Fan
1. **Hardwired Interlocks**
   a. Motor and Bearing High Temperatures
   b. High vibration
   c. Overload
2. **Soft Interlocks**
   a. None

L. **External PCS I/O [Excluding Alarms] –** Foul Air Fan
1. **Hardwired Discrete inputs**
   a. Running
   b. In Remote
   c. At Speed
   d. In Service (disconnect switch position)
2. **Ethernet Discrete Inputs**
   a. None
3. **Serial Discrete Inputs**
   a. None
4. **Hardwired Analog inputs**
   a. Motor and Bearing Temperatures (5)
   b. Vibration
   c. Differential Pressure across Fan
5. **Ethernet Analog inputs**
   a. None

6. **Serial Analog Inputs**
   a. Power Parameters (10)
   b. Breaker status and position

M. **PCS Internally Generated Points:[Point Description][How Generated]** – Foul Air Fan
1. Low Differential Pressure across fan – Purpose is to provide an indication that expected differential pressure is not great enough to maintain permit flow of the air. Setpoint and time delay after starting if not above setpoint. Provide for a 1 percent deadband.
2. Low /Low Differential Pressure across fan– Purpose is to provide an alarm that expected differential pressure is not great enough for proper airflow to the scrubber system. Setpoint and time delay after fan starting if not above setpoint. Provide for a 1 percent deadband.

N. **Existing PCS I/O Used –** Foul Air Fan
1. None

O. **Alarms** – Foul Air Fan
1. **External Hardwired Alarms**
   a. Drive Fault
   b. Motor and Bearing High Temperatures (5)
   c. High Vibration
2. **External Ethernet Alarms**
   a. None
3. **External Serial Alarms**
   a. None
4. **PCS Generated Alarms**
   a. Low Diff Press
   b. Low – Low Diff Press
   c. Fan not Running

P. **PCS Graphics Requirements**

Q. **Ovation Process Historian Points in addition to all external I/O: -** Foul Air Fan
1. No additional points

R. **ODB Historian Points** – Foul Air Fan
1. Differential Pressure across Fan **[Established by Process]**

1.3 **[Sub-System #]** Scrubber (Tower media, sump, and Make-Up Water)

A. **Overview: [English explanation of sub-system process goal and how it supports the system goal]**
1. Foul air is passed through the two stages of the scrubber via the foul air fan. Each stage consists of a cylindrical vessel with filter media above a sump. The sump captures the spray water injected at the top of the media while the foul air enters at the bottom of the media and exhausts at the top, countercurrent to the spray.

2. This subsystem maintains proper water level and temperature (freeze protection) in the sump and to monitor pressure drop across the media from the foul air supply for each of the two scrubber stages. The sump is the water supply for the recirculation system. A

sump heater will automatically maintain a minimum water temperature. It is intended that make up water will be supplied continuously and the flow control valve be manually adjusted to match the expected evaporation and continuous overflow rate from the sump.

B. **[Sub-System] Equipment Description: [List all equipment within sub-system that is connected to PCS][List loop number of equipment][State whether equipment is New, Existing, Provided under Separate Contract]**
   1. Stage 1 Sump Makeup water solenoid valve and flow meter (loop 777112).**[New]**
   2. Stage 1 Sump Level and high level switch (loop 777113) **[New].**
   3. Stage 1 Sump Temperature, Immersion Heater, and thermostat (loop 777113). **[New]**
   4. Stage 1 Differential Pressure Loss (loop 77711). **[New]**
   5. Stage 2 Sump Makeup water solenoid valve and flow meter (loop 777122). **[New]**
   6. Stage 2 Sump Level and high level switch (loop 777123). **[New]**
   7. Stage 2 Sump Temperature, Immersion Heater, and thermostat (loop 777122). **[New]**
   8. Stage 2 Differential Pressure Loss (loop 77712). **[New]**

C. **Related P&IDs [List all P&IDs sheet numbers related to this sub-system]**

D. **Associated DCU [and RIO if applicable]**

E. **Control Descriptions**-Makeup water solenoid valve
   1. **Control Description- Local**
      a. There is no local control near valve.
   2. **Control Description-Remote Panel**
      a. There is no control from remote panel.
   3. **Control Description -PCS – Manual**
      a. The operator can Open and Close the valve manually from PCS.
   4. **Control Description** Hardwired Interlocks/Shutdowns
      a. High Level will close valve.

F. **Control Descriptions**-Sump Immersion Heater and Thermostat Operation
   1. **Control Description- Local**
      a. Off-Auto selector switch and local indicators.
   2. **Control Description- Local Automatic**
      a. Heater operates based on a low temperature switch.
   3. **Control Description Remote PCS**
      a. None.

G. **DCU loss of signal - analog**
   1. Will result in flow readings going to zero and alarm

H. **DCU loss of signal – discrete**
   1. Status indication will stay open

I. **DCU Initialization**
   1. No special instruction

J. **Utility Power Failure**
   1. No special instruction

K. **Monitoring** – Makeup water solenoid valve:
1. **Monitoring – Local panel**
   a. Not monitored.
2. **Monitoring – Remote Panel**
   a. Not monitored.
3. **Monitoring – PCS**
   a. All I/O

L. **External PCS I/O [Excluding Alarms]**
1. **Hardwired Discrete inputs**
   a. Stage 1 and 2 Sump Level High
   b. Stage 1 and 2 Sump Heater On
2. **Ethernet Discrete Inputs**
   a. None
3. **Serial Discrete Inputs**
   a. None
4. **Hardwired Analog inputs**
   a. Stage 1 and 2 sump make up water flow
   b. Stage 1 and 2 sump temperatures
   c. Stage 1 and 2 sump levels
   d. Stage 1 and 2 differential pressures
5. **Ethernet Analog Inputs**
   a. None
6. **Serial Analog Inputs**
   a. None
7. **Hardwired Discrete Outputs:**
   a. Stage 1 and 2 Make up Water Valves Open/Close (maintained)

M. **PCS Internally Generated Points:[Point Description][How Generated]**
1. Stage 1 Low Temp Stage 1 Sump - Derived from Temperature signal, at and above set point of ????
2. Stage 2 Low Temp Stage 2 Sump - Derived from Temperature signal, at and above set point of ????, 1 percent dead band.
3. Stage 1 Low Make up Water Flow – Derived from flow signal, at and below set point of ??? and time delay of ??? after solenoid valve is sent an open signal from PCS.
4. Stage 1 Low Make up Water Flow – Derived from flow signal, at and below set point of ??? and time delay of ??? after solenoid valve is sent an open signal from PCS.

N. **Existing PCS I/O Used**
1. None

O. **Alarms**
1. Stage 1 High Level
2. Stage 2 High Level
3. Stage 1 Low Make up Water Flow (Internal)
4. Stage 2 Low Make Up Water Flow (Internal)
5. Stage 1 Low Temperature (Internal)
6. Stage 2 Low Temperature (Internal)

P. **Ovation Historian Points in addition to all external I/O**
   1. No additional points

Q. **ODB Historian Points**
   1. None

1.4 **[Sub-System #]** Scrubber Recirculation and Spray water System

A. **Overview: [English explanation of sub-system process goal and how it supports the system goal]**
   1. Recirculation Pumps. The function of the recirculation pumps is to recycle the water in the scrubber sumps by drawing the water from the sumps and pumping it on the spray headers above the scrubber media to "wash" the foul air as it is blown upward through the media. Recycle system operates continuously and will be operated manually. A standby recirculation system is provided that can be manually valved for either scrubber stage or the future scrubber stages.
   2. Analyzers. The function of the pH and oxidation reduction potential (ORP) sensors are to analyze the recirculation water. Contaminants in the foul air captured by the water affect the acidity and oxidation reduction potential of the water. The analyzer readings are used to control application of chemicals to bring the water to a neutral status.

B. **[Sub-System] Equipment Description: [List all equipment within sub-system that is connected to PCS][List loop number of equipment][State whether equipment is New, Existing, Provided under Separate Contract]**
   1. Recirc System 1; Pump, pH Analyzer, and seal water (loop 77711x), dedicated to stage 1. **[New]**
   2. Recirc System 2; Pump, pH Analyzer, and seal water (loop 77712x), dedicated to stage 2. **[New]**
   3. Recirc system 3; Pump, pH Analyzer, and seal water (loop 77713x), standby system can be valved to stage 1 or stage 2 as needed, also standby for future scrubber system. **[New]**

C. **Related P&IDs [List all P&IDs sheet numbers related to this sub-system]**

D. **Associated DCU [and RIO if applicable]**

E. **Control Descriptions-**Recirculation Pump
   1. **Control Description- Local**
      a. No Local Control
   2. **Control Description- Remote Panel**
      a. No Remote Panel Control
   3. **Control Description- PCS Manual**
      a. Start and Stop soft switches
   4. **Control Description- PCS Auto**
      a. No PCS Auto Control

F. **Monitoring -**Recirculation Pump:
   1. **Monitoring-Local**
      a. No Local Panel

2. **Monitoring- Odor Scrubber 1 Control Panel.**
   a. Hand-Off-Remote Switch.
   b. (**Recirc Pump 3 ONLY)** Off-DSLF Stage1-DSLF Stage2 – FDF Stage 1 – FDF Stage 2 Switch (FDF Stage 1 and 2 are for future equipment)
   c. On, Off, seal water fail, and Overload indication
3. **Monitoring- PCS**
   a. Hand-Off-Remote Switch

G. **Interlocks-** Recirculation Pump
1. **Hardwired Interlocks/Shutdowns.**
   a. Seal water control and loss of seal water shutdown.
2. **Software Interlock/Shutdown**
   a. Recirculation pump 1 shutdown on low level from stage 1 sump.
   b. Recirculation pump 2 shutdown on low level from stage 2 sump.
   c. Standby recirc pump 3 will interlock to appropriate low sump level switch based on the field selector switch.

H. **DCU loss of signal – analog**
1. Analytical values (pH, ORP) will go to zero.

I. **DCU loss of signal – discrete**
1. Status monitoring will go to "open" indication.

J. **DCU Initialization**
1. No special instruction

K. **Utility Power Failure**
1. No special instruction

L. **External PCS I/O [Excluding Alarms]**
1. **Hardwired Discrete inputs:**
   a. For each of the three recirculation systems; run status. In remote, In Service, Overload status, and seal water fail.
2. **Ethernet Discrete Inputs**
   a. None
3. **Serial Discrete Inputs**
   a. None
4. **Hardwired Discrete Outputs**
   a. For each of the three recirculation systems; maintained pump run/off signal.
5. **Ethernet Discrete Outputs**
   a. None
6. **Serial Discrete Outputs**
   a. None
7. **Hardwired Analog inputs**
   a. Recirculation System 1 pH.
   b. Recirculation System 2 pH, ORP.
   c. Recirculation System 3 pH, ORP.
8. **Ethernet Analog Inputs**
   a. None

9. **Serial Analog Inputs**
   a. None
10. **Hardwired Analog Outputs**
    a. None
11. **Ethernet Analog Outputs**
    a. None
12. **Serial Analog Outputs**
    a. None

M. **PCS Internally Generated Points:[Point Description][How it is Generated]**
1. Stage 1 pH. Will either be the value from Recirc system1 pH or Recirc System 3 pH based on whether Recirc System 3 configuration switch is set to stage 1.
2. Stage 2 pH. Will either be the value from Recirc system2 pH or Recirc System 3 pH based on whether Recirc System 3 configuration switch is set to stage 2.
3. Stage 2 ORP. Will either be the value from Recirc system2 ORP or Recirc System 3 ORP based on whether Recirc System 3 configuration switch is set to stage 2.
4. Recirc Pump System Mismatch. Shall go true (alarm) on any of the following:
   a. Recirc pump 3 standby mode is set to off and Recirc pump 3 is running.
   b. (Recirc pump 3 is set to Stage 1) and (Recirc pump 1 is in Remote or recirc pump 1 is running).
   c. (Recirc pump 3 is set to stage 2) and (Recirc pump 2 is in Remote or recirc pump 2 is running).
5. Stage 1 pressure low (high??) - Alarms at and below a set point of xxx, time delay of xxx after odor control **FAN** is running. 1 percent dead band. Note alarm only need if the Fan is running (odor control system on).
6. Stage 2 pressure low (high??) - Alarms at and below a set point of xxx, time delay of xxx after odor control **FAN** is running. 1 percent dead band. Note alarm only need if the Fan is running (odor control system on).
7. Stage 1 pH low (high???) - Alarms at and below a set point of xxx, time delay of xxx after selected in service recirc pump is running 1 percent dead band.
8. Stage 2 pH low (high???) - Alarms at and below a set point of xxx, time delay of xxx after selected in service recirc pump is running 1 percent dead band.
9. Stage 1 ORP low (high???) - Alarms at and below a set point of xxx, time delay of xxx after selected in service recirc pump is running 1 percent dead band.
10. Recirc Pump not running with Fan, time delay of xx minutes after fan is running.

N. **Existing PCS I/O Used**: Recirculating Pumps
1. None

O. **Alarms:** Recirculating Pumps
1. **External Hardwired Alarms**
   a. None
2. **External Ethernet Alarms**
   a. None
3. **External Serial Alarms**
   a. None

4. **PCS Generated Alarms**
   a. Recirc pump Mismatch is true (Internal)
   b. Stage 1 pH Low (Internal)
   c. Stage 2 pH Low (Internal)
   d. Stage 2 ORP Low (Internal)
   e. Stage 1 pressure low (Internal)
   f. Stage 2 pressure low (Internal)

P. **PCS Graphics Requirements**

Q. **Ovation Historian Points in addition to all external I/O: Recirculating** Pumps
1. Stage 1 pH (internal)
2. Stage 2 pH and ORP (internal)

R. **ODB Historian Points:** Recirculating Pumps
1. Stage 1 pH (internal)
2. Stage 2 pH and ORP (internal)

1.5 **[Sub-System #]** Scrubber Chemical Feed Systems

A. **Overview: [English explanation of sub-system process goal and how it supports the system goal] Chemical Feed. The pumps are used to apply chemical to the scrubber wash water to correct levels of pH and ORP. System will run continuously with automatic speed adjustment to provide the correct amount of chemicals.**

B. **[Sub-System] Equipment Description: [List all equipment within sub-system that is connected to PCS][List loop number of equipment][State whether equipment is New, Existing, Provided under Separate Contract]**
1. H2SO4 Feed Pump and High pressure switch (loops 77750)**. [New]**
2. NaOCL Feed Pump and High pressure switch (loops 77740). **[New]**
3. NaOH Feed Pump and High pressure switch (loops 77730). **[New]**

C. **Related P&IDs [List all P&IDs sheet numbers related to this sub-system]**

D. **Associated DCU [and RIO if applicable]**

E. **Control Descriptions - Scrubber Chemical Feed Systems**
1. **Control Description-Local** control near driven equipment, (integral variable speed drive on pump).
   a. Local-Off-Remote (one switch for start and stop, and speed control)
   b. Start and Stop pushbuttons
   c. Speed Setting input
   d. Status for running, hose fail, speed, and drive fault
2. **Control Description- Remote Panel**– Odor Scrubber 1 Control Panel
   a. On and Off status
   b. Hose fail
3. **Control Description- PCS Manual**
   a. Start and Stop manual soft switch
   b. Manual – Auto Soft switch (speed only)
   c. Manual percent speed set point when in manual

4. **Control Description- PCS Auto**
   a. Speed shall vary (PI control) to maintain either pH or ORP in each stage as follows:
      a) Sulfuric Acid pump will maintain the pH in stage 1 using the stage 1 pH signal.
      b) Caustic Pump will maintain pH in Stage 2 using the stage 2 pH signal.
      c) Hypochlorite pump will maintain ORP in stage 2 using the s Running, In Auto, Hose Fail, Drive Fault, and High pressure for each pump Stage 2 ORP signal.
   b. Special loop tuning and startup/commissioning notes:
      a) For any startup of the system, plant operators will initially manually set the rates for chemical feed. After system has stabilized, operators will place the speed control loop in automatic so loop does not have to be tuned to account for start-up conditions.

F. **Interlocks** - Scrubber Chemical Feed Systems

1. **Hardwired Interlocks/Shutdowns**
   a. High Pressure
   b. Hose Fail, drive Fault
2. **Soft Interlocks/Shutdowns**
   a. None

G. **External PCS I/O:[Excluding Alarms]** Scrubber Chemical Feed Systems

1. **Hardwired Discrete inputs**
   a. Running
   b. In Auto
   c. Hose Fail
   d. Drive Fault
   e. High pressure for each pump
2. **Ethernet Discrete Inputs**
   a. None
3. **Serial Discrete Inputs**
   a. None
4. **Hardwired Discrete outputs**
   a. Start/Stop maintained, for each pump
5. **Ethernet Discrete Outputs**
   a. None
6. **Serial Discrete Outputs**
   a. None
7. **Hardwired Analog inputs**
   a. Speed for each pump
8. **Ethernet Analog Input**:
   a. None
9. **Serial Discrete Inputs**
   a. None
10. **Hardwired Analog outputs**
    a. Speed for each pump
11. **Ethernet Analog Outputs**
    a. None
12. **Serial Analog Outputs**
    a. None

H. **PCS Internally Generated Points**
   1. None.

I. **Alarms:** Scrubber Chemical Feed Systems
   1. **External Hardwired Alarms**
      a. Drive Fault
      b. Hose Fail
      c. High Pressure
   2. **External Ethernet Alarms**
      a. None
   3. **External Serial Alarms**
      a. None
   4. **PCS Generated Alarms**
      a. None

J. **Ovation Historian Points in addition to all external I/O:** Scrubber Chemical Feed Systems
   1. No additional points required.

K. **ODB Historian Points**
   1. None

1.6 **[Sub-System #]** Scrubber Chemical Storage, unloading, and containment

Overview: [English explanation of sub-system process goal and how it supports the system goal] Chemical Supply and Storage. This system provides for truck unloading, storage, leak containment and supply of the chemicals used by the chemical feed system.

1. **[Sub-System] Equipment Description: [List all equipment within sub-system that is connected to PCS][List loop number of equipment][State whether equipment is New, Existing, Provided under Separate Contract]**
2. Sodium Hydroxide Caustic Tank Level and level Switch – Loop 77730. **[New]**
3. Sodium Hypochlorite Tank level and level switch – Loop 77740. **[New]**
4. Sodium Hypochlorite and Hydroxide Containment leak – Loop 7740. **[New]**
5. Sulfuric Acid Tank Level and Level Switch – Loop 77750. **[New]**
6. Sulfuric Acid Containment Leak – Loop 7750. **[New]**

B. **Related P&IDs [List all P&IDs sheet numbers related to this sub-system]**

C. **Associated DCU [and RIO if applicable]**

D. **Control Descriptions -** Scrubber Chemical Storage, unloading, and containment
   1. **Control Description-** Caustic/Hypo Unloading Panel
      a. Silence High Alarm
   2. **Control Description-** Sulfuric Acid Unloading Panel
      a. Silence High Alarm
   3. **Control Description-** Chemical Tanks Level Panel
      a. Silence High Alarm

E. **DCU loss of signal – analog**
   1. Level measurements will go to zero.

F. **DCU loss of signal – discrete**
   1. Status monitoring will go to "open" indication.

G. **DCU Initialization**
   1. No special instruction

H. **Utility Power Failure**
   1. No special instruction

I. **Monitoring:** Scrubber Chemical Storage, unloading, and containment-
   1. **Monitoring**– Caustic/Hypo Unloading Panel
      a. Each tank level and High alarm
   2. **Monitoring–** Sulfuric Acid Unloading Panel
      a. Each tank level and High alarm
   3. **Monitoring**– Chemical Tanks Level Panel
      a. High Level lights for each tank and each containment area

J. **Interlocks/Shutdowns**: Scrubber Chemical Storage, unloading, and containment
   1. None

K. **External PCS I/O:[Excluding Alarms]** Scrubber Chemical Storage, unloading, and containment
   1. **Hardwired Discrete inputs**
      a. Tank High level for each of three tanks
      b. Containment leak in each of two containment areas
   2. **Ethernet Discrete inputs**
      a. None
   3. **Serial Discrete inputs**
      a. None
   4. **Hardwired Discrete outputs**
      a. None
   5. **Ethernet Discrete outputs**
      a. None
   6. **Serial Discrete outputs**
      a. None
   7. **Hardwired Analog inputs**
      a. Tank Level for each of three tanks.
   8. **Ethernet Analog inputs**
      a. None
   9. **Serial Analog inputs**
      a. None
   10. **Hardwired Analog outputs**
      a. None
   11. **Ethernet Analog outputs**
      a. None
   12. **Serial Analog outputs**
      a. None

L. **PCS Internally Generated Points:[Point Description][How Generated]** Scrubber Chemical Storage, unloading, and containment
   1. Caustic Tank Low Level – Derived from level signal, at and below set point of ???? and time delay of 2 seconds.
   2. Hypochlorite Tank Low Level – Derived from level signal, at and below set point of ???? and time delay of 2 seconds.
   3. Hypochlorite Tank Low Level – Derived from level signal, at and below set point of ???? and time delay of 2 seconds.
   4. Caustic Tank High Level – Derived from level signal, at and above set point of ???? and time delay of 2 seconds.
   5. Hypochlorite Tank High Level – Derived from level signal, at and above set point of ???? and time delay of 2 seconds.
   6. Hypochlorite Tank High Level – Derived from level signal, at and above set point of ???? and time delay of 2 seconds.
   7. Caustic tank rate of change and alarm – continuously indicate and monitor the drawdown rate, for any drawdown greater than xxx inches per minute, initiate a leak alarm.
   8. Hypochlorite tank rate of change and alarm – continuously indicate and monitor the drawdown rate, for any drawdown greater than xxx inches per minute, initiate a leak alarm.
   9. Sulfuric Acid tank rate of change and alarm – continuously indicate and monitor the drawdown rate, for any drawdown greater than xxx inches per minute, initiate a leak alarm.

M. **Alarms:** Scrubber Chemical Storage, unloading, and containment
   1. Caustic Tank Alarm – Common High and Low level alarms, calculated or external.
   2. Hypochlorite Tank Alarm - Common High and Low level alarms, calculated or external.
   3. Sulfuric Acid Tank Alarm - Common High and Low level alarms, calculated or external.
   4. Leak Alarm, Sulfuric Acid Containment – Combination of high level in containment as well as calculated high rate of change.
   5. Leak alarm, Caustic and Hypo Containment - Combination of high level in containment as well as calculated high rate of change with either tank.

N. **Ovation Historian Points in addition to all external I/O:** Scrubber Chemical Storage, unloading, and containment
   1. Rate of change for each tank

O. **ODB Historian Points:** Scrubber Chemical Storage, unloading, and containment
   1. Tank Levels for each tank

1.7 **[Sub-System #]** Odor Control DSLF System and Alarm Requirements (In PCS)

A. Odor Control DSLF System Out of Service. Provide a soft "Out of Service" button that:
   1. Disables all alarms associated with the operation of this system.
   2. Disables PCS control outputs of all equipment described as part of this system.
   3. Ovation stores the System "Out of Service" condition as a discrete input in the historian.
   4. Provides visual indication by turning equipment designated as part of this system on the graphics to the designated Out of Service color.

B. PCS Internally Generated points:
   1. One common alarm for all scrubber system alarms not designated as safety or permit in the above subsystems. Description would be “Odor Control – DSLF Trouble.”

C. Alarm Priorities:
   1. Priority 1 Alarms (permit or Safety)
      a. Odor Fan not running
   2. Priority 2 Alarms (equipment and operating alarms)
      a. Odor Control - DSLF Trouble

   3. Priority 4 Alarms (individual equipment alarms when there is a common in Priority 2)
      a. As shown in the individual system descriptions.

D. Provide an alarm screen to view all alarms with this system.

PART 2 ODOR CONTROL – FDF SYSTEM CONTROL STRATEGIES

1.8 **[Sub-System #]** Odor Control –FDF System Overview

Overview: [English explanation of sub-system process goal and how it supports the system goal] The Solid State Reduced Voltage Starter is provided for the future FDF Odor Control system Fan. Under this contract, only the PMT and associated breaker monitoring points are being tied to PCS. Although the starter controls and interlocks will be shown to be provided to match the DSLF odor fan starter, it will not be connected nor tested with PCS at this time, except for the PMT interface.

1.9 **[Sub-System #]** Foul Air Supply

A. System Equipment Description
   1. PMT and Breaker status monitoring of starter for future equipment. – Loop ???

B. External I/O to PCS
   1. PCS Serial Inputs
      a. Power Parameters (10)
      b. Breaker status and position

C. PCS Internally Generated Points
   1. None

D. Ovation Alarms
   1. None

E. Ovation Historian Points in addition to all external I/O
   1. No additional points

F. ODB Historian Points
   1. Power Parameters (10)

PART 3 EYE WASH AND MONITORING

1.10 **[Sub-System #]** Eyewash Monitoring Overview. Activating an eye wash actuates a flow switch that is used for monitoring and alarming.

1.11 Eyewash Monitoring

A. System Equipment Description
1. Eyewash Chemical Room - Loop 8912. **[New]**
2. Eyewash Chemical Unloading **-** Loop 8911. **[New]**

B. **Related P&IDs [List all P&IDs sheet numbers related to this sub-system**]

C. **Associated DCU [and RIO if applicable]**

D. **Control and Monitoring Descriptions:** Eyewash Monitoring
1. **Monitoring and Control Descriptions**-Local
   a. Strobe and horn near eyewash with silence pushbutton
2. **Remote Monitoring -**PCS
   a. Eyewash actuated.
3. **Hardwired Interlocks**
   a. Local silence pushbutton, horn, and strobe

E. **External PCS I/O**
1. PCS Discrete Inputs
   a. Eyewash activated for each eye wash

F. **Alarm Priorities**
1. Priority 1 Alarms (permit or Safety)
   a. Eyewash activated for each eye wash

G. **Alarms**
1. Eyewash activated for each eye wash

H. **Ovation Historian Points in addition to all external points**
1. No additional points required.

I. ODB Historian Points
1. None

1.12 **[Sub-System #]** Eyewash System and Alarm Requirements (In PCS)

A. **Alarm Priorities:**
1. Priority 1 Alarms (permit or Safety)
   a. All eye wash alarms

PART 4 GAS MONITORING

1.13 **[Sub-System #]** Gas Monitoring. This system provides for safety monitoring of gasses that could be produced from the raw chemicals being stored or a combination of chemicals. This system is for monitoring only.

1.14 Gas Monitoring

A. System Equipment Description
1. xxx.
2. xxx.

B. Operation and Monitoring Description
1. Local Monitoring and Control - xxx.
   a. xxx.
2. Remote Monitoring in PCS.
   a. xxx.
3. Hardwired Interlocks.
   a. xxx.

C. External I/O
1. PCS Discrete Inputs.
   a. xxx

D. Alarm Priorities
1. Priority 1 Alarms (permit or Safety).
   a. ??
2. Priority 2 Alarms.
   a. ???
3. Priority 4 Alarms: (individual equipment alarms).
   a. ???

E. Alarms:
1. xxx.

F. Ovation Historian Points in addition to all external points
1. No additional points required.

G. ODB Historian Points
1. None

PART 5 HVAC AND ENVIRONMENTAL

1.15 **[Sub-System #]** HVAC and Environmental Overview

A. Chemical Room. System will monitor operation of equipment and temperature in this area due to possible accumulation of gases in case of failure. Units are expected to operate continuously.

B. Electrical Room. System will monitor operation of equipment in this area due to sensitive nature of equipment in this room to temperature and corrosion. Filtration unit is expected to operate continuously.

1.16 HVAC and Environmental Monitoring and Control

A. System Equipment Description:
  1. Chemical Room Supply Fan - Loop 8923. **[New]**
  2. Chemical Room Exhaust Fan - Loop 8924. **[New]**
  3. Chemical Room Temperature - Loop 8927. **[New]**
  4. Electrical Room Air Filtration Unit - 8921. **[New]**
  5. Electrical Room Air Handling Unit – 8922. **[New]**

B. Operation and Monitoring Description
  1. **Monitoring and Control**-Local
    a. Run status of each fan or unit being monitored
    b. Start and Stop pushbuttons.
  2. **Monitoring and Control** - PCS
    a. Run status of each fan or unit being monitored
  3. Hardwired Interlocks
    a. All controls hardwired with HVAC system

C. External PCS I/O
  1. PCS Discrete Input
    a. Run Status of each fan or unit being monitored
  2. PSC Analog Input
    a. Chemical Room Temperature

D. PCS Internally Generated I/O
  1. High temperature in chemical room, alarm at and above a set point of xxx, xxx delay time, and 1 percent dead band
  2. In areas where keeping H2S out, alarm to detect if systems are down during cold season

E. Alarm Priorities
  1. Priority 1 Alarms (critical, permit or Safety)
    a. None
  2. Priority 2 Alarms (Process, major impact)
    a. None
  3. Priority 3 Alarms (Process, minor impact)
    a. None
  4. Priority 4 Alarms (Electrical)
    a. Alarms related electrical equipment performance)

F. Ovation Historian Points in addition to all external points
  1. No additional points required.

G. ODB Historian Points
  1. None

PART 6 ELECTRICAL BELOW 600 VOLT

1.17 **[Sub-System #]** Electrical Below 600 Volt Overview

A. MCC-67. Provides 480 volt distribution and motor control to equipment in area. Supplied with two sources of power in a Main 1 – Tie – Main 2 arrangement. Main-Tie-Main and large loads (above 100 hp) are provided with PMTs for comprehensive power monitoring as well as breaker health and status. Individual load monitoring and control covered with equipment operating descriptions. Descriptions in this section pertain to distribution only, and as such only cover the Mains and Tie breakers. No other distribution breakers are remotely monitored.

B. Backup/Redundant Power.
   1. An Automatic transfer switch provides two sources of power to a panel board that feeds all 120/240 equipment in the area, including:
      a. Chemical feed pumps
      b. Lighting and receptacles
      c. Control panels
      d. PCS equipment
      e. Instrumentation
      f. Eyewashes
      g. Cameras
   2. An uninterruptable power supply (UPS) which feeds the PCS RIO panel. PCS system monitors status and health of the system.

1.18 **[Sub-System #]** Motor Control Centers

A. System Equipment Description
   1. Main for Line A – Loop 89261
   2. Main for Line B – Loop 89262
   3. Tie Breaker – Loop 89263

B. Operation and Monitoring Description
   1. Local Monitoring and Control – At MCC
      a. All equipment with local operation and indication

C. External I/O
   1. PCS Serial Input
      a. For each breaker, PMT monitoring of 10 power parameters.
      b. For each breaker, monitoring of tripped and Open/Close status.

D. PCS Internally Generated I/O
   1. MCC-67 Trouble – Common alarm for breaker tripped from mains or tie.

E. Alarm Priorities
   1. Priority 2 Alarms
      a. MCC-67 Trouble (Internal)
   2. Priority 4 Alarms: (individual equipment alarms)
      a. Breaker tripped for each main and Tie

F. Ovation Historian Points in addition to all external points
   1. No additional points required.

G. ODB Historian Points.
   1. All 10 power points obtained from each PMT.

1.19 **[Sub-System #]** Backup/Redundant Power Equipment

A. System Equipment Description
   1. ATS-OCALP1 – Loop 8925, 89251, 89252
   2. UPS – 85810

B. ATS Operation and Monitoring Description
   1. Local Monitoring and Control – At ATS
      a. All equipment with local operation and indication.

C. UPS Operation and Monitoring Description:
   1. Local Monitoring and Control – At UPS.
      a. All equipment with local operation and indication.

D. External I/O
   1. PCS Discrete Input
      a. ATS Points; Fail, Source 1 Available, Source 1 Connected Source 2 Available, Source 2 Connected

   2. PCS Ethernet Discrete Input
      a. UPS Points
         1) Bypass Status (UPS out of Service and bypassed)
         2) UPS Status (Common trouble, including operating on battery, loss of supply, etc.)
   3. PCS Ethernet Analog Input
      a. UPS Points
         1) Input voltage
         2) Battery voltage
         3) Output current.
         4) Temperature

E. PCS Internally Generated I/O
   1. UPS Communications timeout
   2. Low Battery voltage
   3. ATS Trouble if (ATS Fail signal) or (Both powers sources not available)

F. Alarm Priorities
   1. Priority 2 Alarms
      a. ATS Trouble
   2. Priority 3 Alarms (PCS Equipment)
      a. UPS Status (Not Normal)
      b. UPS In Bypass
      c. UPS Low Battery Voltage

3. Priority 4 Alarms: (individual equipment alarms)
    a. ATS Fail
    b. ATS Source 1 not available
    c. ATS Source 2 Not available

G. Ovation Historian Points in addition to all external points.
    1. No additional points required.

H. ODB Historian Points
    1. None

APPENDIX B
SAMPLE I/O LIST

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Process	ProcessCMS	ProcessGroup	System	ProcSubSYSTEM	Sub System	Equipment	PNAME	DESC	SET DESC	RESET DESC	ENG UNITS	LOPRANGE	HOPRANGE	IOSIGNAL	IO TYPE	POWER	OVINTERFACE	OINTERFACE	OVINTERFACETYPE	PROTOCOL	ISA_ID	LOOP	ALM PRIORITY	ALM TYPE	ALM DESC	P&ID	Remark
G SOLIDS PROCESSING	G4 SOLIDS DEWATERING	FINAL DEWATERING FACILITIES	SLUDGE FEED	BELT FILTER PRESS		SLUDGE RECIRCULATION PUMPS	FI7273	RECIRC RETURN SLUDGE FLOW			GPM	0	800	4-20MA	AI	SELF	MPTDCU1	SPBRIO5	RIO		FI	7273	2	HI,LO	FLOW	I-6	Existing DCU/RIO
G SOLIDS PROCESSING	G4 SOLIDS DEWATERING	FINAL DEWATERING FACILITIES	SLUDGE FEED	BELT FILTER PRESS		SLUDGE RECIRCULATION PUMPS	PI72721	RECIRC SL VENTURI INLET PRESS			PSI	0	150	4-20MA	AI	SELF	MPTDCU1	SPBRIO5	RIO		PI	72721	2	HI	PRESS	I-11	Existing DCU/RIO
G SOLIDS PROCESSING	G4 SOLIDS DEWATERING	FINAL DEWATERING FACILITIES	SLUDGE FEED	BELT FILTER PRESS		SLUDGE RECIRCULATION PUMP FD	MN7216	RECIRC PUMP 1 ON	RUN	OFF				120VAC	DI	SELF	MPTDCU1	SPBRIO5	RIO		MN	7216					
G SOLIDS PROCESSING	G4 SOLIDS DEWATERING	FINAL DEWATERING FACILITIES	SLUDGE FEED	BELT FILTER PRESS		SBT-3 OUTLET VALVE 1	ZH72701	SBT-3 OUTLET VALVE 1 OPEN	OPEN	NFOPEN				120VAC	DI	SELF	MPTDCU1	SPBRIO5	RIO		ZH	72701					Existing DCU/RIO
G SOLIDS PROCESSING	G4 SOLIDS DEWATERING	FINAL DEWATERING FACILITIES	SLUDGE FEED	BELT FILTER PRESS		SBT-3 OUTLET VALVE 1	ZL72701	SBT-3 OUTLET VALVE 1 CLOSED	CLOSED	NFCLSD				120VAC	DI	SELF	MPTDCU1	SPBRIO5	RIO		ZL	72701					Existing DCU/RIO
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SCUM PUMPING	GT 1-4 SCM WELL		GT 1&3 SCM WELL LVL XMTR	LI61120	GT 1&3 SCM WELL LVL			FT	0	11	4-20mA	AI	FIELD	GTCBDCU1	GTCBDCU1	LOCAL		LI	61120					
I PLANTWIDE SYSTEMS	I4 PLANTWIDE INFRASTRUCTURE	GAS MONITORING	GRAVITY THICKENING CONTROL BUILDING	COMB		GT1 COMBUSTIBLE GAS DETECTOR	AGI61113	GT1 COMBUSTIBLE GAS DETECTOR			PCT	0	100	4-20mA	AI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		AGI	61113					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SLUDGE PUMPING	INSTRUMENTATION		GT3 OUTLT DENSITY XMTR	DI61314	GT3 OUTLT DENSITY			PCT	0	10	4-20mA	AI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		DI	61314					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 COLLECTOR	GT3 COLL		GT3 COLL	YI61313	GT3 COLL TRQ			PCT	0	100	4-20mA	AI	FIELD	GTCBDCU1	GTCBDCU1	LOCAL		YI	61313					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SLUDGE PUMPING	GT3 SLDG PMP 3B		GT3 SLDG PMP 3B	SI61312	GT3 SLDG PMP 3B SPEED			PCT	0	100	4-20mA	AI	FIELD	GTCBDCU1	GTCBDCU1	LOCAL		SI	61312					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SLUDGE PUMPING	GT3 SLDG PMP 3A		GT3 SLDG PMP 3A	SI61311	GT3 SLDG PMP 3A SPEED			PCT	0	100	4-20mA	AI	FIELD	GTCBDCU1	GTCBDCU1	LOCAL		SI	61311					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SCUM PUMPING	GT 1-4 SCM WELL		GT 2&4 SCM WELL LVL XMTR	LI61220	GT 2&4 SCM WELL LVL			FEET	0	11	4-20mA	AI	FIELD	GTCBDCU1	GTCBDCU1	LOCAL		LI	61220					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SLUDGE PUMPING	FLOW		GT2 OUTLT FLOW XMTR	FI61214	GT2 SLUDGE FLOW			GPM	0	250	4-20mA	AI	FIELD	GTCBDCU1	GTCBDCU1	LOCAL		FI	61214					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SLUDGE PUMPING	INSTRUMENTATION		GT2 OUTLT DENSITY XMTR	DI61214	GT2 OUTLT DENSITY			PCT	0	10	4-20mA	AI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		DI	61214					
K ELECTRICAL SYSTEMS	K3 ELECTRICAL 5KV	AREA SUBSTATIONS	ASS1-SC9B	PMT-ASS1-SC9B		BREAKER	JZO81092	ASS1 FDR BRK SC9B BRKR POS	CLSD	OPND							SBBDCU1	ASS1RIO1	LC								
K ELECTRICAL SYSTEMS	K3 ELECTRICAL 5KV	AREA SUBSTATIONS	ASS1-SC9B	PMT-ASS1-SC9B		BREAKER	JZT81092	ASS1 FDR BRK SC9B BRKR TRIP	NORMAL	TRIP							SBBDCU1	ASS1RIO1	LC								
K ELECTRICAL SYSTEMS	K1 ELECTRICAL 15KV	AREA SUBSTATIONS	ASS1 LINE C	FDR BRK SC06		POWER MONITORING	II81085	ASS1 FDR BRKR SC6 CURR			AMPS	0	800	RS485	AI		SBBDCU1	ASS1RIO1	LC								
K ELECTRICAL SYSTEMS	K1 ELECTRICAL 15KV	AREA SUBSTATIONS	ASS1 LINE B	15KV PRI BRK PB2		POWER MONITORING	EI81021	ASS1 PRI BUS PB2 VOLT			VOLTS	0	30000	RS485	AI		SBBDCU1	ASS1RIO1	LC								
K ELECTRICAL	K3 ELECTRICAL 5KV	UNIT SUBSTATIONS	FTF SWGR	FTF SWGR		BREAKER	JZT81605	FTF SWGR FDR BRK MBB TRIP	NORMAL	TRIP	PF	N/A	N/A	ETHERNET	AI		FTFDCU1	ELC		MODBUS TCP							
K ELECTRICAL	K3 ELECTRICAL 5KV	UNIT SUBSTATIONS	FTF SWGR	FTF SWGR		BREAKER	JZO81605	FTF SWGR FDR BRK MBB OPEN	CLSD	OPND	KW	N/A	N/A	ETHERNET	AI		FTFDCU1	ELC		MODBUS TCP							
K ELECTRICAL	K3 ELECTRICAL 5KV	UNIT SUBSTATIONS	FTF SWGR	FTF SWGR		BREAKER	JMG81605	FTF SWGR FDR BRK MBB TEST POS	AVAIL	OOS	VOLTS	N/A	N/A	ETHERNET	AI		FTFDCU1	ELC		MODBUS TCP							
K ELECTRICAL	K3 ELECTRICAL 5KV	UNIT SUBSTATIONS	FTF SWGR	FTF SWGR		POWER MONITORING	JWQ81651	FTF SWGR LINE B ENERGY			VOLTS	ETHERNET	0-1000000000000 MWH	ETHERNET	AI		FTFDCU1	ELC		MODBUS TCP							
K ELECTRICAL	K3 ELECTRICAL 5KV	UNIT SUBSTATIONS	FTF SWGR	FTF SWGR		POWER MONITORING	IAI81651	FTF SWGR LINE B PHA CUR			VOLTS	ETHERNET	0-1200 AMPS	ETHERNET	AI		FTFDCU1	ELC		MODBUS TCP							
K ELECTRICAL SYSTEMS	K5 ELECTRICAL BELOW 600V	UNIT SUBSTATIONS	DEGRITTING DEGUSS	SEC LINE B PWR MON		DEGUSS SEC LINE B PWR MON	JVI85394	DEGUSS SEC LINE B REACT PWR			KVAR	0	2300	RS485	AI		GTCBDCU1	GTCBDCU1	LC		JVI	85394					
K ELECTRICAL SYSTEMS	K5 ELECTRICAL BELOW 600V	UNIT SUBSTATIONS	DEGRITTING DEGUSS	SEC LINE C PWR MON		DEGUSS SEC LINE C PWR MON	IBI85397	DEGUSS SEC LINE C PHB CURR			AMPS	0	2000	RS485	AI		GTCBDCU1	GTCBDCU1	LC		IBI	85397					
K ELECTRICAL SYSTEMS	K5 ELECTRICAL BELOW 600V	UNIT SUBSTATIONS	DEGRITTING DEGUSS	SEC LINE C PWR MON		DEGUSS SEC LINE C PWR MON	ICI85397	DEGUSS SEC LINE C PHC CURR			AMPS	0	2000	RS485	AI		GTCBDCU1	GTCBDCU1	LC		ICI	85397					
K ELECTRICAL SYSTEMS	K5 ELECTRICAL BELOW 600V	UNIT SUBSTATIONS	DEGRITTING DEGUSS	SEC LINE C PWR MON		DEGUSS SEC LINE C PWR MON	JFI85397	DEGUSS SEC LINE C PWR FACTOR			PF	-1	1	RS485	AI		GTCBDCU1	GTCBDCU1	LC		JFI	85397					
K ELECTRICAL SYSTEMS	K5 ELECTRICAL BELOW 600V	UNIT SUBSTATIONS	DEGRITTING DEGUSS	SEC LINE C PWR MON		DEGUSS SEC LINE C PWR MON	JVI85397	DEGUSS SEC LINE C REACT PWR			KVAR	0	2300	RS485	AI		GTCBDCU1	GTCBDCU1	LC		JVI	85397					
K ELECTRICAL SYSTEMS	K5 ELECTRICAL BELOW 600V	UNIT SUBSTATIONS	DEGRITTING DEGUSS	SEC LINE C PWR MON		DEGUSS SEC LINE C PWR MON	JWI85397	DEGUSS SEC LINE C REAL PWR			KW	0	2300	RS485	AI		GTCBDCU1	GTCBDCU1	LC		JWI	85397					
K ELECTRICAL SYSTEMS	K5 ELECTRICAL BELOW 600V	UNIT SUBSTATIONS	DEGRITTING DEGUSS	SEC LINE C PWR MON		DEGUSS SEC LINE C PWR MON	JQI85397	DEGUSS SEC LINE C MWH			MWH	0	1E+009	RS485	AI		GTCBDCU1	GTCBDCU1	LC		JQI	85397					
K ELECTRICAL SYSTEMS	K5 ELECTRICAL BELOW 600V	UNIT SUBSTATIONS	DEGRITTING DEGUSS	SEC LINE C PWR MON		DEGUSS SEC LINE C PWR MON	EBI85397	DEGUSS SEC LINE C PHB VOLT			VOLTS	0	600	RS485	AI		GTCBDCU1	GTCBDCU1	LC		EBI	85397					
K ELECTRICAL SYSTEMS	K5 ELECTRICAL BELOW 600V	UNIT SUBSTATIONS	DEGRITTING DEGUSS	SEC LINE B PWR MON		DEGUSS SEC LINE B PWR MON	EBI85394	DEGUSS SEC LINE B PHB VOLT			VOLTS	0	600	RS485	AI		GTCBDCU1	GTCBDCU1	LC		EBI	85394					
K ELECTRICAL SYSTEMS	K5 ELECTRICAL BELOW 600V	UNIT SUBSTATIONS	DEGRITTING DEGUSS	SEC LINE B PWR MON		DEGUSS SEC LINE B PWR MON	JQI85394	DEGUSS SEC LINE B MWH			MWH	0	1E+009	RS485	AI		GTCBDCU1	GTCBDCU1	LC		JQI	85394					
K ELECTRICAL SYSTEMS	K5 ELECTRICAL BELOW 600V	UNIT SUBSTATIONS	DEGRITTING DEGUSS	SEC LINE B PWR MON		DEGUSS SEC LINE B PWR MON	EAI85394	DEGUSS SEC LINE B PHA VOLT			VOLTS	0	600	RS485	AI		GTCBDCU1	GTCBDCU1	LC		EAI	85394					
I PLANTWIDE SYSTEMS	I4 PLANTWIDE INFRASTRUCTURE	HVAC AND ENVIRONMENTAL	GT 1-4 EXHAUST FANS	GT4 EXH AIR		GT4 EXH AIR	FL61415	GT4 EXH AIR FLOW	ON	OFF				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		FL	61415					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SLUDGE PUMPING	GT4 SLDG PMP 4B		GT4 SLDG PMP 4B	PH61412	GT4 SLDG PMP 4B DISCH PRES	NORMAL	HIGH				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		PH	61412					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SLUDGE PUMPING	GT4 SLDG PMP 4B		GT4 SLDG PMP 4B	FL61412	GT4 SLDG PMP 4B SUCT PRES	NORMAL	LOW				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		FL	61412					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SLUDGE PUMPING	GT4 SLDG PMP 4B		GT4 SLDG PMP 4B	PWL61412	GT4 SLDG PMP 4B SW PRES	NORMAL	LOW				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		PWL	61412					

Process	ProcessCMS	ProcessGroup	System	ProcSubSYSTEM	Sub System	Equipment	PNAME	DESC	SET DESC	RESET DESC	ENG UNITS	LOPRANGE	HOPRANGE	IOSIGNAL	IO TYPE	POWER	OVINTERFACE	OINTERFACE	OVINTERFACETYPE	PROTOCOL	ISA_ID	LOOP	ALM PRIORITY	ALM TYPE	ALM DESC	P&ID	Remark
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 COLLECTOR	GT4 COLL		GT4 COLL	EZC61413	GT4 COLL DISC POS	OPND	CLSD				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		EZC	61413					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 COLLECTOR	GT4 COLL		GT4 COLL	JZC61413	GT4 COLL BRKR POS	CLSD	OPND				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		JZC	61413					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 COLLECTOR	GT4 COLL		GT4 COLL	MN61413	GT4 COLL RUNSTAT	RUN	OFF				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		MN	61413					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 COLLECTOR	GT4 COLL		GT4 COLL	MQ61413	GT4 COLL OVLD	OVLD	NORMAL				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		MQ	61413					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SLUDGE PUMPING	GT4 SLDG PMP 4B		GT4 SLDG PMP 4B	MF61412	GT4 SLDG PMP 4B MTR	NORMAL	FAIL				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		MF	61412					
I PLANTWIDE SYSTEMS	I4 PLANTWIDE INFRASTRUCTURE	HVAC AND ENVIRONMENTAL	GT 1-4 EXHAUST FANS	GT2 EXH FAN		GT2 EXH FAN	JZC61215	GT2 EXH FAN BRKR POS	CLSD	OPND				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		JZC	61215					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SLUDGE PUMPING	GT4 SLDG PMP 4A		GT4 SLDG PMP 4A	HG61411	GT4 SLDG PMP 4A CTRLM	REMOTE	LOCAL				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		HG	61411					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SLUDGE PUMPING	GT3 GRNDR 3A		GT3 GRNDR 3A	MQ61301	GT3 GRNDR 3A OVLD	OVLD	NORMAL				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		MQ	61301					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SLUDGE PUMPING	GT4 SLDG PMP 4A		GT4 SLDG PMP 4A	MF61411	GT4 SLDG PMP 4A MTR	NORMAL	FAIL				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		MF	61411					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SCUM PUMPING	SCM RCRC VLV		SCM RCRC VLV	YY61224	GT 2&4 SCM RCRC VLV CTRLM	READY	NREADY				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		YY	61224					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SCUM PUMPING	SCM RCRC VLV		SCM RCRC VLV	ZH61224	GT 2&4 SCM RCRC VLV POS	OPND	NFOPND				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		ZH	61224					
I PLANTWIDE SYSTEMS	I3 PLANTWIDE SUMP & FLOOD	SUMP AND FLOOD	GRAVITY THICKENERS CONTROL BUILDING	GT 1-4 SUMP LVL		GT 1-4 SUMP	LH60931	GT 1-4 SUMP LEVEL	NORMAL	HIGH				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		LH	60931					
G SOLIDS PROCESSING	G1 SOLIDS THICKENING PSSDG	DIVERTER VALVES	DIVERTER VALVES	E PRI SLDG DVTR VLV1		E PRI SLDG DVTR VLV1	ZH60911	E PRI SLDG DVTR VLV1 POS	OPND	NFOPND				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		ZH	60911					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SLUDGE PUMPING	GT1 GRNDR 1B		GT1 GRNDR 1B	MN61102	GT1 GRNDR 1B RUNSTAT	RUN	OFF				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		MN	61102					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SLUDGE PUMPING	GT1 GRNDR 1A		GT1 GRNDR 1A	EZC61101	GT1 GRNDR 1A DISC POS	CLSD	OPND				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		EZC	61101					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SLUDGE PUMPING	GT1 GRNDR 1A		GT1 GRNDR 1A	HG61101	GT1 GRNDR 1A CTRLM	AUTO	LOCAL				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		HG	61101					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 1-4	GT 1-4 SLUDGE PUMPING	GT1 GRNDR 1A		GT1 GRNDR 1A	IH61101	GT1 GRNDR 1A CURR	HIGH	NORMAL				120VAC	DI	SELF	GTCBDCU1	GTCBDCU1	LOCAL		IH	61101					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 7-10	HH2 GT 7-10 COLLECTOR	GT7 COLL		GT7 COLL	YI61713	GT7 COLL TRQ			PCT	0	100	4-20mA	AI	FIELD	GTCBDCU1	HH2RIO1	RIO		YI	61713					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 7-10	HH2 GT 7-10 SLUDGE PUMPING	GT9 OUTLET		GT9 OUTLT FLOW XMTR	FI61914	GT9 SLUDGE FLOW			GPM	0	250	4-20mA	AI	FIELD	GTCBDCU1	HH2RIO1	RIO		FI	61914					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 7-10	HH2 GT 7-10 SLUDGE PUMPING	GT9 OUTLET		GT9 OUTLT DENSITY XMTR	DI61914	GT9 OUTLT DENSITY			PCT	0	10	4-20mA	AI	SELF	GTCBDCU1	HH2RIO1	RIO		DI	61914					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 7-10	HH2 GT 7-10 COLLECTOR	GT9 COLL		GT9 COLL	YI61913	GT9 COLL TRQ			PCT	0	100	4-20mA	AI	FIELD	GTCBDCU1	HH2RIO1	RIO		YI	61913					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 7-10	HH2 GT 7-10 SCUM PUMPING	SCM WELL		SCM WELL	LI61820	GT 8&10 SCM WELL LVL			FEET	0	11	4-20mA	AI	FIELD	GTCBDCU1	HH2RIO1	RIO		LI	61820					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 7-10	HH2 GT 7-10 SLUDGE PUMPING	GT8 OUTLET		GT8 OUTLT FLOW XMTR	FI61814	GT8 SLUDGE FLOW			GPM	0	250	4-20mA	AI	FIELD	GTCBDCU1	HH2RIO1	RIO		FI	61814					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 7-10	HH2 GT 7-10 SLUDGE PUMPING	GT8 OUTLET		GT8 OUTLT DENSITY XMTR	DI61814	GT8 OUTLT DENSITY			PCT	0	10	4-20mA	AI	SELF	GTCBDCU1	HH2RIO1	RIO		DI	61814					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 7-10	HH2 GT 7-10 COLLECTOR	GT8 COLL		GT8 COLL	YI61813	GT8 COLL TRQ			PCT	0	100	4-20mA	AI	FIELD	GTCBDCU1	HH2RIO1	RIO		YI	61813					
G SOLIDS PROCESSING	G2 SOLIDS THICKENING GT	GRAVITY THICKENERS 7-10	HH2 GT 7-10 SCUM PUMPING	SCM WELL		SCM WELL	LI61720	GT 7&9 SCM WELL LVL			FEET	0	11	4-20mA	AI	FIELD	GTCBDCU1	HH2RIO1	RIO		LI	61720					
I PLANTWIDE SYSTEMS	I6 PLANTWIDE PCS OVATION	INTRUSION	HH2RIO1	HH2RIO1CAB2		HH2RIO1 ENCLOSURE DOOR SW	ZA6003	HH2RIO1 ENCLOSURE DOOR SWITCH	NORMAL	OPEN				120VAC	DI	SELF	GTCBDCU1	HH2RIO1	RIO		ZA	6003					
I PLANTWIDE SYSTEMS	I6 PLANTWIDE PCS OVATION	COMMUNICATIONS	CHBUPS1CAB1	CHBUPS1CAB1		CHBUPS1	II85300	CHBUPS1 OUTPUT AMPS			AMPS	0	25				CHBUPS1	CHBUPS1	Ethernet		II	85300					
I PLANTWIDE SYSTEMS	I6 PLANTWIDE PCS OVATION	COMMUNICATIONS	CHBUPS1CAB1	CHBUPS1CAB1		CHBUPS1	TI85300	CHBUPS1 BATTERY TEMP			DEGF	50	150				CHBUPS1	CHBUPS1	Ethernet		TI	85300					
I PLANTWIDE SYSTEMS	I6 PLANTWIDE PCS OVATION	COMMUNICATIONS	CHBUPS1CAB1	CHBUPS1CAB1		CHBUPS1	EDI85300	CHBUPS1 BATTERY VOLTS			VDC	50	100				CHBUPS1	CHBUPS1	Ethernet		EDI	85300					
I PLANTWIDE SYSTEMS	I6 PLANTWIDE PCS OVATION	COMMUNICATIONS	CHBUPS1CAB1	CHBUPS1CAB1		CHBUPS1	EI85300	CHBUPS1 INPUT VOLTS			VAC	50	130				CHBUPS1	CHBUPS1	Ethernet		EI	85300					
I PLANTWIDE SYSTEMS	I6 PLANTWIDE PCS OVATION	COMMUNICATIONS	CHBUPS1CAB1	CHBUPS1CAB1		CHBUPS1	JF85300	CHBUPS1 BYPASS STATUS	TRUE	FALSE							CHBUPS1	CHBUPS1	Ethernet		JFI	85300					
I PLANTWIDE SYSTEMS	I6 PLANTWIDE PCS OVATION	COMMUNICATIONS	CHBUPS1CAB1	CHBUPS1CAB1		CHBUPS1	JA85300	CHBUPS1 STATUS	NORMAL	ALARM							CHBUPS1	CHBUPS1	Ethernet		JA	85300					
I PLANTWIDE SYSTEMS	I6 PLANTWIDE PCS OVATION	COMMUNICATIONS	CHBUPS1CAB1	CHBUPS1CAB1		CHBUPS1	UPS_85300 COMM	CHBUPS1 COMMUNICATION STAT	NORMAL	FAILED							CHBUPS1	CHBUPS1	Ethernet		UPS_8	85300					
G SOLIDS PROCESSING	G5 SOLIDS POLYMER FEED	POLYMER-DAF	POLYMER PUMPS 13 AND 14	POLYMER PUMP 13		POLYMER PUMP 13	MMD78363	DAF POLYMER PMP 13 CTRL	START								SPBDCU3	SPBDCU3	LOCAL		MMD	78363	1			I-5	
G SOLIDS PROCESSING	G5 SOLIDS POLYMER FEED	POLYMER-DAF	POLYMER PUMPS 10 AND 12	POLYMER PUMP 12		POLYMER PUMP 12	MMB78362	DAF POLYMER PMP 12 CTRL	STOP								SPBDCU3	SPBDCU3	LOCAL		MMB	78362	1			I-5	
G SOLIDS PROCESSING	G5 SOLIDS POLYMER FEED	POLYMER-DAF	POLYMER PUMPS 09 AND 11	POLYMER PUMP 11		POLYMER PUMP 11	MMD78361	DAF POLYMER PMP 11 CTRL	START								SPBDCU3	SPBDCU3	LOCAL		MMD	78361	1			I-5	
B SECONDARY	B2 SECONDARY SEDIMENTATI	SECONDARY WAS	WEST WAS PUMPING	WAS PUMP 02		W SEC WSP-2	XX2502	W SEC WSP-2 VFD	NORMAL	FAULT							WSEBDCU1	WSEBRIO1	RIO		XX	2502	2			I-8	
B SECONDARY	B2 SECONDARY SEDIMENTATI	SLUDGE COLLECTORS	W SEC SED BASIN 10	LONGT COLLECTOR 10B		W SEC SED LC-10B	YH28422B	W SEC SED LC-10B TRQ	NORMAL	HIGH							WSEBDCU1	WSEBRIO1	RIO		YH	28422E	2			I-9	
B SECONDARY	B2 SECONDARY SEDIMENTATI	SECONDARY SCUM 06	SEC SCUM HOPPER 06	SCUM PUMP 06A		W SEC SCP-6A	TH29863	W SEC SCP-6A MTR TEMP	NORMAL	HIGH							WSEBDCU1	WSEBRIO1	RIO		TH	29863	2			I-10	

APPENDIX C
POINT NAME, TAG AND LOOP NUMBER CONVENTIONS

Each I/O point name is unique for the plant and consists of two parts: an ISA like prefix and a loop number. This point name is critical for the ovation system and is the main coordination item that ties together all aspects of the design, construction, and programming.

Loop Numbering Convention

Every loop number in the plant is unique. The number may vary from three to six characters. The convention used for identifying loop numbers is as follows:

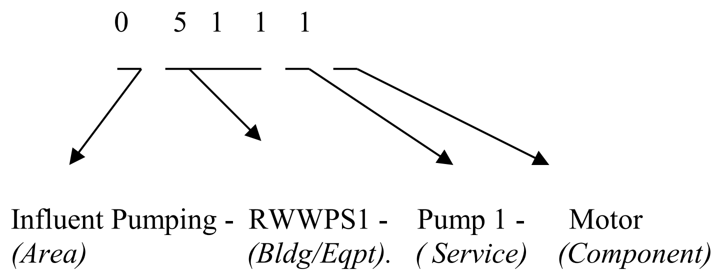
1. The first number defines the process area.
2. The second and third numbers define the building or equipment in the process area.
3. The fourth and fifth numbers define the secondary service or component of the process equipment.
4. The sixth number is for additional delineation required by some equipment.

Following are the Process Area Numerical Identifiers:

Process Area	Numerical Identifier
Influent Pumping	0
Primary Process	1
Secondary Process	2
Nitrification Process	3
ENRF and Dual Purpose Sedimentation	4
Filtration and Disinfection	5
Thickening and Digestion	6
Solids Processing (Dewatering and Sludge Loading)	7
Electrical Monitoring, Plantwide (stormwater pump stations, sewage ejectors, etc.)	8
Chemical Systems, Plantwide (including eyewashes)	9
Tunnel Dewatering Pump Station and Enhanced Clarification Facility	12

The remaining digits are assigned by the designer in a logical hierarchy that is coordinated with the P&IDs, I/O list and plan drawings. Number ranges for each Project are typically provided to the designer.

An example (RWWPS1 Pump1 Motor) is given below:



Example Loop Number:

Figure C-1. Process Area Numerical Identifiers

DC Water ISA Table

The ISA component of the tag is based on ANSI/ISA-S5.1 "Instrumentation Symbols and Identification". Up to three letters are used to identify instrument function. Samples of this are shown below. ISA components must be unique for each loop to ensure uniqueness for the I/O tag names. Set and Rest values are samples only and should relate to electrical schematics and functionality requirements of the designer.

Table is continually updated, request updated version prior to beginning work. Most commonly used ISA codes are provided in Table C-1.

DC Water PCS Standard I/O

For every new process upgrade in the Blue Plains Advanced Waste Water Treatment Plant, the corresponding new equipment or devices to be installed must be interfaced, monitored and controlled via the existing PCS. In order to assist the PDE in identifying the process signals, Table C-2 lists standard process variables, status indications and alarm contacts. The listing shows the typical required signals for equipment or devices in the process.

Table C-2 is intended to be a reference list for most equipment. It is acknowledged that there may be more or less points available for specific equipment under the design. In these cases, the PDE shall add or delete points to ensure that PCS will provide the operators with the critical information required by the process.

Table C-1. Commonly Used ISA Codes

ISA	Process Variable	Set	Reset	Remarks
AA	H2S GAS	NORMAL	CAUTION	
AAH	H2S GAS	NORMAL	WARNING	
AAHH	H2S GAS	NORMAL	ALARM	
AAI	AMMONIA	0 - XXX	PPM	
ABH	COMMON ALARM	ALARM	NORMAL	
AC	CHLORINATION LEVEL	NORMAL	LOW	
ACH	CHLORINATION LEVEL	NORMAL	HIGH	
ACHH	CHLORINATION LEVEL	NORMAL	HI-HI	
ACI	CHLORINE GAS	0 - XXX	PPM	
ACX	GAS DETECTOR	FAIL	NORMAL	
AD	D.O. LEVEL	NORMAL	LOW	
ADI	D.O.	0 - XXX	PPM	
AFI	PHOSPHATE	0 - XXX	PPM	
AGD	GAS MONITOR	CLSD	OFF	
AGH	GAS MONITOR	OPND	OFF	
AGI	COMBUSTIBLE GAS	0 - XXX	LEL	
AGM	GAS MONITOR	DCONEC	CONECT	
AGX	GAS MONITOR	DCONEC	CONECT	
AHI	HYDROGEN SULFIDE	0 - XXX	PPM	
AI	ANALYSIS INDICATION OUTFALL	0 - XXX	PH, MG/L or DEG F	
AJH	SULFUR DIOXIDE	NORMAL	HIGH	
AJHH	SULFUR DIOXIDE	NORMAL	HI-HI	
AJI	SULFUR DIOXIDE	0 - XXX	PPM	
AJX	S02 DETECTOR	FAIL	NORMAL	
AL	SLUDGE DENSITY	NORMAL	LOW	
AMD	METHANOL LEAK	ALARM	NORMAL	
AMI	T.O.D.	0 - XXX	PPM	
ANI	NITRATE	0 - XXX	PPM	
AOC	ORP CTR	0 - 100	PCT	

ISA	Process Variable	Set	Reset	Remarks
AOH	ORP LEVEL	NORMAL	HIGH	
AOHK	HIGH ORP ALARM LIMIT	0 - XXXX	mV	
AOI	ORP	0 - XXX	PPM	
AOK	PH	0 - XXX	PH	Set point
AOL	ORP LEVEL	NORMAL	LOW	
AOLK	LOW ORP ALARM LIMIT	0 - XXXX	mV	
APC	POLYMER CONCENTRATION	0 - XXX	PPM	
APH	PH	NORMAL	HIGH	
APHK	HIGH PH ALARM LIMIT	0 - XXX	PH	
API	PH	0 - XX		
APK	NAOH PUMP SPEED STP	0 - XXX	PCT	Set point
APL	PH	NORMAL	LOW	
APlK	LOW PH ALARM LIMIT	0 - XXX	PH	
AQI	OXYGEN	0 - XXX	PCT	
ARI	RESIDUAL CHLORINE		PPM	
ASI	SUSPENDED SOLIDS	0 - XXX	PPM or MG/L	
ASX	PROCESS DOSE	0 - XXX		
ATI	TURBIDITY	0 - XXX	NTU	
AWI	HUMIDITY	0 - XXX	PPM	
AXI	CONCENTRATION	0 - XXX	PERCENT	
AXQ	POLY CONCENTRATION	0 - XXX	PCT	
AXS	CONCENTRATION	0 - XXX	PERCENT	Set point - AO
CH	CONDUCTIVITY	HIGH	NORMAL	
CI	CONDUCTIVITY	0 - XXX	SIEMENS	
CL	CONDUCTIVITY	LOW	NORMAL	
CSH	MOISTURE / HUMIDITY	HIGH	NORMAL	
DI	DENSITY			
EAI	PHASE A VOLT	0 – XXX	KVOLTS	or VOLTS
EBI	PHASE B VOLT	0 – XXX	KVOLTS	or VOLTS
EBI	PHASE B VOLT	0 – XXX	KVOLTS	or VOLTS
ECI	PHASE C VOLT	0 – XXX	KVOLTS	or VOLTS

ISA	Process Variable	Set	Reset	Remarks
EDI	UPS BATTERY VOLTAGE	0 – XXX	VOLTS	
EI	VOLTAGE	0 – XXX	KVOLTS	or VOLTS
EL	VOLTAGE	NORMAL	LOW	
ELA	CIRCUITBREAKER	NORMAL	ALARM	
EN	VOLTAGE	ON	OFF	
EU	MCC VOLTAGE STATUS			
EX	PMT STATUS	OK	OFF	
EZC	DISCONNECT POSITION	CLOSED	OPEN	
FC	FLOW CONTROL	0 – 100	PCT	
FF	FLOW TRANSMITER STATUS	NORMAL	FAIL	
FH	FLOW	NORMAL	HIGH	
FHC	PEAK FLOW CONTROL MODE	ON		
FI	FLOW	0 – XXX	MGD	or GPM
FIF_	FLOW SET POINT	LOSS	NORMAL	
FIO	FLOW	0 – XXX	MGD	For local indication
FL	FLOW	LOW	NORMAL	
FQ	SAMPLER PACE	0 – XXX	PCT	
FMC_	AVERAGE FLOW	ON	OFF	Output
FMC	AVERAGE FLOW	ON	OFF	
FN	FLOW CONTROL	REMOTE	LOCAL	
FOX	FLOW DETECTION	NORMAL	LOSS	
FQI	PROCESS FLOW	0 – XXX	MGD	
FQS_	SLUDGE FLOW	0 – XXX	PCT	Set point
FQS	CNTFG RATIO SET POINT	0 – XXX	%	Indication
FS_	CNTFG SETPOINT	0 – XXX	PCT	Set point
FS	CNTFG FLOW SETPOINT	0 – XXX	GPM	Indication
FWL	SEAL WATER FLOW	NORMAL	LOW	
FWL_	SEAL WATER FLOW	LOW	NORMAL	Alarm latched after time delay
H	BASIN SELECTION	BSNXX		
HA	CONTROL MODE	AUTO	MANUAL	Non PCS ctrl

ISA	Process Variable	Set	Reset	Remarks
HAK	CONTROL MODE	ALARM ACKNL	N ACKNL	
HAR	ALARM SILENCE	TRUE	FALSE	
HAS_	CNTFG CONTROL MODE	FLOW	RATIO	Output
HAS	CNTFG CONTROL MODE	FLOW	RATIO	Indication
HD	FAN SWITCH POSITION	ON	OFF	
HG	CONTROL MODE	REMOTE	LOCAL	PCS on-off Control
HH	CONTROL MODE	HAND	NHAND	
HM	FAN SWITCH POSITION	MANUAL	OFF	
HMY_	SYSTEM MODE	BYPASS	OPERATE	
HS	CONTROL MODE	SELECTED	N SELECT	
HT_	TIMER RESET	ON	OFF	
HY	CONTROL MODE	COMPUTER	MANUAL	PCS analog control
IAI	PH A CURRENT	0 – XXX	AMPS	
IBI	PH B CURRENT	0 – XXX	AMPS	
ICI	PH C CURRENT	0 – XXX	AMPS	
IH	CURRENT	NORMAL	HIGH	
IHH	CURRENT	NORMAL	ALARM	
II	CURRENT	0 – XXX	AMPS	
ISH	OVER CURRENT RELAY LOCKOUT	NORMAL	LOCKOUT	
IU	CURRENT	UNBAL	NORMAL	
JA	UPS	ALARM	NORMAL	
JF	UPS BYPASS	TRUE	FALSE	
JFI	POWER FACTOR.	0 – XXX		
JFX	BREAKER FAN	NORMAL	FAIL	
JL	POWER STATUS	NORMAL	FAIL	
JMG	BREAKER 52H	AVAIL	OOS	
JMN	AUTOMATIC TRANSFER SWITCH	ON	NORMAL	
JMX	AUTOMATIC TRANSFER SWITCH	ON	EMERG	

ISA	Process Variable	Set	Reset	Remarks
JQI	MCC REAL POWER	0 – XXX	KW	
JST	PROT RELAY FAIL	NORMAL	FAIL	
JTX	BREAKER	NORMAL	FAIL	
JUT	UV/OV ALARM/TRIP	NORMAL	ALARM/TRIP	
JVI	REACTIVE POWER	0 – XXX	KVAR	
JWI	REAL POWER	0 – XXX	KW	
JWQ	ENERGY	0 – XXX	KWH	
JZC	SWITCH POS	CLOSED	OPEN	
JZF	BREAKER FAILURE	NORMAL	FAIL	
JZO	BREAKER POS	OPEN	CLOSED	
JZT	BREAKER POS	TRIPPED	NORMAL	
K	TIME			
KB_	STOP DELAY TIMER	ON	OFF	Output
KB	STOP DELAY TIMER	ON	OFF	
KD_	CYCLE TIMER	ON	OFF	Output
KD	CYCLE TIMER	ON	OFF	
KI	TIMER	0 - XXX	SEC	
KIH_	PROCESS TIMER	0 - XXX	SEC	Output
KIH	PROCESS TIMER	0 - XXX	SEC	
KIK_	PROCESS TIMER	0 - XXX	SEC	Output
KIK	PROCESS TIMER	0 - XXX	SEC	
KIL_	PROCESS TIMER	0 - XXX	SEC	Output
KIL	PROCESS TIMER	0 - XXX	SEC	
KIM_	PROCESS TIMER	0 - XXX	SEC	Output
KIM	PROCESS TIMER	0 - XXX	SEC	
KP_	CONTROL GAIN	0 - XXX		Output
KP	CONTROL GAIN	0 - XXX		
KQ_	TIME SET POINT	0 - XXX	MINS	Output
KQ	TIME SET POINT	0 - XXX	MINS	
KQI	RUNTIME/STOP TIMER	0 - XXX	MINS / HOUR	
LA	LEVEL INDICATOR	NORMAL	ALARM	

ISA	Process Variable	Set	Reset	Remarks
LDH	DIFF. LEVEL HIGH	TRUE	FALSE	
LDHH	DIFF. LEVEL HIGH	TRUE	FALSE	
LDI	DIFFERENTIAL LEVEL	0 - XXX	IN	
LDL	DIFF. LEVEL LOW	TRUE	FALSE	
LH	LEVEL	NORMAL	HIGH	
LHA	HI LEVEL ALARM	HIGH ALARM		DO for local alarm
LHH	LEVEL	NORMAL	HIGH-HIGH	
LHK	LEVEL NAOCL	0 - XXX	FEET	
LI	LEVEL	0 – XXX	FEET	
LIK	LEVEL SELECTION	ON	OFF	
LIO	LEVEL	0 – XXX	FEET	AO for local indication
LL	LEVEL	NORMAL	LOW	
LLH	LUBE LEVEL	ALARM	NORMAL	
LLK	LOW LEVEL ALARM LIMIT	0 – XXX	FEET	
LLL	LEVEL	NORMAL	LO-LO	
LM_	MID LEVEL	TRUE	FALSE	
LN	LEVEL SENSOR	FAIL	NORMAL	
LOA	LUBE OIL LEVEL	LOW ALARM		DO for local alarm
LOL	LUBE OIL LEVEL	NORMAL	LOW	
LP	LEVEL PERMISIVE	TRUE	FALSE	
LQ_	LEVEL SET POINT	0 - XXX	INCH / PCT	Output
LQ	LEVEL SET POINT	0 - XXX	INCH / PCT	
LWH	SEAL WATER LEVEL	HIGH	NORMAL	
LWL	SEAL WATER LEVEL	LOW	NORMAL	
LX	LEVEL SENSOR	NORMAL	FAIL	
MB	LOADING	PAUSE	RESUME	
MBI	LOCAL CONTROL IND	STOP	NOT START	DI
MDA	START ALARM	ALARM START		DO for local alarm
MDI	LOCAL CONTROL IND.	START	NOT RUN	DI
ME	BURNER CONTROL	ENABLE	NENABL	
MF	FAIL STATUS	NORMAL	FAIL	

ISA	Process Variable	Set	Reset	Remarks
MFI	LOCAL CONTROL IND	FWD	NOT FWD	DI
MG	STATUS	AVAIL	O-O-SERVICE	
MKD	CONTROL	RUN		
MKE	CONTROL	ENABLE		
MKF	CONTROL	RUN FWD		
MKR	CONTROL	RUN REV		
MMB	CONTROL	STOP		
MMD	CONTROL	START		
MMF	CONTROL	FWD		
MMR	CONTROL	REV		
MMS	PUMP	ESTOP		Output
MMX	START	INHIBIT		
MN	RUN STATUS	RUN	OFF	
MNF	RUN STATUS	FWD	OFF	
MNQ	COUNTER	0 - XXX		
MNR	RUN STATUS	REV	OFF	
MP	PRIMED STATUS	PRIMED	NOT PRIMED	
MQ	OVERLOAD	OVERLOAD	NORMAL	
MR	BACK SPIN	BACK SPIN	NORMAL	
MRI	LOCAL CONTROL IND.	REV	NOT REV	DI only
MS	EMERGENCY STOP	EMER. STOP	NORMAL	
OS	SCREEN SENSOR	DETECT	NDETECT	
OX	PUMP SEAL	FAILURE	NORMAL	
OXA	PUMP SEAL	FAILURE ALRM		DO for local alarm
PDH	DIFFERENTIAL PRESSURE	NORMAL	HIGH	
PDHK	HIGH DIFF PRES ALARM LIMIT	0 – XXX	INWG	
PDI	DIFFERENTIAL PRESSURE	0 – XXX	IN H20	or PSID
PDL	DIFFERENTIAL PRESSURE	NORMAL	LOW	
PH	PRESSURE	NORMAL	HIGH	
PHH	PRESSURE	NORMAL	HIGH	

ISA	Process Variable	Set	Reset	Remarks
PHU	HYD. PRESS	LOAD	UNLOAD	
PI	PRESSURE	0 - XXX	PSIG	
PL	PRESSURE	NORMAL	LOW	
POI	L.O. PRESSURE	0 - XXX	PSI	
POL	L.O. PRESS	NORMAL	LOW	
PPH	VACUUM SUCTION	HIGH	NORMAL	
POLL	L.O. PRESS	LO-LO	NORMAL	
PSL	SUCTION PRESSURE	NORMAL	LOW	
PWL	SEAL WTR PRES	NORMAL	LOW	
PWL_	SEAL WTR PRES	LOW	NORMAL	Alarm latched after time delay
QA	LAG PUMP	ON	OFF	
QD_	AUTO MODE	ON	OFF	Output
QD	AUTO MODE	ON	OFF	
QDF	AUTO MODE	ALARM	NORMAL	
QIK_	PRIORITY	X - XX		Output
QIK	PRIORITY	X - XX		
QMD	MANUAL MODE	ON	OFF	
QN_	ONLINE MODE	ON	OFF	Output
QN	ONLINE MODE	ON	OFF	
QX	MOIST SEAL	NORMAL	FAIL	
RSP	CONCENTRATION SETPOINT	0 - 100	%	
SC	SPEED CONTROL	0 - 100	PCT	
SDH	DIFFERENTIAL SPEED	HIGH	NORMAL	
SDI	DIFFERENTIAL SPEED	0 – XXX	RPM	
SDL	DIFFERENTIAL SPEED	LOW	NORMAL	
SDS	DIFFERENTIAL SPEED	0 – XXX	RPM	Set point - AO
SFI	DIFFERENTIAL/BOWL SPEED	0 – XXX	RPM, %	Set point - AO
SH_	SPEED	HIGH	NORMAL	Alarm latched after time delay
SI	SPEED	0 - 100	PCT	

ISA	Process Variable	Set	Reset	Remarks
SIH_	PEAK FLOW SPEED	0 - 100	PCT	Set point
SIH	PEAK FLOW SPEED	0 - 100	PCT	
SIM_	AVERANGE FLOW SPEED	0 - 100	PCT	Set point
SIM	AVERANGE FLOW SPEED	0 - 100	PCT	
SL	ZERO SPEED	NORMAL	ZERO	
SL_	SPEED	LOW	NORMAL	Alarm latched after time delay
SLS	CONVEYOR MOTION	RUN	OFF	
SS_	SPEED SETPOINT	0 – XXX	%	Set point
SS	SPEED SETPOINT	0 – XXX	%	
TB	BEARING TEMPERATURE	0 – XXX	DEG F	
TBH	BEARING TEMPERATURE	HIGH	NORMAL	
TBHH	BEARING TEMPERATURE	HI - HI	NORMAL	
TBI	IN BEARING TEMPERATURE	0 – XXX	DEG F	
TBL	LOWER BEARING TEMP	0 – XXX	DEG F	
TBM	MIDLE BEARING TEMP	0 – XXX	DEG F	
TBO	OUT BEARING TEMPERATURE	0 – XXX	DEG F	
TBT	THRUST BEARING TEMP	0 – XXX	DEG F	
TBU	UPPER BEARING TEMP	0 – XXX	DEG F	
TH	TEMPERATURE	HIGH	NORMAL	
THA	TEMPERATURE	HIGH ALARM		DO for local alarm
THH	TEMPERATURE	HIGH	NORMAL	
THK_	HIGH TEMP ALARM LIMIT	0 – XXX	DEG C	Set point
THK	HIGH TEMP ALARM LIMIT	0 – XXX	DEG C	
TI	TEMPERATURE	0 – XXX	DEG F	
TL	TEMPERATURE	LOW	NORMAL	
TL	TEMPERATURE LOW	ALARM	NORMAL	
TLK_	LOW TEMP ALARM LIMIT	0 – XXX	DEG C	Output
TLK	LOW TEMP ALARM LIMIT	0 – XXX	DEG C	
TWI	WINDING TEMP	0 – XXX	DEG F	

ISA	Process Variable	Set	Reset	Remarks
TWH	WINDING TEMP	NORMAL	HIGH	
UAH	TROUBLE	ALM HORN		DO
UAL	TROUBLE	ALM LIGHT		DO
URA	READY STATUS	READY	NOT READY	DO
UX	TROUBLE	NORMAL	TROUBLE	
VH	VIBRATION	NORMAL	HIGH	
VHH	VIBRATION	NORMAL	HI - HI	
VSA	FIRE ALARM	SPRVSR	NORMAL	
VX	VIBRATION	NORMAL	FAULT	
VXH	VIBRATION AXIS X	HIGH	NORMAL	
VXHH	VIBRATION AXIS X	HI – HI	NORMAL	
VXI	"X" VIBRATION	0 – XXX	MIL	
VYH	VIBRATION AXIS Y	HIGH	NORMAL	
VYHH	VIBRATION AXIS Y	HI - HI	NORMAL	
VYI	"Y" VIBRATION	0 – XXX	MIL	
VZH	VIBRATION AXIS Z	HIGH	NORMAL	
VZHH	VIBRATION AXIS Z	HI - HI	NORMAL	
VZI	"Z" VIBRATION	0 – XXX	MIL	
WH	WEIGHT	NORMAL	OVERWEIGHT	
WI	WEIGHT	0 – XXX	TONS	
WIO	WEIGHT	0 – XXX	TONS	AO for local indic.
WQ	VOLUME SETPOINT	0 – XXX	LBS	
XA	PROCESS ALARM	ON	OFF	
XC_	COM ALARM	ON	OFF	Any alarm active (Do Not send to Alarm List)
XF_	FAIL STATUS	FAIL	NORMAL	Motor failure
XFF	CONVEYOR FOWARD	ALARM	NORMAL	
XHS	CONTROL MODE	ON	LFF	Any logic state selected by PCS operator
XHS_	CONTROL MODE	ON	OFF	Any logic state selected by PCS operator
XI	ANALOG INPUT	0 – XXX	XXX	Miscellaneous use
XLF	ALARM BEACON	ON	OFF	

ISA	Process Variable	Set	Reset	Remarks
XMH	WATER IN LUBE OIL	ALARM	NORMAL	
XNF	MOTOR VFD	FWD	OFF	
XNR	MOTOR VFD	REV	OFF	
XP_	PERMIS	ALARM	NORMAL	Loss of permissive
XR_	ALM RESET REQD	FALSE	TRUE	Latched alarm is active
XS_		ON	OFF	General point name for any logic state
XT	FAN BAG	BROKEN	NORMAL	
XX	VFD	FAIL	NORMAL	
YAL	ANNUNCIATOR	NORMAL	ALARM	
YH	TORQUE	NORMAL	HIGH	
YHH	TORQUE	FAIL	NORMAL	
YI	TORQUE	0 – 100	PCT	
YY	POLY VLV CTRLM	REMOTE	LOCAL	
ZA	CABINER DOOR	NORMAL	OPEN	
ZB	POSITION SENSOR	ON	OFF	
ZC	POSITION CTRL	0 – 100	PCT	
ZCO	VALVE, GATE	OPEN	CLOSE	Output
ZD	POSITION	DISCHARGING	NOT DISCHARGING	
ZF_	FAIL STATUS	ALARM	NORMAL	Valve failure ZHA_ or ZLA_ is true.
ZF	POSITION SENSOR	ON	OFF	
ZH	VALVE, GATE	OPEN	NF OPEN	
ZHA	FAIL TO OPEN	ALARM	NORMAL	
ZHA_	FAIL TO OPEN	ALARM	NORMAL	Alarm latched after time delay
ZI	POSITION	0 – XXX	PCT	
ZKO	VALVE, GATE CONTROL	OPEN		
ZL	VALVE, GATE	CLOSED	NFCLOSED	
ZLA	FAIL TO CLOSE	ALARM	NORMAL	
ZLA_	FAIL TO CLOSE	ALARM	NORMAL	Alarm latched after time delay

ISA	Process Variable	Set	Reset	Remarks
ZM	VALVE, GATE POSITION	NORMAL	5 PCT OPEN	
ZMC	VALVE, GATE CONTROL	CLOSE		
ZMD	CONTROL	DISCHARGE		
ZMH	VALVE	DISCHR		Output
ZML	VALVE	MIX		Output
ZMM_	VALVE POSITION	REST		
ZMO	VALVE, GATE CONTROL	OPEN		
ZQ	SURGE	SURGE	NORMAL	
ZQF	BELT STATUS	FAIL	NORMAL	
ZR	POSITION	RECIRC'ING	NOT RECIRC'ING	
ZT	TIPPING SWITH	ALARM	OFF	
ZX	FILTER DOOR	OPEN	CLOSED	
ZXA	TIPPING	ALARM	NORMAL	for grit

1. Character "_" in point prefix indicates that point is an internal point to Ovation (i.e., not an external point such as hardwired I/O point or from 3rd party device like a PMT or PLC).

Table C-2. PCS Standard I/O

Equipment/ Structure	Type	Size	Process Variable	ISA	Alarm	Remarks
PUMP STATION			Basement Level High	LH	YES	
			Basement Flood	LHH	YES	
			Combustible Gas Value	AI		
SUMP			Level Status High	LH	YES	
WET WELL			Level Value	LI		
TANK			Level Value	LI		
			Level Status High	LH	YES	
			Level Status High High	LHH	YES	
			Level Status Low	LL	YES	
PUMP, SUMP			Hand /Auto	HA		
			Run Status	MN		
			Fault	XA	YES	
PUMP	CS	<100 hp	Disconnect Status	EZC		Constant Speed
			Remote Status	HG		
			Run Status	MN		
			Overload Status	MQ	YES	
PUMP	VS	<100 hp	Disconnect Status	EZC		Variable Speed
			Remote Status	HG		
			Run Status	MN		
			Motor Current	II		
			Motor Power	JWI		
			Overload Status	MQ	YES	
			Remote Speed Control Status	HY		
			Speed Indicator	SI		
			Speed Control	SC		
			VFD Fail Status	XX	YES	
PUMP	CS	>100 hp	Disconnect Status	EZC		
			Remote Status	HG		

Table C-2. PCS Standard I/O (continued)

Equipment/ Structure	Type	Size	Process Variable	ISA	Alarm	Remarks
			Run Status	MN		
			Overload Status	MQ	YES	
			Vibration 1	VH	YES	
			Vibration 2	VH	YES	
			Vibration 3	VH	YES	
			Bearing Temp 1	TBI		
			Bearing Temp 2	TBI		
			Bearing Temp 3	TBI		
			Bearing Temp 4	TBI		
			Bearing Temp 5	TBI		
			Bearing Temp 6	TBI		
			Bearing Temp High	TBH	YES	
			Reverse Rotation	MR		
PUMP	VS	>100 hp	Disconnect Status	EZC		Variable Speed
			Remote Status	HG		
			Run Status	MN		
			Overload	MQ	YES	
			Remote Speed Control Status	HY		
			Speed Indicator	SI		
			Speed Control	SC		
			Motor Current	II		
			Motor Power (KW)	JWI		
			VFD Fail	XX	YES	
			Vibration 1	VH	YES	
			Vibration 2	VH	YES	
			Vibration 3	VH	YES	
			Bearing Temp 1	TBI		
			Bearing Temp 2	TBI		

Table C-2. PCS Standard I/O (continued)

Equipment/ Structure	Type	Size	Process Variable	ISA	Alarm	Remarks
			Bearing Temp 3	TBI		
			Bearing Temp 1High	TBH	YES	
			Bearing Temp 2 High	TBH	YES	
			Bearing Temp 3High	TBH	YES	
MIXER	CS		Disconnect	EZC		Constant Speed
			Remote Status	HG		
			Run Status	MN		
			Start Command	MMD		
			Stop Command	MMB		
			Drive Fault	XF	YES	
			Torque, High	YH	YES	
			Temp, High	TH	YES	
MIXER	VS		Disconnect	EZC		Variable Speed
			Remote Status	HG		
			Remote Speed Control Status	HY		
			Run Status	MN		
			Start Command	MMD		
			Stop Command	MMB		
			Speed Indicator	SI		
			Speed Control	SC		
			VFD Fault	XX	YES	
			VFD Torque High	YH	YES	
			Drive Fault	XF	YES	
			Torque, High	YH	YES	
			Temp, High	TH	YES	
VALVE, Motor Operated	O/C		Disconnect Status	EZC		Open/Close
			Remote Status	HG		

Table C-2. PCS Standard I/O (continued)

Equipment/ Structure	Type	Size	Process Variable	ISA	Alarm	Remarks
			Fully Open Status	ZH		
			Fully Closed Status	ZL		
			Torque High	YH	YES	
			Open Command	ZMO		
			Close Command	ZMC		
VALVE, Motor Operated	Mod		Remote Status	HG		Modulating
			Fully Open Status	ZH		
			Fully Closed Status	ZL		
			Torque High	YH	YES	
			Analog Position	ZI		
			Position Control	ZC		
VALVE, Pinch	O/C		Remote Status	HG		
			Fully Open Status	ZH		
			Fully Closed Status	ZL		
			Torque High	YH	YES	
			Open Command	ZMO		
			Close Command	ZMC		
EYEWASH, Emergency			Flow Switch	FS		
FLOWMETER			Flow	FI		
PRESSURE TRANSMITTER			Pressure	PI		
PRESSURE TRANSMITTER			Differential Pressure	PDI		
PRESSURE SWITCH			Pressure High	PH	YES	
PRESSURE SWITCH			Pressure Low	PL	YES	
ANALYTICAL, Chlorine			Chlorine Residual	ARI		
ANALYTICAL, ORP			ORP	AOI		
ANALYTICAL, ORP			ORP Level High	AOH	YES	

Table C-2. PCS Standard I/O (continued)

Equipment/ Structure	Type	Size	Process Variable	ISA	Alarm	Remarks
ANALYTICAL, ORP			ORP Level Low	AOL	YES	
ANALYTICAL, PH			PH	API		
ANALYTICAL, Suspended Solids			Suspended Solids	ASI		
ANALYTICAL, Turbidity			Turbidity	ATI		
ANALYTICAL, Humidity			Humidity	AWI		
ANALYTICAL, Conductivity			Conductivity High	CH	YES	
ANALYTICAL, Conductivity			Conductivity	CI		
ANALYTICAL, Conductivity			Conductivity Low	CL	YES	
ANALYTICAL, Density			Density	DI		
FLOW PACING			Sampler Pacing Signal	FQ		PCS DO
SEAL WATER			Flow Switch	FWL		
GATE, Slide	O/C		Remote Status	HG		
			Fully Open Status	ZH		
			Fully Closed Status	ZL		
			Torque High	YH	YES	
			Open Command	ZMO		
			Close Command	ZMC		
MOTOR Drive, Screen			Disconnect Status	EZC		
			Remote Start/Stop Status	HG		
			Start Command	MMD		
			Stop Command	MMB		
			Run Status	MN		
			Overload Status	MQ		

Table C-2. PCS Standard I/O (continued)

Equipment/ Structure	Type	Size	Process Variable	ISA	Alarm	Remarks
			Jam	XF		
			EStop Status	MS		
			VFD Fault	XX		
			VFD Torque	YI		
			Remote Speed Control Status	HY		
			Speed Indicator	SI		
			Speed Control	SC		
			Motor Temp High	TH		
MOTOR Drive, Conveyor			Disconnect Status	EZC		
			Remote Start/Stop Status	HG		
			Run FWD Command	MKF		
			Run REV Command	MKR		
			Run FWD Status	MNF		
			Run REV Status	MNR		
			Overload Status	MQ		
			E-Stop Status	MS		
			Belt Tracking	ZHA		
			Zero Speed	SL		

APPENDIX D
SAMPLE LOOP DRAWING AND POINT TO POINT DIAGRAMS

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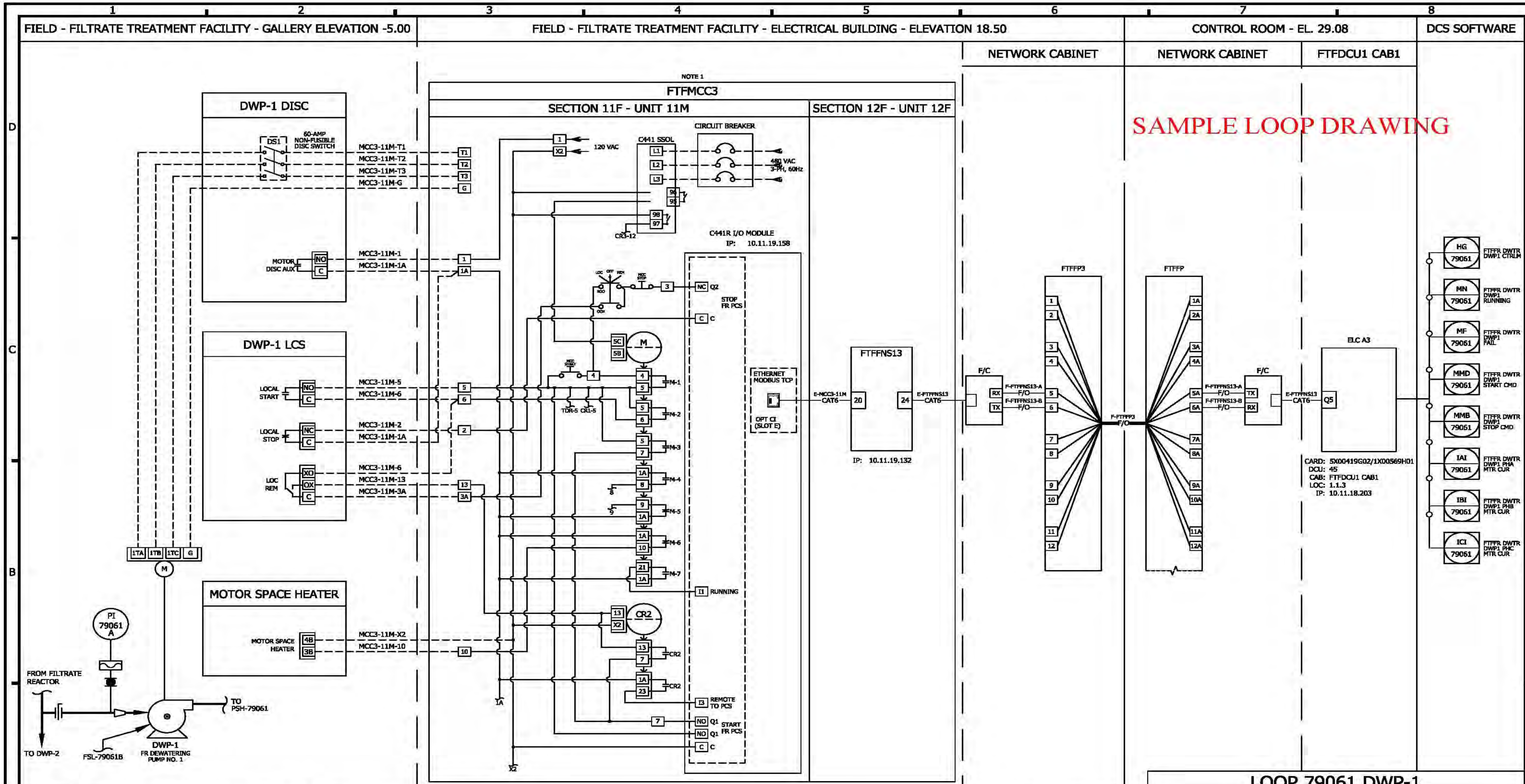
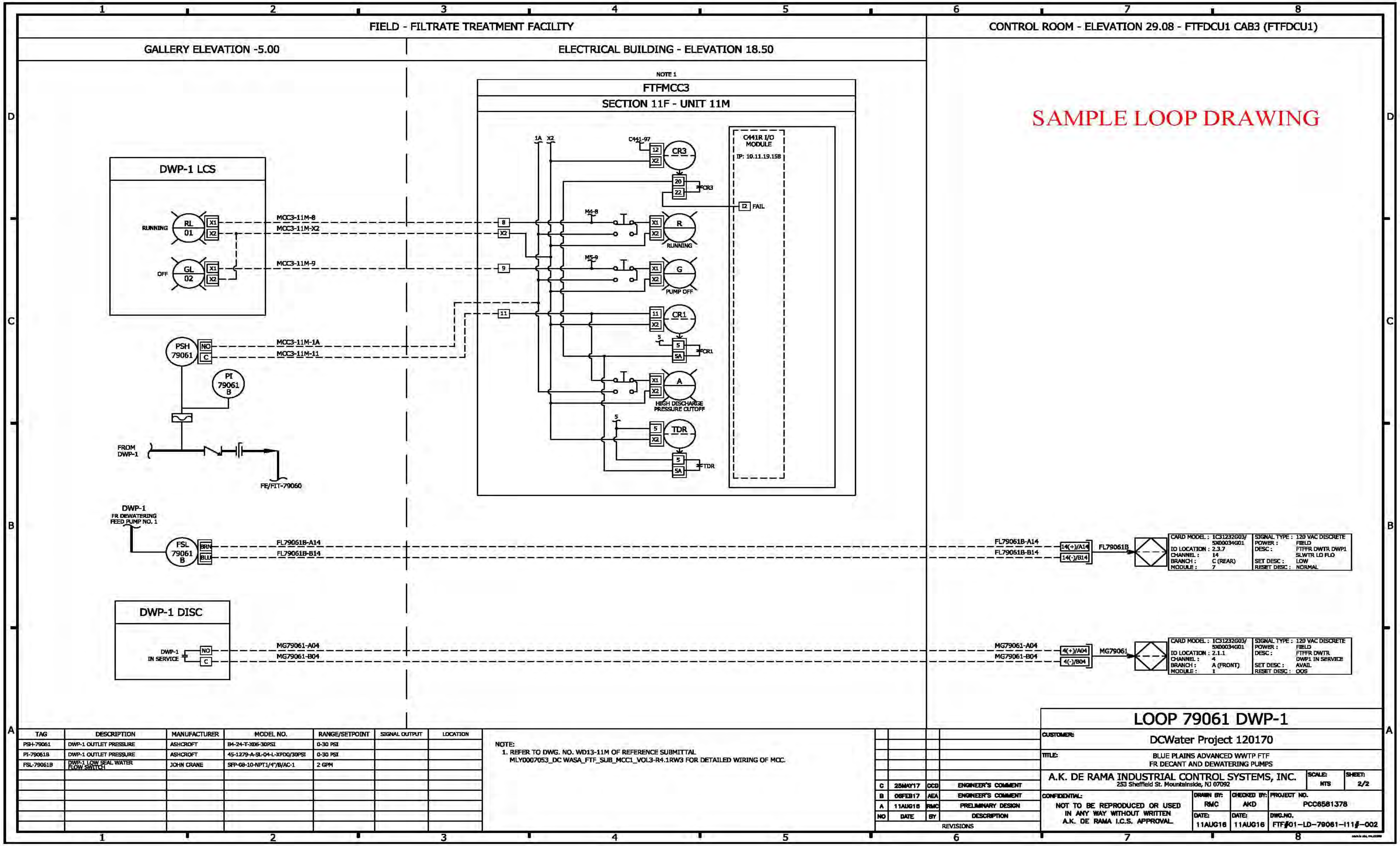
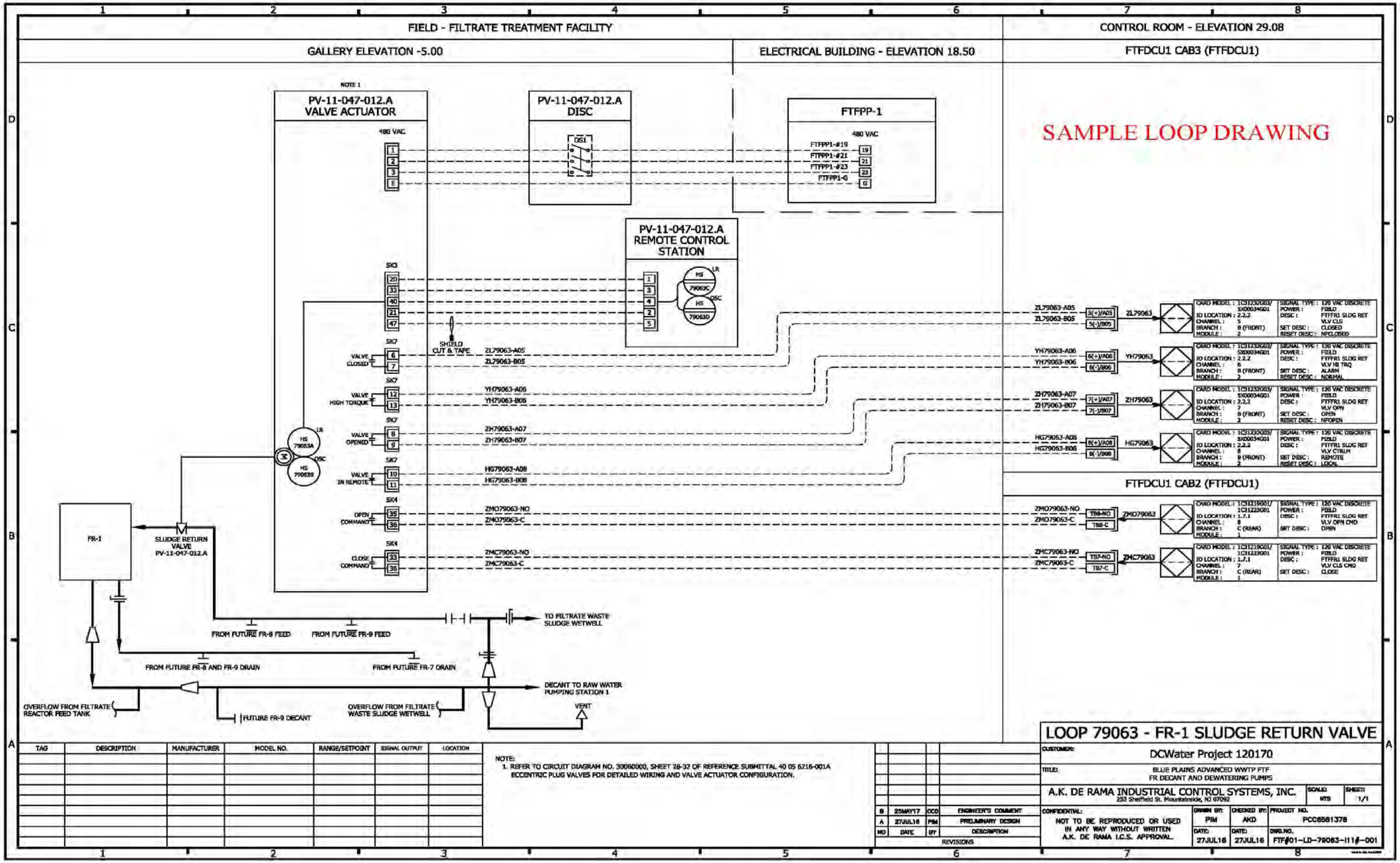
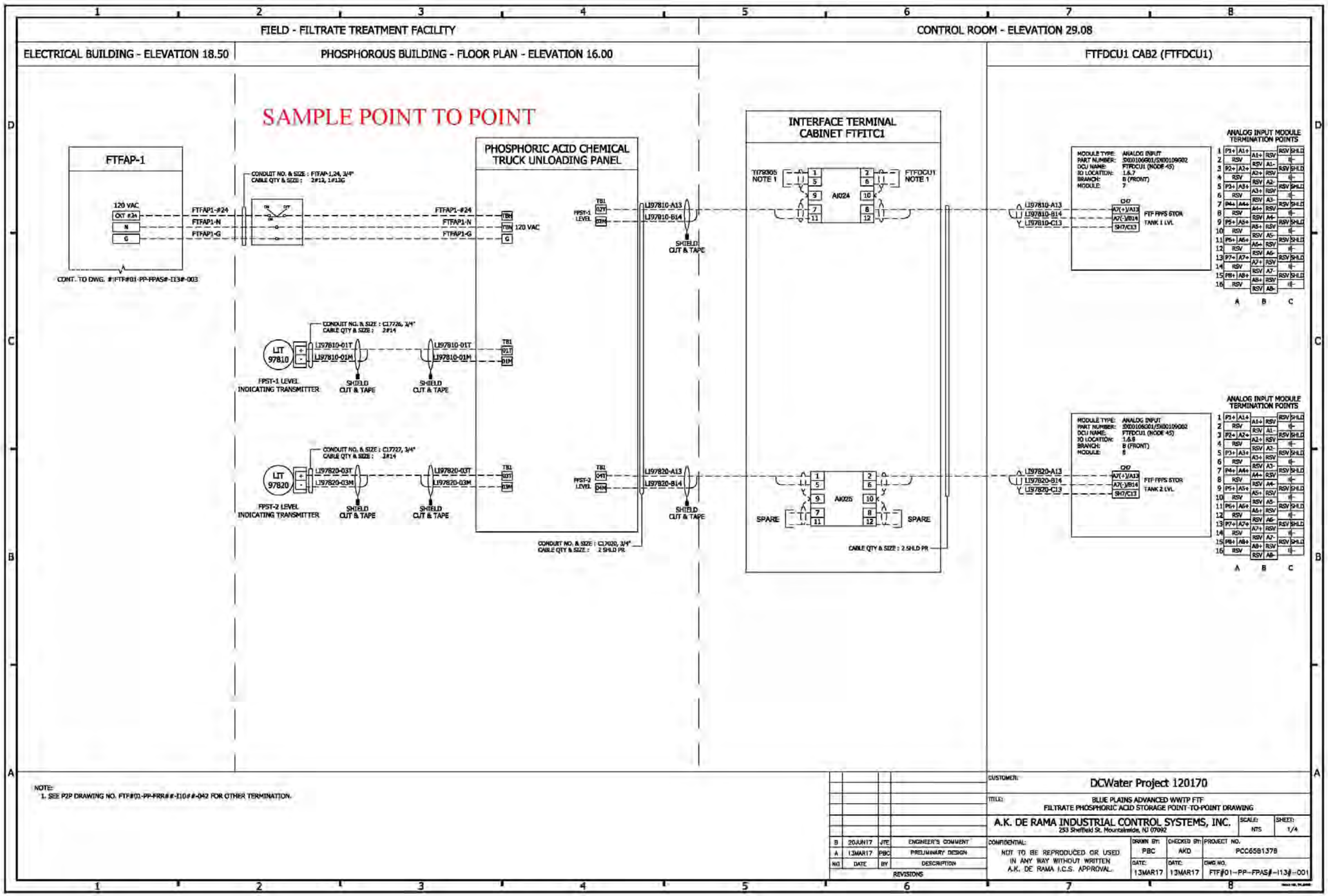


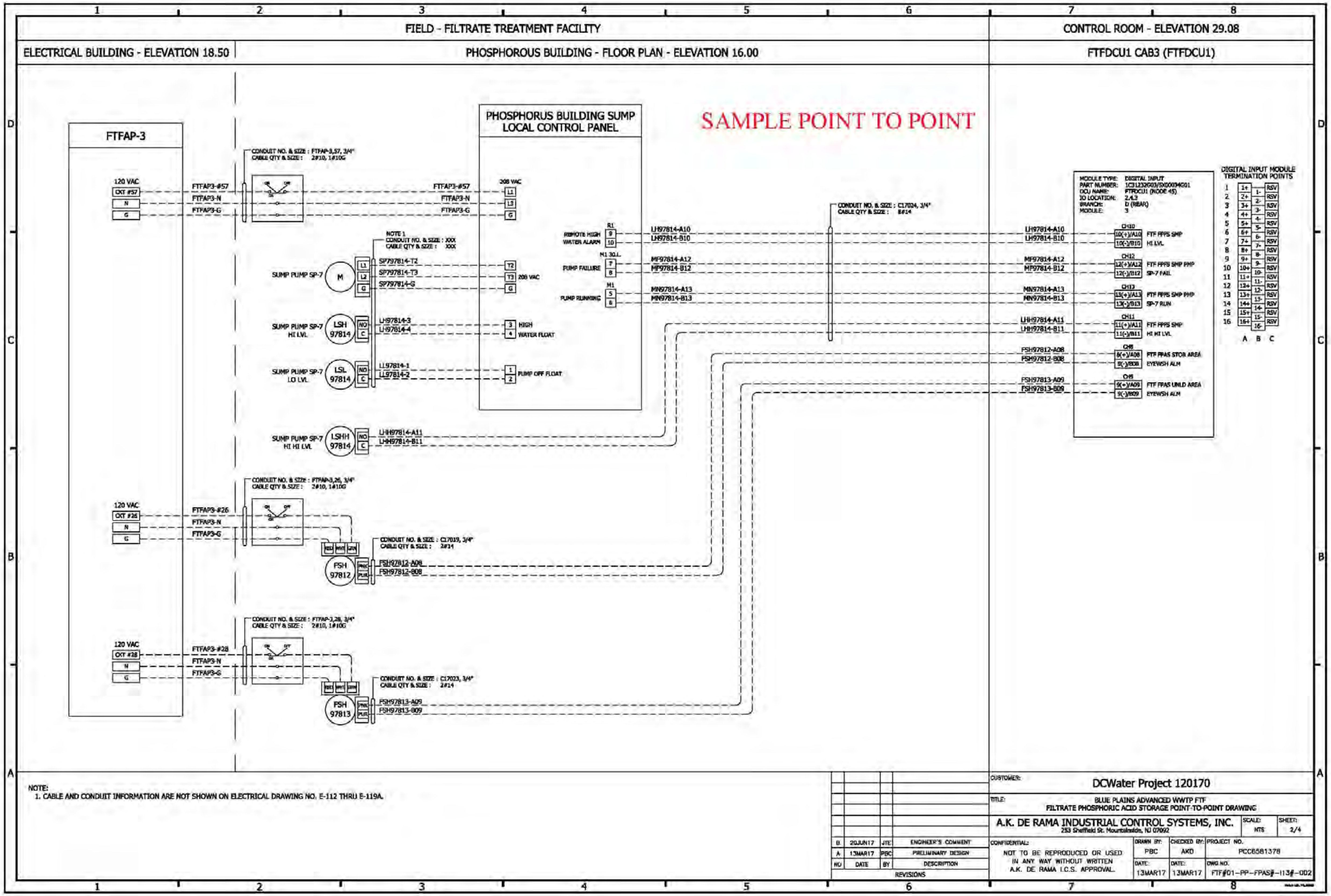
TAG	DESCRIPTION	MANUFACTURER	MODEL NO.	RANGE/SETPOINT	SIGNAL OUTPUT	LOCATION
PI-79061A	DWP-1 INLET PRESSURE	ASHCROFT	45-1279-A-SL-04-L-XPDO/30PSI	0-30 PSI		

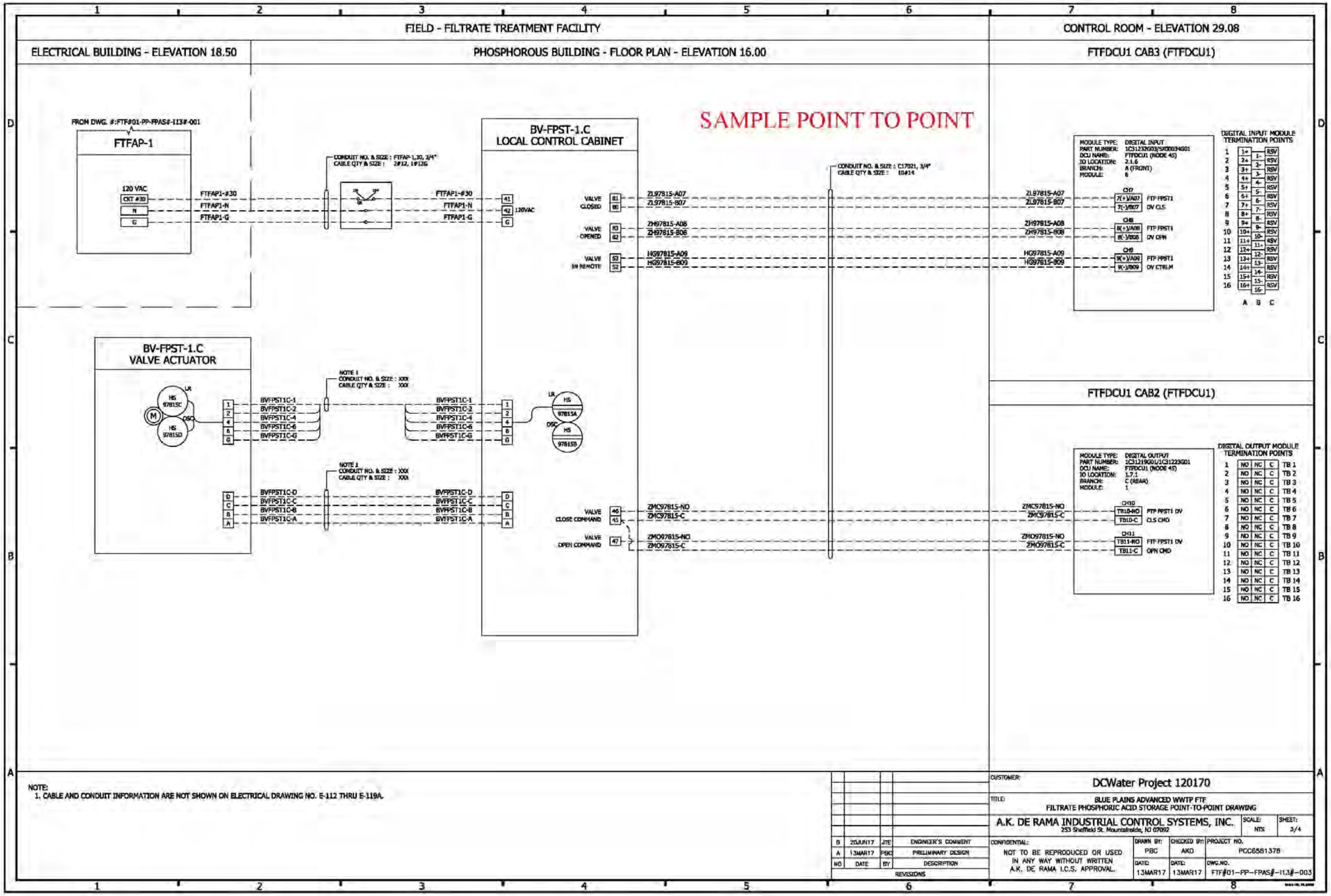
NOTE:
1. REFER TO DWG. NO. WD13-11M OF REFERENCE SUBMITTAL MLY0007053_DC WASA_FTF_SUB_MCC1_VOL3-R4.1RW3 FOR DETAILED WIRING OF MCC.

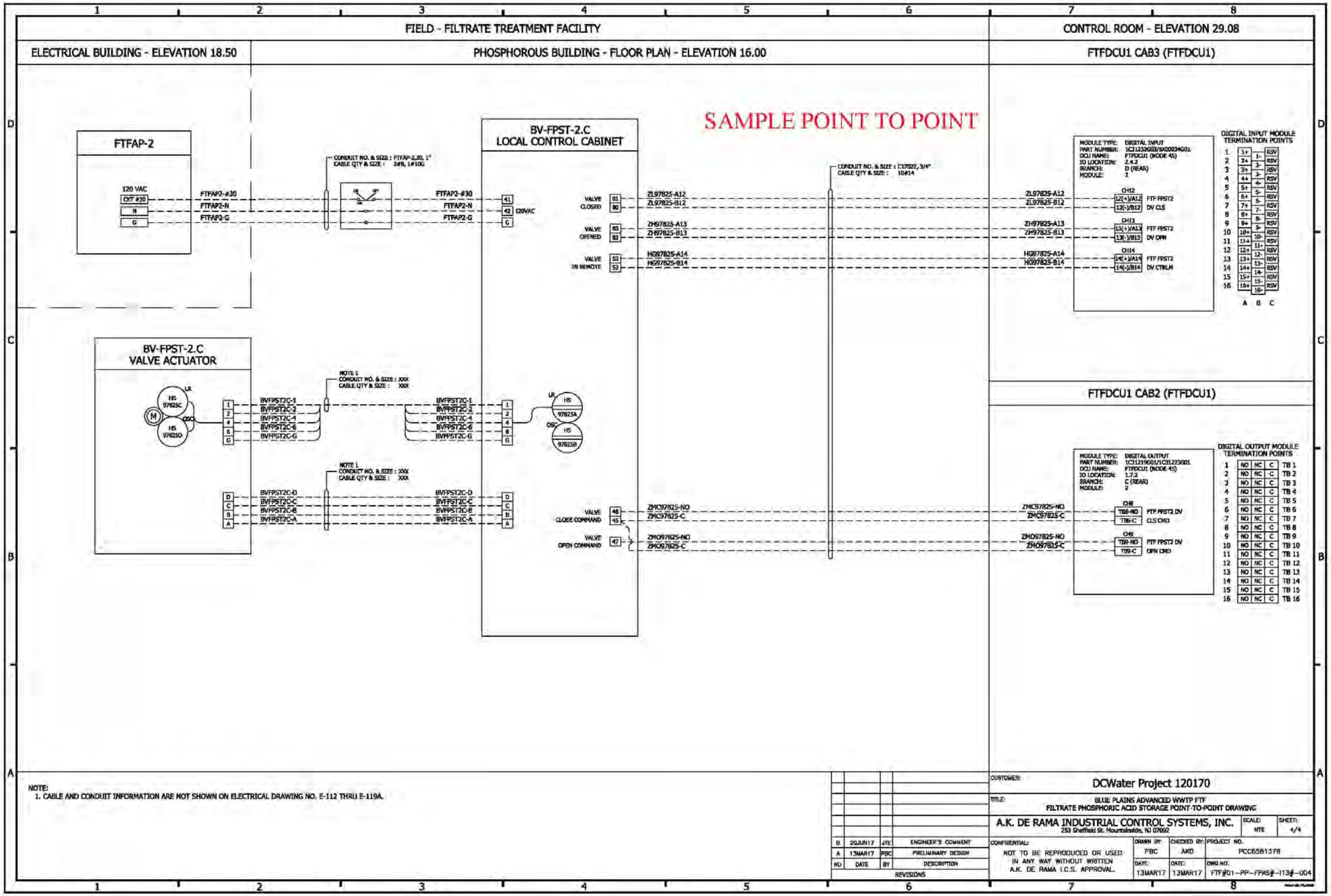

FIELD - FILTRATE TREATMENT FACILITY
CONTROL ROOM - ELEVATION 29.08 - FTFDCU1 CAB3 (FTFDCU1)
GALLERY ELEVATION -5.00
ELECTRICAL BUILDING - ELEVATION 18.50
NOTE 1
FTFMCC3
SECTION 11F - UNIT 11M
SAMPLE LOOP DRAWING
DWP-1 LCS
RUNNING
OFF
MCC3-11M-8
MCC3-11M-X2
MCC3-11M-9
C441R I/O MODULE
IP: 10.11.19.158
FAIL
CR3
RUNNING
PUMP OFF
CR1
HIGH DISCHARGE PRESSURE CUTOFF
TDR
MCC3-11M-1A
MCC3-11M-11
FROM DWP-1
FE/FIT-79060
DWP-1
FR DEWATERING FEED PUMP NO. 1
FL79061B-A14
FL79061B-B14
FL79061B
CARD MODEL : IC3123G03/ 5X00034G01
IO LOCATION : 2.3.7
CHANNEL : 14
BRANCH : C (REAR)
MODULE : 7
SIGNAL TYPE : 120 VAC DISCRETE
POWER : FIELD
DESC : FTFFR DWTR DWP1 SLWTR LO FLO
SET DESC : LOW
RESET DESC : NORMAL
DWP-1 DISC
DWP-1 IN SERVICE
MG79061-A04
MG79061-B04
MG79061
IO LOCATION : 2.1.1
CHANNEL : 4
BRANCH : A (FRONT)
MODULE : 1
DESC : FTFFR DWTR DWP1 IN SERVICE
SET DESC : AVAIL
RESET DESC : OOS
LOOP 79061 DWP-1
CUSTOMER: DCWater Project 120170
TITLE: BLUE PLAINS ADVANCED WWTP FTF FR DECANT AND DEWATERING PUMPS
A.K. DE RAMA INDUSTRIAL CONTROL SYSTEMS, INC.
253 Sheffield St. Mountainside, NJ 07092
SCALE: NTS
SHEET: 2/2
CONFIDENTIAL: NOT TO BE REPRODUCED OR USED IN ANY WAY WITHOUT WRITTEN A.K. DE RAMA I.C.S. APPROVAL.
DRAWN BY: RMC
CHECKED BY: AKD
PROJECT NO. PCC6581378
DATE: 11AUG16
DATE: 11AUG16
DWG.NO. FTF#01-LD-79061-I11#-002
C 25MAY17 CCD ENGINEER'S COMMENT
B 06FEB17 AEA ENGINEER'S COMMENT
A 11AUG16 RMC PRELIMINARY DESIGN
NO DATE BY DESCRIPTION
REVISIONS
TAG | DESCRIPTION | MANUFACTURER | MODEL NO. | RANGE/SETPOINT | SIGNAL OUTPUT | LOCATION
PSH-79061 | DWP-1 OUTLET PRESSURE | ASHCROFT | B4-24-T-X06-30PSI | 0-30 PSI
PI-79061B | DWP-1 OUTLET PRESSURE | ASHCROFT | 45-1279-A-SL-04-L-XPD0/30PSI | 0-30 PSI
FSL-79061B | DWP-1 LOW SEAL WATER FLOW SWITCH | JOHN CRANE | SFP-08-10-NPT1/4"/B/AC-1 | 2 GPM
NOTE:
1. REFER TO DWG. NO. WD13-11M OF REFERENCE SUBMITTAL MLY0007053_DC WASA_FTF_SUB_MCC1_VOL3-R4.1RW3 FOR DETAILED WIRING OF MCC.


FIELD - FILTRATE TREATMENT FACILITY
GALLERY ELEVATION -5.00
ELECTRICAL BUILDING - ELEVATION 18.50
CONTROL ROOM - ELEVATION 29.08
FTFDCU1 CAB3 (FTFDCU1)
PV-11-047-012.A
VALVE ACTUATOR
PV-11-047-012.A
DISC
FTFPP-1
SAMPLE LOOP DRAWING
PV-11-047-012.A
REMOTE CONTROL
STATION
FTFDCU1 CAB2 (FTFDCU1)
FR-1
SLUDGE RETURN VALVE PV-11-047-012.A
TO FILTRATE WASTE SLUDGE WETWELL
DECANT TO RAW WATER PUMPING STATION 1
LOOP 79063 - FR-1 SLUDGE RETURN VALVE
DCWater Project 120170
BLUE PLAINS ADVANCED WWTP FTF
FR DECANT AND DEWATERING PUMPS
A.K. DE RAMA INDUSTRIAL CONTROL SYSTEMS, INC.
NOTE:
1. REFER TO CIRCUIT DIAGRAM NO. 30080000, SHEET 28-32 OF REFERENCE SUBMITTAL 40 05 6216-001A ECCENTRIC PLUG VALVES FOR DETAILED WIRING AND VALVE ACTUATOR CONFIGURATION.


FIELD - FILTRATE TREATMENT FACILITY
CONTROL ROOM - ELEVATION 29.08
ELECTRICAL BUILDING - ELEVATION 18.50
PHOSPHOROUS BUILDING - FLOOR PLAN - ELEVATION 16.00
FTFDCU1 CAB2 (FTFDCU1)
SAMPLE POINT TO POINT
FTFAP-1
PHOSPHORIC ACID CHEMICAL TRUCK UNLOADING PANEL
INTERFACE TERMINAL CABINET FTFITC1
ANALOG INPUT MODULE TERMINATION POINTS
FPST-1 LEVEL INDICATING TRANSMITTER
FPST-2 LEVEL INDICATING TRANSMITTER
SHIELD CUT & TAPE
SPARE
NOTE:
1. SEE P2P DRAWING NO. FTF#01-PP-FRR##-I10##-042 FOR OTHER TERMINATION.
DCWater Project 120170
BLUE PLAINS ADVANCED WWTP FTF
FILTRATE PHOSPHORIC ACID STORAGE POINT-TO-POINT DRAWING
A.K. DE RAMA INDUSTRIAL CONTROL SYSTEMS, INC.
NOT TO BE REPRODUCED OR USED IN ANY WAY WITHOUT WRITTEN A.K. DE RAMA I.C.S. APPROVAL.


FIELD - FILTRATE TREATMENT FACILITY
CONTROL ROOM - ELEVATION 29.08
ELECTRICAL BUILDING - ELEVATION 18.50
PHOSPHOROUS BUILDING - FLOOR PLAN - ELEVATION 16.00
FTFDCU1 CAB3 (FTFDCU1)
SAMPLE POINT TO POINT
FTFAP-3
PHOSPHORUS BUILDING SUMP LOCAL CONTROL PANEL
SUMP PUMP SP-7
DIGITAL INPUT MODULE TERMINATION POINTS
NOTE:
1. CABLE AND CONDUIT INFORMATION ARE NOT SHOWN ON ELECTRICAL DRAWING NO. E-112 THRU E-119A.
DCWater Project 120170
BLUE PLAINS ADVANCED WWTP FTF
FILTRATE PHOSPHORIC ACID STORAGE POINT-TO-POINT DRAWING
A.K. DE RAMA INDUSTRIAL CONTROL SYSTEMS, INC.
NOT TO BE REPRODUCED OR USED IN ANY WAY WITHOUT WRITTEN A.K. DE RAMA I.C.S. APPROVAL


FIELD - FILTRATE TREATMENT FACILITY
CONTROL ROOM - ELEVATION 29.08
ELECTRICAL BUILDING - ELEVATION 18.50
PHOSPHOROUS BUILDING - FLOOR PLAN - ELEVATION 16.00
FTFDCU1 CAB3 (FTFDCU1)
SAMPLE POINT TO POINT
FTFAP-1
BV-FPST-1.C LOCAL CONTROL CABINET
BV-FPST-1.C VALVE ACTUATOR
FTFDCU1 CAB2 (FTFDCU1)
DIGITAL INPUT MODULE TERMINATION POINTS
DIGITAL OUTPUT MODULE TERMINATION POINTS
NOTE:
1. CABLE AND CONDUIT INFORMATION ARE NOT SHOWN ON ELECTRICAL DRAWING NO. E-112 THRU E-119A.
DCWater Project 120170
BLUE PLAINS ADVANCED WWTP FTF
FILTRATE PHOSPHORIC ACID STORAGE POINT-TO-POINT DRAWING
A.K. DE RAMA INDUSTRIAL CONTROL SYSTEMS, INC.
NOT TO BE REPRODUCED OR USED IN ANY WAY WITHOUT WRITTEN A.K. DE RAMA I.C.S. APPROVAL.


FIELD - FILTRATE TREATMENT FACILITY
CONTROL ROOM - ELEVATION 29.08
ELECTRICAL BUILDING - ELEVATION 18.50
PHOSPHOROUS BUILDING - FLOOR PLAN - ELEVATION 16.00
FTFDCU1 CAB3 (FTFDCU1)
SAMPLE POINT TO POINT
FTFAP-2
BV-FPST-2.C
LOCAL CONTROL CABINET
BV-FPST-2.C
VALVE ACTUATOR
FTFDCU1 CAB2 (FTFDCU1)
DIGITAL INPUT MODULE TERMINATION POINTS
DIGITAL OUTPUT MODULE TERMINATION POINTS
NOTE:
1. CABLE AND CONDUIT INFORMATION ARE NOT SHOWN ON ELECTRICAL DRAWING NO. E-112 THRU E-119A.
DCWater Project 120170
BLUE PLAINS ADVANCED WWTP FTF
FILTRATE PHOSPHORIC ACID STORAGE POINT-TO-POINT DRAWING
A.K. DE RAMA INDUSTRIAL CONTROL SYSTEMS, INC.
NOT TO BE REPRODUCED OR USED IN ANY WAY WITHOUT WRITTEN A.K. DE RAMA I.C.S. APPROVAL.

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APPENDIX E
PLC DESIGN AND INTERFACE GUIDELINES

1. INTRODUCTION

1.1. Background

The DC Water Process Control System (PCS) is based on an Ovation Distributed Control System (DCS).

Most of the PLCs connected to the Ovation DCS were provided over many years under capital improvement projects designed and implemented by numerous companies. As a result, the PLCs vary widely in terms of programming philosophy, vendor, model, communication protocol, interface hardware, spare parts, support, documentation, etc.

1.2. Purpose

The purpose of this document is to provide a set of guidelines to promote consistency throughout multiple projects and therefore simplify maintenance/support for DC Water. With this end in mind, this document must be updated regularly, updated as new requirements are discovered and lessons are learned in the design coordination process.

This document communicates high level requirements to designers of capital improvement projects where an Ovation DCS interface is required. In particular, this document describes PLC interface methods currently in use by the Ovation DCS that are the basis for future interfaces.

This document covers many situations a designer will encounter. Other scenarios (e.g., high availability, redundancy, fault tolerance, etc.) will require consultation with Emerson Process Management (EPM) for a custom solution. This document is not intended to take the place of good design, system integration, and proactive coordination. Each project will require a careful review of this material against the objectives of the project to determine the appropriate and best interface techniques.

2. COORDINATION AND DOCUMENTATION

2.1. Coordination

Designers shall include requirements for coordination between the PLC programmer/supplier and Emerson to properly interface the PLCs with the Ovation DCS.

The PCS Program Manager shall, upon request, provide all IP addresses for new equipment to the PDE. The PDE shall provide a control system configuration drawing depicting all network nodes that require an IP address. The drawing will be provided to the PCS Program Manager prior to control system related submittals. The PCS Program Manager shall return the drawing complete with IP addresses assigned within two weeks of receipt. The control system supplier will include the IP address information with control system submittals.

2.2. Coordination Material

All PLC systems shall be specified to provide the following information to the PCS Program Manager through submittals and service manuals. The material shall be provided at specific points in the project lifecycle as indicated below in Table E-1. For each item, provide a printed hardcopy. In addition, on optical media, provide a printed PDF and the original working (source) files used to print the documents. The contractor shall send regular updates as needed to coordinate efforts with the PCS Program Manager.

Table E-1. Timing of Coordination Document Delivery to PCS Program Manager

Document Description	Contractor Submittals	Development & Startup	Service Manuals
1. Logical System Configuration Drawing	Original	Revised	Final
2. Physical System Configuration Drawing	Original	Revised	Final
3. Hardwired I/O List	Original	Revised	Final
4. Data Flow Diagram	Original	Revised	Final
5. Panel Drawings	Original	Revised	Final
6. Ovation DCS Data Exchange Memory Map	Original	Revised	Final
7. Control Strategies	Original	Revised	Final
8. PLC program listing	Original	Revised	Final
9. PLC logic element labels			Final
10. PLC memory contents			Final
11. PLC programming software & license			Final
12. PLC program source code			Final

Logical System Configuration Drawing – Provide drawings showing logical interaction of all network devices and nodes. Emphasize how the components work together rather than how they are physically connected. Include all connected components except cable connectors, patch panels, media converters and unmanaged physical devices (e.g., hubs). Include labels for each drawing element to clearly annotate node name, IP address, network segment speed, virtual local area network (VLAN) name, and communication protocols.

Physical System Configuration Drawing – Provide drawings showing physical connection of all network devices and nodes. Emphasize how the components are connected. Include all connected components to allow disassembly and reassembly of the field equipment using only these drawings as a reference. Include labels for each drawing element to clearly annotate node name, IP address, network segment speed, VLAN name, cable type, terminal strips, patch panel ports, bulkhead adapters, wire/terminal pairs, equipment vendor, model number, etc. Labels must be complete and match all equipment, enclosures, terminals, cables, wire labels, etc. to be used or currently in use in the field.

I/O Point List – List of physical inputs and outputs connected to each PLC. Include tag name, description, and point type. For analogs, provide high range, low range, alarm limits, and engineering units. For discrete, provide set definition, reset definition, point inversion requirements, and alarm state. The tag names must follow the tag naming convention established by the PCS Program Manager available upon request. These tag names shall be used throughout the material described in this interface guidelines document.

Data flow diagram – Drawing showing all applications and services which communicate across the network(s). Include service names, application names, node IP addresses, IP ports, protocols, and initiating node. Provide typical drawings to minimize volume of information. With each typical drawing, provide a legend to indicate where the typical drawing can be applied and basic reference information unique to each instance.

Panel Drawings – Drawings which show details of power distribution, communication, and analog/discrete inputs/outputs. Drawings must be complete and exactly match installed field conditions. All components, wires, and cables must be clearly and accurately labeled in the panels and on the drawings.

Ovation DCS Data Exchange Memory Map – An Excel spreadsheet that an Ovation DCS programmer can use to configure the interface to the PLC, add new tags to the Ovation DCS, and develop graphics. Includes all information and fields from the Input/Output Point List described above. Also, includes data types, calculated (virtual) points (e.g., fail to start, flow total, elapsed time, etc.) not obtained from real I/O. Include additional fields (columns) as needed or upon request.

Control Strategies – Written narratives produced by the designer, of the process monitoring and control requirements. Special requirements for failure conditions and equipment controllability checks need to be included by the designer. Examples include: hold last good value upon PCS communications fail, force a control loop set point to certain values during faults, etc. All control modes and transitions between control modes needs to be clearly defined and explained – include requirements for bumpless transfer between all control modes.

PLC Program Listing – A readable document that depicts the PLC control logic in a traditional fashion (e.g., ladder logic, function block programming, etc.). Must include logic element labels and rung comments that describe the operation of the logic. Rung comments must be coordinated with and reflect the requirements established in the control strategies.

PLC Logic Elements Labels – A listing of all control elements used in a PLC application (e.g., coils, contacts, function blocks, etc.).

PLC Memory Contents – The contents of each memory location. This memory includes values for totalization, tuning, control that are typically lost when a new processor is installed, an existing processor is reset, or operational settings are not initialized to known values on program startup.

PLC Programming Software and License – The software installed on a computer that is used to program the PLC, configure the PLC, upload/download applications, force memory, etc. Examples include Schneider Concept, Rockwell RS Logic 5000, etc.

PLC Program Source Code – The application logic and configuration specific to a particular installation (e.g., Filter Backwash Control, etc.).

Password Listing – The control system integrator must provide usernames and passwords for all equipment. Updates shall be provided whenever this information changes, so DC Water has access to all systems in production.

2.3. Startup & Testing

During system startup, the contractor shall provide a programmer familiar with the PLC logic provided. The programmer shall have the experience, project background knowledge, and authority necessary to make field changes while on site.

The contractor shall test the DCS to PLC interface and operation of the control system to ensure designer requirements have been met. The PCS Program Manager shall act as the Ovation DCS liaison and work with the Contractor during loop checkout and testing.

3. COMMUNICATION WITH OVATION DCS

3.1. Communication Interfaces

This section documents existing interface methods which connect the Ovation DCS to PLCs. New interfaces shall be consistent with the existing interfaces having many of the following common features:

1. Communication between the Ovation DCS and PLCs is achieved with either Allen Bradley or MODBUS communication protocols. Allen Bradley protocols (AB CSP/PC, AB EIP, and AB EIP/PCCC) use Ethernet. MODBUS protocols use either Ethernet (IEEE 802.3) or Serial (RS-485).

2. Control related commands (e.g., start/stop, open/close, auto/manual, etc.) issued to a PLC from the Ovation DCS shall be transmitted with momentary bit values, not maintained bit values. The PLC logic must latch the momentary bits from the Ovation DCS and hold the equipment in the intended operational state until a momentary bit is received from Ovation DCS to reverse the previous action. Based on past experience, this is the preferred interface approach because it is less disruptive to the process during fault conditions (e.g., communication outages primary/secondary server failover, etc.).

   The decision to use momentary/maintained outputs for hardwired PLC outputs and control circuits is up to the designer; the requirement described above is solely for the Ovation DCS/PLC communications interface.

3. Some protocols, depending upon desired functionality, require special network switches and switch configurations. For example, some Allen Bradley protocols have special requirements related to the following subjects: VLAN, full duplex capability on all ports, auto-negotiation and manually configurable speed/duplex, IGMP snooping, port mirroring, STP, QoS, and SNMP. The designer is expected to design a robust industrial network appropriate for their project.

4. Some communication protocols such as CIP over EtherNet/IP are designed to be tag based, not register based. This particular protocol driver may require validation of tags upon startup or after a communications outage. The duration of the validation phase can be significant for large I/O point counts and must be considered by the designer from reliability, controllability, and general system performance perspectives.

5. Some communication protocols handle higher resolution 32-bit data types differently (e.g., double precision, real, float, etc.). The designer and system integrator shall coordinate PLC memory and communication drivers to directly map memory in to Ovation tags. This will be done to avoid having to swap words and/or bytes to link the Ovation tag to PLC memory. Some examples of how tags can be read by drivers include: "high byte first high word first", "high byte first low word first", "low byte first high word first", "low byte first low word first", etc. If this is not managed carefully, three (3) or more tags may be needed to rearrange byte/word order into a final destination tag. This can drastically affect systems with tag based licensing.

   If this byte/word cannot be managed, use 16-bit registers to transmit integers with a shifted decimal place (e.g., x10 transmits 12.4 as 124 x100 transmits 124.5 as 12450, etc.) – note that this approach drastically reduces resolution and accuracy. However, if high resolution and/or accuracy is needed to use the multiple tag approach only as a last resort.

6. The number of PLCs, registers, bits, tags, etc. supported by these links depends upon numerous requirements including: network speed, port speed, communication payload (number of bits/registers), protocol, and update rate. The designer is expected to design an interface that meets or exceeds performance requirements specific to their project. This will require research beyond the scope of this document.

There are three (3) methods to connect a PLC to the Ovation System. They are:

1. **<u>Link Controller & Remote Link Controller</u>**– Emerson provides two types of gateway card modules, called link controllers. Link controllers are available in both serial and Ethernet connections. Ethernet link controllers will be used, even where serial to Ethernet converters are required. Care must be taken to ensure protocol and drivers are available for the Ethernet controllers solution during design. Note the Ethernet link controller is not currently available for Remote I/O installations but will be in the future and should be coordinated during design. Currently, I/O should be limited to 2000 points and also has to be coordinated with bus limitations within a specific DCU cabinet.

2. **<u>Third Party (Distributed Controller Port, Ethernet)</u>** – This has been used effectively for a small network of PLCs. An Ovation third-party driver is loaded into a DCU specific to the PLC and/or communication protocol. The Ovation DCS communicates to PLCs across an Ethernet network.

3. **<u>SCADA Communication Servers (Ethernet, Redundant)</u>** – This has been used effectively with larger networks of PLCs. The Ovation SCADA Server software is loaded on to a workstation. The SCADA Server is configured to poll PLCs. Although a serial connection is possible, only Ethernet connections will be used with the Ovation DCS.

The Ovation Smart Docs listing in Attachment A has a listing of documents with more detail on each method listed above.

3.2. Communication Drivers

The Ovation system supports interfaces to PLCs through message protocols. Refer to the Ovation specifications and documentation that define the types of messages transmitted over an Ovation communication interface. Refer to Attachments A and B for important Ovation driver reference material.

3.3. Efficient Communication Overview

One of the goals of these Guidelines is to provide efficient and secure communication from an Ovation DCS to PLCs and PLC type devices (both classes of devices will be referred to as PLCs in this document). Programming issues must also be addressed to insure proper control of the plant processes.

The primary benefit of efficient communication is that process data is retrieved as quickly as possible. If configured correctly, it is possible that PLC data can be scanned and updated at or near the same rate of the DCS Hardwired I/O.

The first way to gain efficiency is to communicate to the PLC at the fastest possible communication speed. For serial interfaces, this means that the baud rate should be set to the fastest setting supported by both the PLC and the Ovation interface. For Ethernet interfaces, standard Ethernet speed (10Mbs) is typically sufficient but Fast Ethernet speed (100Mbs) is preferred.

The next way to gain efficiency is to reduce the number of communications between the Ovation system and the PLC. There is a limit to the number of values (registers) that can be exchanged with a PLC in one message. This limit varies by communication protocol. If the number of values required exceeds this number, multiple communications are required. **There can be adverse control reactions if inputs to a control strategy arrive at different times because multiple messages are used. Therefore, messages should be minimized and PCS control logic needs to account for such latency.**

For MODBUS, values can be “packed” into contiguous holding registers to reduce the address ranges of these points. In this case, rather than reading Digital Inputs, Analog Inputs, and Calculated Values from different register address ranges, (requiring three communication requests), all these values can be read from contiguous holding registers, reducing the number of requests required, possibly down to one. The same is true for output points. Typically, all output points (Digital, Analog, Calculated) from Ovation to the PLC should be written to holding registers. The PLC can then read these values from the holding registers and write them to their final destination.

By following this register layout design, the number of communications between the PLC and DCS is minimized and the communication efficiency is maximized. This “pre-planning” requires detailed coordination between PLC programmer and the DCS integrator prior to commissioning.

3.4. PLC Discrete Data ‘Packing’

Whereas analog data can be simply moved or copied into and out of holding registers, discrete data will need to be ‘packed’ into the holding registers. Packing the discrete data into holding registers results in a 16:1 compression ratio (for 16-bit registers) and fewer messages.

By utilizing this technique, the need for a separate discrete data message is eliminated. The ‘packed’ holding registers can then be arranged along with other ‘analog’ registers for efficient data transfer. Once the message is received by the Ovation DCS, the discrete data bits will be ‘unpacked’ from the holding register. Similarly, the PLC program will also need to ‘unpack’ the discrete data registers sent from the Ovation DCS for use in the PLC logic.

3.5. Data Transfer Area

Efficient communication between the Ovation DCS and PLCs will require a well designed and documented holding register area of PLC memory. This Data Transfer Area (DTA) will be divided into eight distinct areas, or groups of contiguous registers. The arrangement of these registers must provide sufficient flexibility to support future expansion. The following hypothetical example illustrates the general layout of the DTA.

Table E-2. Data Transfer Area Example

Command	Range Description	Status	Register Range
	Analog From Master	Inactive	Registers 45001 - 45100
CMD 1	Analog From Master	Active	Registers 45101 - 45150
	Digital From Master *	Active	Registers 45151 - 45200
	Digital From Master *	Inactive	Registers 45201 - 45300
	Analogs To Master	Inactive	Registers 45301 - 45400
CMD 2	Analog To Master	Active	Registers 45401 - 45450
	Digital To Master *	Active	Registers 45451 - 45500
	Digital To Master*	Inactive	Registers 45501 - 45550

* Digital information packed into analog registers

This general example illustrates the method to efficiently exchange information using two MODBUS commands (1 Read and 1 Write). Note: register ranges in this example are provided for illustration and do not reflect the register ranges to be used in the actual PLC programming application. This example also shows how registers are reserved for future expansion. The future registers are arranged in contiguous blocks both before and after the registers that will be transferred based on immediate needs (those shown bold). This will minimize the impact of adding future data transfer points and by doing so will maximize the efficiency of each MODBUS command. To incorporate future points, the existing MODBUS commands will simply be modified to include a new offset register (starting register of the message command) or an updated message length to transfer the additional data registers or both.

Note: Some calculated data and set points are to be performed using real numbers, not integers. Note that each real value requires two 16 bit registers. Failure to reserve two registers for each real value will lead to undesirable results.

3.6. Transfer of Digital and Analog Inputs

When digital or analog input data is transferred, the data shall be arranged in the DTA in the same order in which the field I/O points are connected at the input module. This ensures that future I/O connected to spare points can be easily added and will minimize or eliminate additional programming to transfer new points to the Ovation DCS.

3.7. Time Synchronization

At 12:00 noon, each day, the Ovation DCS will send a bit to each PLC to reset and synchronize the PLC clocks. This will be a bit that is part of a register with other packed digital information. The PLC will perform all necessary logic to reset the PLC clock. The Ovation DCS will only send the synchronization bit once per day at noon.

This function will ensure that calculated daily values throughout the PLC (if any) are performed during the same time interval. It also addresses coordination of daylight saving time.

3.8. Communication Status Monitoring

The PLC has a responsibility to ignore erroneous data sent to it by the DCS. The DCS, as well, has a responsibility to notify operators if the PLC is not operating as designed. This is typically accomplished through the use of watchdog timers.

The PLC utilizes a watchdog timer from the DCS to verify that the DCS is communicating correctly and is capable of generating control commands (set points, etc.). If the PLC determines that watchdog timer is not functioning, then the PLC should revert to non-DCS control mode.

Similarly, the DCS utilizes a watchdog timer from the PLC to verify that the PLC is communicating correctly and that the application program is running. If the DCS determines that the watchdog timer is not functioning, the DCS should generate an alarm and revert to non-DCS control mode for the I/O associated with the PLC.

The actual response (e.g., alter control mode, hold last good value, etc.) in the PLC and for any given fault situation needs to be determined by the Designer and documented in the Control Strategies.

One way to generate a Watchdog Timer is to have an incrementing analog value. This value could be a calculated integer value or the current wall clock seconds, for example. One possible scenario is described below:

- The PLC generates a watchdog timer value that changes often (e.g., PLC clock seconds) and writes it to a register in the PLC. This register location should be adjacent to the existing analog values being read from the PLC by the DCS.
- The DCS reads this value and monitors it to insure that it is changing.
- If this value does not change within a specified number of seconds (10 seconds, for example), then an alarm is generated and the DCS application logic assumes that control is reverted to non-DCS mode in the PLC.
- The DCS also generates a watchdog timer value and writes it to a register in the PLC. This register location should be adjacent to the existing analog output values being written to the PLC by the DCS.
- The PLC reads this value and monitors it to insure that it is changing.
- If this value does not change within a specified number of seconds (10 seconds, for example), then the PLC reverts to non-DCS mode. A PLC generated alarm point [displayed on an operator interface terminal (OIT)] may or may not be required and should be addressed on a case-by-case basis, based on customer needs.

3.9. Analog Data

3.9.1. Analog Input Scaling

Analog inputs are acquired from analog input modules and placed into registers as raw un-scaled ‘counts’ (typically ranged 0-4095, 0-32767, etc.) The PLC program logic shall scale inputs to their engineering ranges and convert them to real numbers. Once the analog inputs have been scaled, all further references shall be in engineering units and used as real number values.

3.9.2. Analog Input Out of Range Alarms

The PLC programming shall generate an alarm if an analog input value is less than 3.9 mA or greater than 20.1 mA.

The PLC shall clamp values less than 4 mA at the 4 mA value to prevent miscalculations (e.g., negative flow accumulation). Similarly, the PLC shall clamp values greater than 20 mA at the 20 mA level. This example used a signal with a 4-20 mA input. This concept shall be applied to other types of signals as well (e.g. 0-10 vDC, 1-5 vDC, etc.).

3.9.3. Analog Outputs

Analog output values represented in engineering units must be scaled to the appropriate raw count range and converted to the appropriate word type before they can be sent to an analog output module.

All process related variables and calculated points in the PLC are to remain as real numbers throughout the PLC programming. Analog output scaling is only performed as a final step before data is sent to the analog output module.

4. PLC Control Logic Overview

4.1. Overview

PLCs are typically configured to allow local control as well as DCS control. This is generally supervisory in nature. In some instances, there may be multiple control modes, including Local (hardwired), PLC Manual, PLC Automatic, and DCS Mode. PLC control modes must be coordinated closely with the DCS to insure both proper control and bumpless transfers between modes.

The first point to be aware of is “Who is in charge of the control mode”. Most of the time, a local PLC interface or a hardwired switch is used to select between the available control modes. The PLC is, therefore, notified of the current control mode and must make this information available to the DCS. The DCS must use this information to determine if set point values from the PLC should be tracked.

The PLC must take an active role in the communication interface when control is involved. Typically, separate input areas are provided for each of the different control input devices external to the PLC (i.e., Switch Panel, Soft Panel, and DCS). The PLC can then decide, based on the current control mode, which input device to accept inputs from.

For MODBUS, different blocks of holding registers are typically used for each input device. The PLC, based on the current control mode, then moves the values from the appropriate set of holding registers to the “actual” input holding registers. This prevents problems with timing issues related to input device set point tracking. This also prevents a poorly programmed input device from ignoring the current control mode and overwriting valid set point values.

The Designer must write control strategies that clearly explain how bumpless transfer is to be achieved in the transition between all possible control modes.

4.2. Analog Control

Analog control typically involves the calculation of a set point value that is sent to the PLC for it to act upon. Set point tracking must be handled manually when performing control through a PLC interface. For example, when the PLC control logic is in “DCS” mode, the Ovation control logic is responsible for calculating the defined set point outputs to the PLC. However, when the PLC is not in DCS mode, the Ovation control logic must “track” the PLC calculated set point values. When configured correctly, this allows a bumpless transition between DCS and non-DCS control modes in the PLC. The Designer must write control strategies that clearly explain bumpless transfer requirements.

This type of tracking scenario requires that the set point values be read as inputs from one set of registers in the PLC and written as outputs to a different set of registers in the PLC. The PLC logic is then responsible for utilizing the correct set point based on the current control mode.

4.3. Discrete Control

Digital control typically involves open/close or start/stop type logic outputs to the PLC. While a single bit can be used as a command output (1=open, 0=close), experience has shown this to be prone to process bumps during redundancy failovers. It is preferable to utilize separate bits for these commands; one bit to open, a different bit to close. The commands are sent as a “one-shot” or pulse output and are acted upon by the PLC on a zero to one transition.

4.4. Ovation DCS Set point and Command ‘READ-BACK’

When a PLC is operating in Ovation DCS mode, set points and commands from Ovation DCS will be handled as follows:

- A set point/command is sent from the Ovation DCS.
- The remote site PLC receives the set point/command, and then moves this value to a location in the Data Transfer Area (DTA) that will be read back by the Ovation DCS.
- The Ovation DCS reads back the set point/command and the operator can view the updated value.

This ‘read-back’ technique allows the operator at the Ovation DCS to verify that set points commands are properly communicated to the remote sites. With this approach, there are no assumptions made about transmission and receipt of the commands.

5. Control Hierarchy Overview

5.1. Control Modes

Several levels and modes of operational control will exist for process control equipment and systems. Operators usually have the ability to monitor and control equipment via local manual controls, via the local PLC operator interfaces, or through remote control available from the Ovation DCS. The selection of these modes of operation will be made available through the use of hardwired field switches and software selector switches.

5.1.1. Local Manual Control

Hardwired Computer/Local field switches provide selection of Local or Computer control for remote site equipment. All equipment must be equipped with local manual control that overrides PLC and Ovation DCS control. This is intended for use primarily during maintenance functions and is not intended for normal process control operation.

5.1.2. Computer Control

When the Computer/Local field switch is placed in the Computer position, equipment will be controlled by the PLC in either PLC mode or Ovation DCS mode. This mode selection is determined by the position of the hardware or software PLC/Ovation DCS switch in the PLC Operator Interface Terminal (OIT). A hardwired switch is recommended where accessibility is important and an OIT failure must not preclude access.

5.1.2.1. Computer Control – PLC Mode

When control is passed to the PLC, the operator will control equipment from the local OIT graphic screens. While in PLC mode, the operator can select Auto or Manual operation via a software switch on the OIT screens. These modes are described below:

- **Manual** - Operator will control equipment manually via the OIT interface.
- **Auto** - Automatic control and sequencing is accomplished via the PLC's program logic.
- **PCS Mode -** Transfers control to PCS.

While in PLC mode, commands and set point changes from the Ovation DCS are not executed by the PLC control logic. PCS control will not be allowed when in PLC Auto or Manual mode. Control of PLC/PCS mode shall be at the PLC or PLC OIT.

5.1.2.2. Computer Control – Ovation DCS Mode

When PCS mode is selected, the operator will control equipment from the Ovation DCS graphic screens on Ovation workstations. While in Ovation DCS mode, the operator can select automatic or manual operation via a software switch on the Ovation DCS graphic screens. These modes are described below:

- **Manual** - Operator will control equipment manually via the Ovation DCS graphics.
- **Auto** - Automatic control and sequencing parameters are transferred to the remote site via the Ovation DCS-PLC interface.

While in Ovation DCS mode, operators will be prohibited from invoking commands and manipulating process control set points at the local OIT graphic screen.

5.2. Calculated Values

Although not normally required, the designer **may** decide that the PLC needs to calculate values locally because high accuracy is required. Examples include aggregation (e.g., max, min, avg, total, etc.). Performing calculations locally ensures that errors due to PCS communications outages are eliminated (e.g., flat-lined data, etc.). This is a prudent step when the calculated data affects plant permit data, billing, and other uses sensitive to accuracy.

In such cases, the PLC program shall collect, calculate and store important data. These calculated values will be moved to the DTA for transfer to Ovation PCS.

The contractor shall coordinate calculation data types with the PCS Program Manager.

The following calculation methods will be used where the Designer feels high accuracy data is required.

5.2.1. Runtime Calculation

Runtimes are calculated for all equipment whose run statuses are monitored by the PLC. Two separate runtimes will be calculated; Daily Runtime and Accumulated Runtime.

These calculations will use double precision (i.e. 32 bit) integer data types. The current day runtime register will increment each second the associated equipment is running. At midnight, the current day runtime register will be added to the accumulated runtime register associated with that piece of equipment. The total runtime will be calculated by the Ovation PCS system before display. The current day value will then be reset to zero once. A 32-bit unsigned integer has a maximum value of 4,294,967,295 (i.e., FFFF FFFF in hexadecimal). This run timer has a maximum value that slightly exceeds 136 years.

The accumulated runtime register is reset automatically by the PLC when the maximum value is reached. The operator will not have the ability to reset these accumulator values. It is expected that the values will only be reset through a programming laptop by qualified personnel.

The contractor shall coordinate rollover values with the PCS Program Manager.

5.2.2. Flow Totalization

Flow totals are calculated for all required process flows that are monitored by the PLC. The following example illustrates a typical flow totalization calculation:

Each second the following calculation is performed in PLC logic.

Totalized flow: (Flow Value (mgd) / 86400) + Total accumulated flow.

In this example, the flow rate is expressed in MGD and the Total accumulated flow is expressed in MG. This calculation, executed once a second by the PLC, adds an increment of flow to the total accumulated flow each time the calculation is performed. Since the calculation is performed once per second, the flow rate is divided by 86400 (i.e., the number of seconds in a day.) The result is the total accumulated flow in millions of gallons. If the flow is represented in engineering units other than MGD, the appropriate conversion constants will need to be substituted into the calculation.

At the end of each day, the program shall take the current day’s totalized values, move them to a different register storage area for yesterday’s data and reset the new current day’s value to zero. Current daily totals and yesterday’s accumulated values shall be moved to the DTA for transfer to Ovation PCS.

The contractor shall coordinate rollover values with the PCS Program Manager.

5.2.3. Minimum, Maximum and Average Calculations

In addition to calculating totalized process values, it is often important for the PLC to capture and calculate minimum, maximum and average daily values. Current day and previous day values shall be moved to the DTA in order to be communicated to the Ovation PCS. Typically, one week of these values are to be moved into a separate area of DTA memory for manual 'one shot' retrieval from Ovation PCS. Please note that this type of weekly storage and data retrieval may not be required for all projects – only where a loss of data must be avoided.

5.2.3.1. Minimum Value Calculation

PLC programming shall be implemented to calculate the minimum daily value for the required process I/O points. This is achieved in PLC logic by performing the following:

- At the beginning of each day, reset the minimum value holding register to the maximum value. For example, if a particular flow rate's upper range limit is 4.00 MGD, then move a value of 65535.00 into the holding register.
- On the first scan of the logic, the PLC will compare the process value to the holding register. If the process value is less than the holding register, then move the current process value into the holding register. If the process value is greater than or equal to the holding register value, then the last value will remain until a process value less than the holding register is evaluated.
- This routine is performed continuously though out the day, and yields the minimum value.
- At the day's end, today's minimum value is moved to yesterday's minimum value and the current day's value is set.
- The current day's minimum value is set to a maximum permissible value in order to ensure that the PLC's first scan will move a valid process value into the holding register.

5.2.3.2. Maximum Value Calculation

PLC programming shall be implemented to calculate the maximum daily value for the required process I/O points. This is achieved in PLC logic by performing the following:

- At the beginning of each day, reset the maximum value holding register to zero. For example, if a particular flow rate lower range limit is 0.00 MGD, then move a value of 0.00 into the holding register.
- On the first scan of the logic, the PLC will compare the process value to the holding register. If the process value is greater than the holding register, then move the current process value into the holding register. If the process value is less than or equal to holding register value, then the last value will remain until a process value less than the holding register is evaluated.
- This routine is performed continuously though out the day, and yields the maximum value.
- At the day's end, today's maximum value is moved to yesterday's maximum value and the current day's value is reset.

- The current day's maximum value is set to a minimum permissible value in order to ensure that the PLC's first scan will move a valid process value into the holding register.

5.2.3.3. Average Value Calculation

PLC programming shall be implemented to calculate the average daily value for the required process I/O points. This is achieved in PLC logic by performing the following:

- At the beginning of each day, the PLC will begin to count a predefined sample rate to capture data. In this example the sample rate will be 5 seconds.

- Every 5 seconds the PLC will increment the count, capture the current process value and perform this calculation:

  Daily Average = (Current process value + Accumulated process value) / count

- This routine is performed continuously though out the day, and yields the average value.

- At the day's end, today's average value is moved to yesterday's average value and the current day's value is reset to zero. The PLC will also reset the number of counts to zero.

6. Alarm Handling

6.1. Overview

Alarming is primarily an HMI function. While the HMI obtains its process data from the PLC, the PLC is not to be used to manage alarm activity. This means that all of the latching and acknowledgement functions are handled exclusively on the remote OIT alarm screens (if provided) and the Ovation DCS alarm screens. Alarms viewed and acknowledged at the remote site OIT screens will be handled independently of the alarms processed and managed by operations at the Ovation DCS workstations. To clarify, alarms acknowledged at the remote site OIT will not serve as an acknowledgment to alarms displayed by the Ovation DCS and vice-versa. Ovation Workstations implemented using an OIT device are considered Ovation workstations within this context.

Consider three types of alarms:

6.1.1. Alarm conditions sensed by dedicated discrete inputs (DI).

These alarms are sent directly to Ovation DCS. These DI alarms may also be used by the PLC logic as software interlocks for process control. These DI's remain energized as long as the process condition remains in alarm.

6.1.2. Discrete alarms generated by the PLC based on process conditions, or a combination of process conditions.

The PLC generates alarms if equipment fails to perform as expected. These alarms remain on in the PLC while the alarm condition exists. Some of these alarms might require a manual reset by the operator. The Ovation system manages alarm reporting and acknowledgment within the Ovation DCS. Acknowledging and resetting are separate, independent operator functions.

6.1.3. Alarms generated based on analog measurements.

The PLCs process each analog input value to detect specified signal levels for Low-Low, Low, High, and High-High condition. Since these alarms are used by the HMI and Ovation DCS systems, they are generated in PLC logic and not in the Ovation DCS. Out of range alarms will be generated in PLC logic.

Provide alarm conditioning as a standard method of limiting nuisance alarms (i.e., dead band, dead band with minimum duration timers, etc.). Adjust alarm conditioning settings to ensure only valid alarms are received by the PCS.

Implementation of alarm prioritization will be determined based on client feedback.

Appendix E

Attachment A – Ovation Documentation

This guide references Ovation Release 3.2 documentation obtained from an Emerson SmartDocs CD. The PDF materials of the CD (listed in Table E-3 below) were last updated in May 2009. Contact Emerson Process Management for reference material specific to design criteria.

Table E-3. SmartDoc CD Contents (May 2009)

Document Title	Reference
Foundation Fieldbus User Guide for Ovation 3.2	OW320_30
ICCP Interface User Guide	U3_1055
LC-ABB Turbine Controller Interface User Guide	U3_1057
LC-MP3 Interface User Guide	U3_1060
LC-OPTO 22 Interface User Guide	U3_1058
LC-Woodward Governor 501 Interface User Guide	U3_1056
Link Controller (LC) Loader User Guide	CON_004
Link controller (LC) Toolkit User Guide	U3_1022
Link Controller User Guide	U3_1021
Ovation Data Link Server User Guide	CON_003
Planning Your Ovation System	REF_1005
Profibus User Guide for Ovation 3.2	OW320_36
Redundant Modbus Interface	CON_020
Reliance PLC Interface User Guide	U3_1059

Appendix E

Attachment B – Interface Matrix

For convenience, the hardware/device spreadsheet and release version spreadsheet from ***Planning Your Ovation System RF_1005 May 2009*** are provided below (user of this document are encouraged to check for updates). These two spreadsheets contain the following information:

Table E-4 lists hardware or devices used in a communication interface.

- Physical connection used for an interface.
- Protocol that the interface uses to send messages.
- Available platform(s) for the interface.
- Interface options to connect to Ovation

Table E-5 shows the release version information.

- Communication interface name.
- Ovation software releases that support the interface.
- Related Ovation documentation to help you connect, configure, and use the interface

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Table E-4. Hardware or Devices Used in a Communication Interface

HARDWARE / DEVICE	PHYSICAL CONNECTION	MESSAGE PROTOCOL	PLATFORM	OVATION INTERFACE OPTIONS	RELEASE REFERENCE
Modicon PLC GE Fanuc 90/30 Bently Nevada SEL2030 Limitorque Master Station Limitorque Master Station II EIG Power Monitor DMMS 300+ EIG Nexxus 1250 Modicon Quantum PLC Modicon Momentum PLC Modicon Compact PLC Modicon TXS Momentum	Ethernet	Modbus TCP, Open Modbus TCP - Master - No redundancy or special configuration required	Controller	Third Party I/O Interface	TPIO-1
		Modbus TCP, Open Modbus TCP - Master	Controller	Third Party I/O Interface	TPIO-9
			MMI	SCADA 2.2 Workstation Interface	SS-3
	Serial	Modbus RTU - Master	I/O	RLC Card Modbus Version 2.0	IO-2
			I/O	RLC Card Modbus Version K	IO-1
			MMI	SCADA 2.2 Workstation Interface	SS-1
		Modbus ASCII - Master	I/O CARD	RLC Card Modbus Version K	IO-1
			MMI	SCADA 2.2 Workstation Interface	SS-2
Allen Bradley PLC 5	Ethernet	CSP/PCCC	Controller	Third Party I/O Interface	TPIO-4
			MMI	SCADA 2.2 Workstation Interface	SS-8
		EIP/PCCC	MMI	SCADA 2.2 Workstation Interface	SS-10
	Serial	DF1	I/O	RLC Module Allen Bradley Interface	IO-4
Allen Bradley SLC 5	Ethernet	CSP/PCCC	Controller	Third Party I/O Interface	TPIO-2
			MMI	SCADA 2.2 Workstation Interface	SS-8
		EIP/PCCC	MMI	SCADA 2.2 Workstation Interface	SS-10
	Serial	DF1	I/O	RLC Module Allen Bradley Interface	IO-4
Allen Bradley MicroLogix	Ethernet	EIP/PCCC	Controller	Third Party I/O Interface	TPIO-6
			MMI	SCADA 2.2 Workstation Interface	SS-16
	Serial	DF1	MMI	SCADA 2.2 Workstation Interface	SS-6
Allen Bradley ControlLogix	Ethernet	EIP/PCCC	Controller	Third Party I/O Interface	TPIO-3
			MMI	SCADA 2.2 Workstation Interface	SS-8
	Serial	DF1	I/O	RLC Module Allen Bradley Interface	IO-4
AB Power Monitor 2	Serial	DF1	MMI	SCADA 2.2 Workstation Interface	SS-8
			I/O	RLC Module Allen Bradley Interface	IO-4
SCADAPAK Schweitzer SEL-3301 Power Measurement 8500 ION Meters	Ethernet	DNP 3.0 Master	MMI	SSCADA 2.2 Workstation Interface	SS-19
	Serial	DNP 3.0 Master	MMI	SCADA 2.2 Workstation Interface	SS-18
Kepware Modicon RSLinx	Ethernet	OPC	MMI	OPC Client Mapper	WS-2
GE Genius I/O Blocks	Ethernet	GE Genius	Controller	Third Party I/O Interface	TPIO-12
MHI Turbine Control System	Ethernet	D-EHC	Controller	Third Party I/O Interface	TPIO-11
Toshiba Turbine Control System	Ethernet		Controller	Third Party I/O Interface	TPIO-10

HARDWARE / DEVICE	PHYSICAL CONNECTION	MESSAGE PROTOCOL	PLATFORM	OVATION INTERFACE OPTIONS	RELEASE REFERENCE
GE Mark V Turbine Control GE Mark VI Turbine Control	Ethernet	GSM	Controller	Third Party I/O Interface	TPIO - 8
RTP EIOBC	Ethernet	RTP	Controller	Third Party I/O Interface	TPIO - 7
GE Speedtronic Mark IV	Serial		I/O	RLC Card GE Mark IV Interface	IO-5
IMPACC	Serial		I/O	RLC Card IMPACC Interface	IO-6
OPTO22	Serial		I/O	RLC Card OPTO22 Interface	IO-7
HR2500E	Serial		I/O	RLC Card HR2500E Interface	IO-8
SIEMENS S5	Serial		I/O	RLC Card Siemens S5 Interface	IO-10
YORK TT	Serial		I/O	RLC Card York TT Interface	IO-11
SEABUS	Serial		I/O	RLC Card Seabus Interface	IO-9
Rosemount Fieldbus Devices 848T, 848L, etc Yokogawa EJA Devices Fisher DVC Any Foundation Fieldbus Device	Ovation 3.1 or later	Fieldbus	I/O	Foundation Fieldbus I/O Module	BM-2
	Ovation 2.3 - 3.0	Fieldbus	Controller	Foundation Fieldbus Gateway	GW-4
	Ovation 1.X (Solaris)	Fieldbus	Controller	Modbus VIA Rosemount 3420 Gateway	GW-3
Limitorque Accutronix MX Eaton Cutler Hammer MCC Auma Siemens Simocode Siemens TXP I/O Any Profibus Device	Ovation 3.1 or later	Profibus	I/O	Profibus I/O Module	BM-1
	Ovation 3.0 or earlier (Windows)	Profibus	Controller	Modbus VIA PKV-50 PB Gateway	GW-1
	Ovation 1.X (Solaris)	Profibus	Controller	Modbus VIA PKV-50 PB Gateway	GW-1
Asco Valves StoneL Turck Any DeviceNet Device	Ovation 3.1 or later	Profibus	I/O	DeviceNet I/O Module	BM-3
	Ovation 3.0 or earlier (Windows)	Profibus	Controller	Modbus VIA PKV-50 DN Gateway	GW-2
	Ovation 1.X (Solaris)	Profibus	Controller	Modbus VIA PKV-50 DN Gateway	GW-2
Oil Systems PI Interface	Ethernet	PI to Ovation Interface	MMI	PI to Ovation Interface	WS-4
		OPC	MMI	OPC	WS-2

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Table E-5. Release Version Information

REL REF	COMMUNICATION INTERFACE	OVATION SOLARIS							OVATION WINDOWS														RELATED DOCUMENTATION (available on SmartDocs)	NOTES
		1.2	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.1.6	2.2	2.3	2.4	3.0	3.0.1	3.0.2	3.0.3	3.0.4	3.1	3.1.1	3.1.2		
	Third Party I/O Ethernet																							
TPIO-1	Modbus	X	X	X	X	X*	X*	X*	X	X	X	X	X	X	X*	X*	X*	X*	X*	X*	X*	X*	Applicable Controller User Guide	* Supports redundancy/failover
TPIO-2	AB SLC500	X	X	X	X	X*	X*	X*	X	X	X	X	X	X	X*	X*	X*	X*	X*	X*	X*	X*	Applicable Controller User Guide	
TPIO-3	AB Controllogix5000					X*	X*	X*	X	X	X	X	X	X	X*	X*	X*	X*	X*	X*	X*	X*	Applicable Controller User Guide	Supports PLC5 addressing only
TPIO-4	AB PLC 5	X	X	X	X	X*	X*	X*	X	X	X	X	X	X	X*	X*	X*	X*	X*	X*	X*	X*	Applicable Controller User Guide	
TPIO-5	AB SLC500	X	X	X	X	X*	X*	X*	X	X	X	X	X	X	X*	X*	X*	X*	X*	X*	X*	X*	Applicable Controller User Guide	
TPIO-6	AB MicroLogix w/NET-ENI					X*	X*	X*							X*	X*	X*	X*	X*	X*	X*	X*	Applicable Controller User Guide	
TPIO-7	RTP I/O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	Applicable Controller User Guide	
TPIO-8	GE Mark V/VI	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	GE Mark V/VI (U3-1053, WIN57)	
TPIO-9	Modbus-R															X	X	X	X	X	X	X	Redundant Modbus (CON_020)	
TPIO-10	Toshiba										X	X	X	X	X	X	X	X	X	X	X	X	Ovation Toshiba (WIN58, CON_023)	
TPIO-11	MHI										X	X	X	X	X	X	X	X	X	X	X	X	Ovation Toshiba (WIN58, CON_023)	
TPIO-12	GE Genius														X	X	X	X	X	X	X	X	GE Genius (CON_031, OW230_31)	
	Ethernet Gateway Interfaces -																							
GW-1	Profibus via PKV-50				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	For Windows and Solaris (CON_011)	
GW-2	DeviceNet via PKV-50				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	For Wlindows and Solaris (CON_021)	
GW-3	Fieldbus Rosemount 3420				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
GW-4	Foundation Fieldbus Gateway												X	X	X	X	X	X	X				Foundation Fieldbus (OW230_30, OW240_30, OW300_30)	
	SCADA Server 2.2																							
	Master Protocols																							
SS-1	Modbus RTU				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	
SS-2	Modbus ASCII				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	
SS-3	Modbus Open/TCP				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	
SS-4	AB PLC5 DF1				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	File Type Access (ex. N7:0)
SS-5	AB SLC5 DF1				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	File Type Access (ex. N7:0)
SS-6	AB MicroLogix DF1				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	File Type Access (ex. N7:0)
SS-7	AB Control Logix DF1				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	File Type Access (ex. N7:0)
SS-8	AB PLC5 Ethernet (CSP/PCCC)				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	File Type Access (ex. N7:0)
SS-9	AB SLC5 Ethernet (CSP/PCCC)				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	File Type Access (ex. N7:0)
SS-10	AB PLC5 Ethernet (EIP/PCCC)				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	File Type Access (ex. N7:0)
SS-11	AB SLC5 Ethernet (EIP/PCCC)				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	File Type Access (ex. N7:0)
SS-12	AB ControlLogix Ethernet (EIP/PCCC)				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	File Type Access (ex. N7:0)
SS-13	AB ControlLogix Ethernet (EIP/Native)				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	Native w/Tagnames

REL REF	COMMUNICATION INTERFACE	OVATION SOLARIS							OVATION WINDOWS														RELATED DOCUMENTATION (available on SmartDocs)	NOTES
		1.2	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.1.6	2.2	2.3	2.4	3.0	3.0.1	3.0.2	3.0.3	3.0.4	3.1	3.1.1	3.1.2		
SS-14	AB PLC5 w/NETENI (EIP/PCCC)				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	File Type Access (ex. N7:0)
SS-15	AB SLC5 w/NETENI (EIP/PCCC)				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	File Type Access (ex. N7:0)
SS-16	AB MicroLogix w/NETENI (EIP/PCCC)				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	File Type Access (ex. N7:0)
SS-17	AB ControlLogix w/NETENI (EIP/PCCC)				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	File Type Access (ex. N7:0)
SS-18	DNP 3.0 Serial				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	
SS-19	DNP 3.0 Ethernet				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	
	Slave Protocols																							
SS-21	Modbus RTU				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	
SS-22	Modbus ASCII				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	
SS-23	Modbus Open/TCP				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	
SS-24	DNP 3.0 Serial				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	
SS-25	DNP 3.0 Ethernet				X	X	X	X					X	X	X	X	X	X	X	X	X	X	SCADA User Guide (SCA220_01)	
	Workstation Interfaces																							
WS-1	OPC Server			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OPC for Windows/Solaris (CON_16)	
WS-2	OPC Client Mapper			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	OPC for Windows/Solaris (CON_16)	
WS-3	OPC Alarm & Events													X	X	X	X	X	X	X	X	X	OPC for Windows/Solaris (CON_16)	
WS-4	PI to Ovation																						Refer to Oil Systems PI documentation	Contact Emerson for valid releases
	Bus Module Interfaces																							
BM-1	Profibus Module																			X	X	X	Profibus User Guide (OW310_36, OW311_36, OW312_36)	
BM-2	Fieldbus Module																			X	X	X	Fieldbus (OW310_30, OW311_30)	
BM-3	DeviceNet Module																					X	DeviceNet (OW312_38)	
	RLC Interfaces (Serial Links)																							
IO-1	Modbus version K	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	Link Controller Modbus (U3-1050)	Supports ASCII and RTU
IO-2	Modbus version 2.0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	Link Controller Modbus (CON_015)	
IO-3	Modbus Slave	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	QLC Modbus Slave (U0-1141)	
IO-4	AB PLC 5 / PLC 2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	QLC/RS232/AB (U0-1130)	
IO-5	GE Speedtronic Mark IV	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	Link Controller GE Mark IV (U3-1049)	
IO-6	IMPACC	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	IMPACC Interface (U0-1120)	
IO-7	Opto 22	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	QLC/RS232/OPTO22 (U0-1137, U3-1058)	
IO-8	HR2500E	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	QLC/RS232/HR2500E (U0-1138)	
IO-9	SEAbus	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	QLC/RS485/SEAbus (U0-1140)	
IO-10	Siemens S5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	QLC/RS232/Siemens (U0-1134)	
IO-11	YorkTT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	QLC/RS232/YorkTT (U0-1133)	

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY
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"SERVING THE PUBLIC - PROTECTING THE ENVIRONMENT"

PROJECT
DESIGN MANUAL
VOLUME 2 - FACILITIES DESIGN

SECTION 8B – SCADA DESIGN GUIDELINES

April 2015

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AUTHORIZATION FORM

Revision Number	Date	Content
Draft 1	6/1/2014	Initial Draft
Draft 2	10/9/2014	Second Draft
Draft 3	12/10/2014	Third Draft
Draft 4	4/1/2015	Fourth Draft

This 2018 version was authorized by:

Duncan Mukira PE, Supervisor, Control Systems Section

9/25/18
Date

AUTHORIZATION FORM

Revision Number	Date	Content
Draft 2	6/19/98	Project Design Manual Volume 2 - Facilities Design Section 8 – Instrumentation
Draft 3	04/29/2005	Section 8 – Instrumentation
Draft 4	09/01/2010	Section 8 – Instrumentation and Process Control
Draft 4, Rev1	09/01/2010	TOC update
Draft 5	04/18/2012	Updated 8.4.1 to comply CSI 50 Div format
Rev 5	03/01/2013	Updated per Log of Revisions, March 2013 edition
Rev 6 and 7	08 & 09/2013	Updated as indicated in Log of Revisions
Rev 8	05/2014	Updated as shown in Log of Revisions
Rev 9	05/2015	Updated as shown in Log of Revisions
Rev 10	10/2015	Updated as shown in Log of Revisions
Rev 11	01/2018	Updated as shown in Log of Revisions
Rev 12	08/2018	Updated as shown in Log of Revisions

This 2018 version was authorized by:

9/25/18

Duncan Mukira PE, Supervisor, Control Systems Section Date

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Draft 4	4/1/2015	Fourth Draft

This 2018 version was authorized by:

9/25/18

Duncan Mukira PE, Supervisor, Control Systems Section — Date

SECTION 8B, SCADA DESIGN GUIDELINES LOG OF REVISIONS (made after the Dec. 2014 Draft)		
Paragraph	**Brief Description of Revision**	**Comments (or Date)**
Entire document	Formatting and Section 8B numbering of pages, paragraph headings, Tables, and Figures. Changed page footer date.	4-1-2015

SECTION 8B – SCADA DESIGN GUIDELINES
TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMNS AND ABBREVIATIONS

AC	Alternating current
AI	analog input
ANSI	American National Standards Institute
API	American Petroleum Institute
AO	analog output
ATS	automatic transfer switch
AWG	American Wire Gauge
CAD	computer-aided design
CD	control description; or compact disc
CFR	Concept Finalization Report
CIP	Capital Improvement Program
CSI	Construction Specifications Institute
DC	direct current
DC Water	District of Columbia Water and Sewer Authority
DDCS	Department of Distribution and Conveyance Systems
DETS	Department of Engineering and Technical Services
DI	discrete input
DO	discrete output
DVD	Digital video disc
HI	human interface
HMI	human machine interface
HVAC	heating, ventilation, and air conditioning
I&C	Instrumentation and Controls
I/O	input/output
IED	Intelligent End Device
IP	internet protocol
ISA	International Society of Automation
MCC	motor control center
NEMA	National Electrical Manufacturers Association
NC	normally closed
NO	normally open
NPDES	National Pollutant Discharge Elimination System
O&M	operation and maintenance
OEM	original equipment manufacturer
OIT	operator interface terminal
ORP	oxidation reduction potential
P&ID	Process and Instrumentation Drawing
PAC	programmable automation controller
PCS	Process Control System
PDE	Project Design Engineer

PDF	Portable document format
PLC	Programmable Logic Controller
PMT	power monitoring transformer
PVC	polyvinyl chloride
RIO	remote input/output
RTD	resistance thermal device
SCADA	Supervisory Control and Data Acquisition
UPS	uninterruptible power supply
VAC	Volts alternating current
VDC	Volts direct current
VFD	variable frequency drive
VSD	variable speed drive
VLAN	virtual local area network
WCLT	Witnessed Combined Loop Test
WSPM	Water and Sewer Pumping Maintenance

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PROJECT DESIGN MANUAL
VOLUME 2 – FACILITIES DESIGN

8B. SCADA INSTRUMENTATION AND CONTROL

This section describes general and technical requirements for instrumentation and control for District of Columbia Water and Sewer Authority (DC Water) facilities in relation to the Wonderware Supervisory Control and Data Acquisition (SCADA) System currently used by Department of Distribution and Conveyance Systems (DDCS). This section outlines design criteria and provides guidelines for the preparation of drawings, specifications, contract documents, and system implementation. This section includes requirements that integrate the requirements for control and monitoring of all equipment and processes across all typical design and construction divisions.

8B.1 PURPOSE

This document provides a set of guidelines intended to promote the consistent application of vendor hardware and software throughout the DC Water DDCS SCADA system. The goal is reduce the variability of SCADA related work ultimately delivered across multiple future projects/initiatives involving multiple parties. This document helps in this regard by eliminating some of the relatively simple decision making that occurs during nearly every design; thus, leaving the designer to focus on the remaining functional, performance, and technical design issues for a given project. DC Water needs consistency in the SCADA system in order to simplify operation, maintenance, support and expansion of SCADA. With this end in mind, this document must be updated regularly as new requirements are discovered, reusable material emerges, and lessons are learned in the design and implementation process.

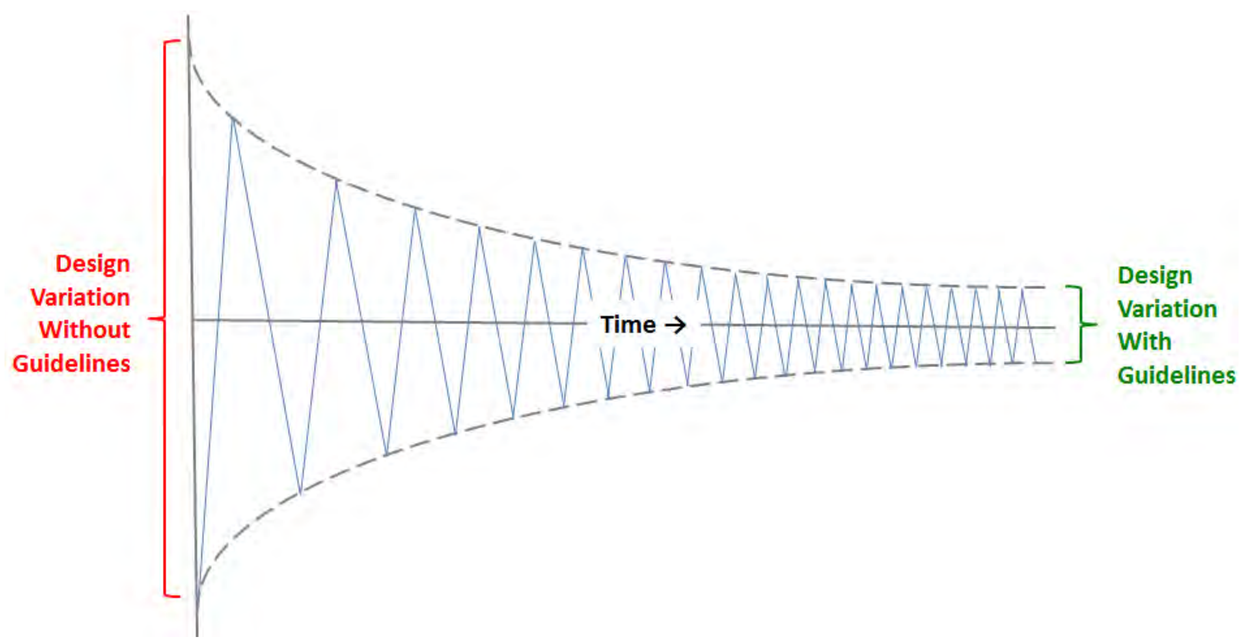

Figure 2-8B-1. Design Guidelines Reduce Variability of Delivered Solutions

This document contains guidelines for use by a wide audience. It is intended to be used by designers of capital improvement projects, internal design initiative staff, on-call SCADA support staff, and DC Water SCADA support staff. In other words, these guidelines should be followed regardless of the project delivery approach. These guidelines apply equally to anyone whose work will affect the DDCS SCADA System.

This document covers many situations a designer will encounter. Other scenarios (e.g., high availability, redundancy, fault tolerance, etc.) may require a custom solution. This document is not intended to take the place of good design, system integration, and proactive coordination. Each project will require a careful review of the material in this section against the objectives of the project to determine the appropriate and best approach.

The appendices at the end of these guidelines contain sample material referenced in the main body of the guidelines. These sample materials originate from many different sources and are not coordinated. They represent the best available samples when the guidelines were written and will be updated as newer and better examples are discovered or produced. The intent of providing these samples is to create a general vision of the types of deliverables and content expected by DC Water; they are not to be considered standard design templates.

All projects shall adhere to these guidelines to the extent feasible and practical. Use guideline material where it is applicable and in the opinion of the designer represents what is in the best interest of DC Water; inform DC Water where an exception is recommended along with the engineering justification for the deviation from the guidelines. In other words, all engineers, designers, integrators, and support staff shall be solely accountable for the outcome of their work. All exception should be approved by DC Water.

The SCADA Master Plan completed in March 2013 recommended the development of these guidelines. The Master Plan has been reviewed for material to be included herein. Users of this document are encouraged to request a copy of the Master Plan and review it to better understand some of the background and supporting details of these guidelines. These guidelines are meant to support the Master Plan, not replace it. The Master Plan has many recommendations that require procedural/organizational change and therefore not applicable to or included in the guidelines at this time.

8B.2 GENERAL

The requirements outlined in this section apply to all design efforts and other work that have the potential to affect the DDCS Wonderware SCADA System.

For design work, specific requirements are contained within the individual conceptual design report, which may supplement the requirements outlined in this section. Where the conceptual design deviates from this manual the design engineers should ask DC Water for guidance.

DC Water requires all design work to be stamped by a professional engineer licensed in the District of Columbia. DC Water may choose to waive this requirement for smaller projects. Request additional information is from DC Water Department of Engineering and Technical Services (DETS) regarding this requirement.

Obtain approval in writing to deviate from the standards and requirements presented in this manual. It is not acceptable to assume design reviewers will pick up on deviations hidden in the detailed design or electrical schematics. Design reviews are focused more on conceptual requirements.

Review existing equipment or processes that are being modified for conformance with these guidelines and requirements and design modifications/replacement as required, bringing them into conformance with these guidelines. Deviations from this policy due to cost or other concerns shall be specifically discussed with DC Water.

Design work will be checked against this section and the conceptual design report for compliance, and the design will not be considered complete or acceptable unless it meets the requirements outlined in these documents.

All instrumentation, processes, and equipment shall be designed and coordinated to provide for accurate and reliable control and monitoring of all processes and facilities. The instrument and control system design has to cross all division boundaries to ensure that all equipment, regardless of which division it is specified, operates as an integrated system for DC Water.

Processes and systems in the water distribution, sewer collection and storm water collection systems will be controlled and monitored through the Wonderware SCADA System hosted at both Bryant Street Pump Station and Main Pump Station.

Provide local controls at individual pieces of equipment and backup controls as required for maintenance, for operation when the control system is temporarily unavailable, or as directed by DC Water.

8B.3 NOMENCLATURE CLARIFICATION

The phrase “remote SCADA site” is used throughout these guidelines. This phrase refers to any location that has equipment polled by either the water distribution or sewer/stormwater collection Wonderware SCADA systems. This includes Bryant Street Water Pumping Station and Main Pumping Station, in the context of polled equipment. These two sites are regarded as “central SCADA sites” when the context of the subject matter is either of the two Wonderware systems.

The phrase “programmable logic controller” or “PLC” refers to any traditional PLC product and also the newer programmable automation controllers (PACs) that may currently exist in the SCADA system or may be provided in the future.

The phrase “Wonderware SCADA System” or “DDCS SCADA System” refers to the Wonderware SCADA system that replaced the previous DAQ SCADA System, not the Blue Plains Plant SCADA system that will serve the tunnel system and connect to the existing Emerson Ovation Distributed Control System. This document is not intended to be used for the SCADA system serving the tunnel system.

The term “designer”, in this section, refers collectively to any individual or group of individuals intending to alter the DC Water DDCS SCADA system. This term is commonly associated with technical staff in a CIP project, but also refers to any DC Water internal or external support staff intending to make changes to the SCADA system.

8B.4 INTERFACE TO THE EXISTING SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

The existing SCADA system is based on Wonderware’s System Platform. New sites are being added to SCADA through internal projects and CIP projects.

For CIP projects, a general contractor sub-contracts with a systems integrator to implement the remote site PLC, operator interface terminal (OIT), and field instrumentation. DC Water assists with wide area communication network infrastructure and cyber security. Wonderware configuration is also provided by the systems integrator; however, DC Water deploys the configuration to the live system.

Coordinate all modifications to the existing Wonderware SCADA system with DC Water during the design process. Note that all point names have to be unique across the SCADA system. DC Water is responsible for coordinating and assigning all loop numbers and loop numbers shall be requested early in the design phase of each project. DC Water is managing multiple internal and CIP contracts and will help clarify equipment layout, termination, and coordination requirements.

For any work performed on the live system, the party acting as the Integrator must perform a full backup of the target system (e.g., Wonderware, PLC, OIT, etc.) prior to beginning work. Incremental backups must be performed each day work as work progresses and a full backup to both local and external storage media every Friday.

8B.5 SAMPLE DOCUMENTS

The appendix represents a collection of the best available sample documents consolidated from a variety of sources. These are provided to show the general requirements of documents to be delivered under design projects. The information on the drawings may need additional content or revision to meet the requirements described in the following section (8B.6). DC Water expects to update documents in the appendix as newer and better material becomes available.

8B.6 REQUIRED DRAWINGS AND FORMATS

Refer to the concept design report before beginning the detailed design. The detailed design must reflect the intentions of the concept design and Concept Finalization Report (CFR). Refer to the appendices for examples of each drawing described below.

8B.6.1 I&C Drawing Arrangement

Present instrumentation and controls (I&C) drawings in a logical manner, following the process trains. Use the following sequence for types of drawings:

- Legend, symbols, and general notes.
- Process and Instrumentation Drawings
- Process Flow Diagram Drawings
- Network and Communication Drawings
- Software Architecture Drawings
- Data Flow Drawings
- Control Panel Drawings
    - Control Panel Layout Drawings
    - Control Panel Elementary Drawings
    - Alternating current (AC) and direct current (DC) Power Distribution Drawings
- Single Line Diagram Drawing
- Control and Equipment Room Layout Drawings
- Area Classification Drawings
- Field Interface Electrical Schematic Drawings
    - Motor Control Center Schematics
    - Variable Frequency Drive Schematics

    - Switchgear Schematics
    - Motorized Valve Schematics
    - Other Field Interface Schematics
- Wire & Conduit Drawings
- Ductbank Schedules & Detail Drawings
- Instrument Mounting Detail Drawings
- Loop Drawings

8B.6.2 Drawing Coordination

The physical location of instruments is shown on the drawings prepared by the other design disciplines. Locate equipment as indicated below:

- Mechanical – Locate all field instruments, show interface to mechanical piping (pipe taps, insertion meters, etc.).
- Structural – Locate instruments on:
    - Stilling wells.
    - Special equipment access railings.
    - Antennas including antenna base and guy wire fittings and considering wind-loading factor.
- Electrical
    - Locate all equipment that requires electrical power supply connection.
    - Locate all equipment requiring signal or communications interconnection.
- Architectural – Locate control panels and enclosures on floor plan layouts.

Care must be taken to specify or detail the field mounting location of all instruments, remote-mounted controls and indicators or displays so that equipment can be easily maintained, read, and operated. Details or coded notes should be used to define the location and orientation of controls and indicators so that they can be safely accessed and read. For example, if motor-operated valves are required to be mounted 10 feet in the air or over water-filled basins, valve/gate actuator controls and indicators must be located such that the valve can be operated from the floor or operating deck. Indicators or displays should face the operator and be located so that they can be easily read.

8B.6.3 Process and Instrumentation Drawings

The Process and Instrumentation Drawings (P&IDs) are required to show all piping, valves, equipment, instruments, controls, input/output points, and all required interlocks. The P&IDs must show all Input/Output (I/O) points connecting to the SCADA system. The P&IDs must be closely coordinated with the I/O Point List and Control Descriptions. The P&IDs should be shown on as few drawings as possible to minimize switching back and forth between drawings. The P&IDs must include the equipment tag for major field equipment (e.g., pumps, motors, valves, etc.). The P&IDs must also show electrical I/O in the form of a typical one-line diagram [e.g., incoming station power, transformers, power distribution, generator, transfer switch, motor control centers (MCCs), lighting panels, etc.]. The P&IDs must also show facility type I/O (e.g., security, heating, ventilation, and air conditioning (HVAC), sump pumps, etc.).

Present all tankage, piping, and equipment in an arrangement similar to that of the actual facility. Show all functions, including those in the PLC. Because the P&ID details both the field equipment functions and those included in the PLC, the P&IDs must be separated into three horizontal sections. The bottom section details all process equipment and field instrumentation; the middle section details the instrument functions located in local control panels and motor controllers; and the top section details the inputs and outputs for the SCADA system. The legend of symbols used in computer-aided design (CAD) was derived from the International Society for Automation publication ISA-S5.1, Instrument Symbols and Identification.

The P&ID drawings shall show all control signals and equipment across disciplines including hardwired interlocks and panels from which signals originate, signals are routed, or signals terminate. Control signals shall correspond to electrical wiring such that number, type, and routing can be determined and verified. Signals shall be separated or labeled such that termination on one end can be traced to the other end, grouping of signals into a common line shall be avoided.

See Appendix A for "Sample Process & Instrumentation Drawings."

8B.6.4 Process Flow Diagram Drawings

Provide drawings showing hydraulic definition of the flow of process. Provide size of pipe, tank dimensions, capacities of tanks, capacity of wet wells, capacities of pumps, nominal pressures in the pipes, ANSI rating of the pipes, pipe material, flange connections, pump curves, and definition of each valve in the process stream.

See Appendix C for "Sample Process Flow Diagram."

8B.6.5 Network and Communication Drawings

Provide drawings showing the general physical connection of all network devices and nodes. Include Ethernet, bus- instruments, serial and other communications between SCADA-related equipment (e.g., Servers, PLCs, OITs, power monitoring transformers (PMTs), routers, switches, uninterruptible power supplies (UPSs), original equipment manufacturer (OEM) packages, instruments, etc.). Emphasize how the components are connected. Include all connected components to allow disassembly and reassembly of the field equipment using only these drawings as a reference. Include labels for each drawing element to clearly annotate node name, installed location, internet protocol (IP) address, network segment speed, virtual local area network (VLAN) name, cable type, unique cable identified, communication rates, terminal strips, patch panel ports, bulkhead adapters, wire/terminal pairs, equipment vendor, model number, etc. Labels must be complete and match all equipment, enclosures, terminals, cables, wire labels, etc. to be used or currently in use in the field.

This drawing is provided to establish general intent. It does not and should not get down to the level of cable connector type, scaled physical depiction, terminal numbers, etc.

See Appendix D for "Sample Network and Communication Drawing."

8B.6.6 Software Architecture and Data Flow Drawings

Provide drawings showing logical interaction of all major software components, network devices and nodes. Emphasize how the elements work together in terms of data flow rather than how they are physically connected. Include all connected components except cable connectors, patch panels, media converters and unmanaged physical devices (e.g., hubs). Include labels for each drawing element to clearly annotate software component, node name, IP address, IP ports, network segment speed, VLAN name, communication protocols, and initiating node. The drawings shall include host hardware device name, communication port, Ethernet port, protocol, speed, communication initiating application, data transmission directions, etc.

See Appendix E for "Sample Software Architecture and Data Flow Drawings."

8B.6.7 Control Panel Drawings

8B.6.7.1 Control Panel Layout Drawings

Show a front view of all control panels to be provided with all instruments and nameplates shown. Front view shall be drawn to scale. Provide each instrument and nameplate with individual identification numbers and a schedule detailing the instrument/component tag number. List the exact engraving of the nameplate adjacent to the panel. Include the annunciator window engraving in a separate schedule. Provide a panel title, and list the depth, height, width, and door location below the title. Identify the construction material and the National Electrical Manufacturers Rating (NEMA) rating. Coordinate with panel schedules.

Show an internal view of all control panels. Show details regarding the layout of internal subpanels. Show all components to be mounted to subpanel. All subpanel views shall be drawn to scale. Ensure the panel design will accommodate the equipment it will contain.

See Appendix F for "Sample Control Panel Drawings."

8B.6.7.2 Control Panel Elementary Drawings

Provide drawings which show details of power wiring, communication, and analog/discrete inputs/outputs. Include I/O card model number, terminal numbers, and terminal function (e.g., Input 1, Input 2, etc.). Include field terminals, input field devices, output field devices, field device identifiers, location identifiers, I/O Point List ISA tag name, PLC/Base/Slot/Point data, Wonderware object, attribute, wire colors, overcurrent protection, switches, lights, receptacles, etc. Label relay output cards terminals with contact function (e.g., NO, NC).

See Appendix F for "Sample Control Panel Drawings."

8B.6.7.3 AC & DC Power Distribution Drawings

Provide drawings which show details of AC and DC power distribution within and between SCADA-related enclosures (e.g., PLC panels, control panels, UPS, bypass switches, instruments, etc.). Include all overcurrent devices and switches provided for disconnecting power to one or more loads. Indicate the source of all power feeds and the rating of overcurrent protection devices.

See Appendix F for "Sample Control Panel Drawings."

8B.6.8 Single Line Diagram Drawing

Provide a single line diagram that depicts the incoming power to the remote SCADA site, distribution of power within the facility down to 480 VAC. Include all switchgear, motor control centers, variable frequency drives (VFDs), motors, gates, valves, lighting panels, power panels, etc. Include all power monitoring transmitters and PLC I/O points related to power. Identify all I/O for electrical system diagnosis of electrical equipment connected to SCADA via hardwired I/O or communication protocol.

See Appendix G for “Sample Single Line Diagrams.”

8B.6.9 Field Interface Electrical Schematic Drawings

Electrical schematics shall be laid out by equipment or system being controlled. Schematics shall show all interrelated signals and controls that are wired into a control circuit on one schematic. A separate schematic per drawing where the intent cannot be determined on one schematic is not acceptable. Schematics shall clearly identify the location of all connections that are remote from the “base” starter or control panel location. The “base” starter or control panel location shall be clearly identified as part of the title block notes. Typical schematics shall list all equipment for which the schematic applies. Contacts and interfaces to the PLC shall be clearly identified with the ISA designation and description that match the I/O Point List. Ensure set/reset designation in the I/O Point List match the schematics.

Schematics shall be electrically complete and show completed circuits within each schematic even if the schematic spans multiple panels. It is not acceptable to show “continuation” lines between panels for control portions. Physical wire tagging in field shall match tagging used on electrical drawings.

See Appendix H for “Sample Field Electrical Interface Diagrams.”

8B.6.10 Control and Equipment Room Layout Drawings

Provide room layouts for SCADA equipment to be provided such as: PLC panels, termination cabinets, control panels, UPS, workstations, printers, furniture, etc. Use an architectural room layout with doors and windows identified. Show all existing equipment and other applicable physical constraints. These drawings indicate the proposed layout of all equipment including furniture and chairs. Illustrate clearance for doors and access to equipment. Ensure that UPS installation have adequate clearance and ventilation to prevent the UPS system from overheating.

See Appendix I for “Sample Control and Equipment Room Layout Drawings.”

8B.6.11 Wire & Conduit Drawings

Provide wire & conduit drawings that show power, communications and I/O related to SCADA. Show existing equipment half tone and new equipment bold so it stands out on the drawing. Home runs (see conduit C-1 on the Sample Wire/Conduit Drawing & Schedule in Appendix J) may be used to indicate the conduit ID using the “from” location on the wire and conduit schedule. Where a specific conduit route is required show a continuous line between the “from” and “to” points on the drawing (see conduit C-4 on the Sample Wire/Conduit Drawing & Schedule in Appendix J). Use a schedule to list the conduit ID, size, material, and contents.

Run 120 VAC I/O signals in separate conduits from other signal types.

Analog I/O signals may be run in the same conduit as 24 VDC I/O signals.

Use polyvinyl chloride (PVC) coated rigid galvanized steel at Collection and Stormwater sites. Use rigid galvanized steel at Distribution sites.

Include all communication cabling and conduit for SCADA network communications. Coordinate demarcation points with DC Water IT.

See Appendix J for "Sample Wire & Conduit Drawings." Add an additional column to the schedule that includes the tagnames of the I/O signals in each conduit, where applicable.

8B.6.12 Ductbank Schedules & Detail Drawings

The need for electrical ductbank at remote SCADA sites should be rare. When applicable, provide ductbank schedules and details that show power, communications and I/O related to SCADA.

Show the physical run and dimensions of the ductbank from origination to termination point. Show a cross-section of the ductbank and indicate the overall ductbank dimensions and diameter of each internal conduit. Use a schedule to list ductbank barrel dimension and contents. Use a schedule to list the conduit ID, size, material, and contents; include other information pertinent to the project.

Ductbank may be used to run power and fiber optic cable only. Do not run I/O signals in ductbank. Exceptions require the permission of DC Water.

Direct buried conduit may be used at small facilities with the permission of DC Water.

See Appendix K for "Sample Ductbank Schedules & Detail Drawings." Add an additional column to the schedule that includes the tagnames of the I/O signals in each ductbank conduit, where applicable.

8B.6.13 Area Classification Drawings

Provide plan and section drawings that clearly illustrate area classification boundaries. Indicated confined space areas. Indicate where hazardous and corrosive gasses (e.g., methane, hydrogen sulfide, carbon dioxide, etc.) will be prone to accumulation.

See Appendix L for "Sample Area Classification Drawings."

8B.6.14 Instrument Mounting Detail Drawings

Use instrument mounting details to depict the distinct installation requirements of all instruments to be provided. Adhere to manufacturer recommendations when producing the instrument mounting details. Instrument mounting details must be appropriate for the final installed locations of each instrument.

See Appendix M for "Sample Instrument Mounting Detail Drawings."

8B.6.15 Loop Drawings

Use loop drawings to show point-to-point wiring details between conduit endpoints; in this context, a conduit is any product used to route wire/cable between two locations (e.g., conduit, wire way, cable tray, etc.). The drawings should include the plc/base/slot/point/memory address information inside PLC enclosures. Ensure the loop drawings adhere to current ISA standards.

See Appendix N for "Sample Loop Drawings."

8B.7 REQUIRED SPECIFICATIONS AND FORMATS

Prepare specifications in accordance with DC Water standards, Construction Specifications Institute (CSI) specifications, and other supporting information available through DC Water's LiveLink. Develop specifications that meet the requirements of this document and the design intent of the designer.

DC Water guideline specifications only indicate portions of the overall requirements for a project and are generic in nature. The guideline specs do not include all the technical/coordination requirements that would be specific to one project. The designer is required to review and submit modifications to the guideline specs to incorporate all design requirements, latest technical requirements, and coordinate the specifications and drawings across the project.

Prior to design, coordinate with DC Water to verify what guideline specifications may exist and obtain copies of the latest versions available. If additional specifications are required for a project, refer to the DC Water Guideline Specification Masters General Instructions (latest edition) for instructions and format requirements for preparing project specifications.

8B.7.1 Specification Arrangement

The following states high-level expectations of several Division 1 specifications identified as having one or more special requirements specific to the DDCS SCADA System. Other Division 1 specifications will be required subject to the professional discretion of the designer for each project. The Section numbers shall conform to the latest edition of the CSI MasterFormat. Request confirmation and comply with latest DC Water's specification writing standards.

- **01 21 00 Allowances**
  This section includes the following:
  - Allowances for computer hardware and software related to SCADA to ensure DC Water receives the most current product offerings from vendors and also longer useful asset life.
- **01 12 16 Construction Sequencing**
  This section includes the following:
  - For work involving an existing facility, the designer must develop a detailed transition plan that explains how operation will be maintained throughout construction. This applies to all work involving existing SCADA and/or PLC system components functional at the time work begins.
- **01 31 00 Project Coordination**
  This section includes the following:
  - Requirements for coordination of work with other Contractors working concurrently at a DDCS facility.
  - Requirements for coordination of work requiring the involvement of DC Water staff or their representatives.
  - Requirements for DC Water SCADA system change management practices and procedures to be followed.
  - Coordination procedures and protocols to be followed.
  - Related Sections:
    - 01 31 19 - Project Meetings
    - 01 32 16 - Construction Schedule
    - 01 33 00 - Submittals
    - 01 53 00 - Maintenance of Plant Operations During Construction
- **01 31 19 Project Meetings**
  This section includes the following:
  - Requirements for project meetings to review construction schedules and coordinate work.
  - Related Sections:
    - 01 31 00 - Project Coordination

    - 01 32 16 - Construction Schedule

- **01 32 16 Construction Schedule**

  This section includes the following:
  - Construction milestones.
  - Requirements to support coordination of work by other contractors, DC Water departments and DC Water staff.
  - Related Sections:
    - 01 31 00 - Project Coordination
    - 01 33 00 - Submittals

- **01 33 00 Submittals**

  This section includes the following:
  - Requirements for submittals from the Systems Integrator and Contractor.
  - Related Sections:
    - 01 31 00 - Project Coordination
    - 01 32 16 - Construction Schedule

- **01 33 10 Document Management**

  This section includes the following:
  - Requirements for Contractor to upload final Service Manuals and other documentation to DC Water's Oracle Primavera Contract Manager® document management system.
  - Related Sections:
    - 01 75 20 - Service Manual
    - 01 78 39 - Project Record Documents

- **01 43 00 Quality Requirements**

  This section includes the following:
  - Requirements for inspection and certification by third party entities.
  - Instrument installations should be certified by the manufacturer and include manuals needed to operate and maintain SCADA.
  - Related Sections:
    - 01 32 16 - Construction Schedule
    - 01 33 10 - Document Management

- **01 75 20 Service Manual**

  This section includes the following:
  - Requirements for manuals needed to operate and maintain SCADA.
  - Related Sections:
    - 01 32 16 - Construction Schedule
    - 01 33 10 - Document Management

- **01 76 00 Testing, Adjusting, Balancing**

  This section includes the following:
  - Requirements for testing products and systems provided under a project.
  - The designer must develop a comprehensive testing plan that demonstrates acceptable performance and response in all operating scenarios, both normal and failure modes.
  - Test results must be submitted to DC Water in writing upon successful completion of the testing.
  - Related Sections:
    - 01 91 00 - Equipment System Commissioning

- **01 78 39 Project Record Documents**
  This section includes the following:
  - Requirements for maintaining design documents during construction to match installed field conditions. This is for the purpose of DC Water inspection during construction.
  - Requirements to edit design documents for submission to DC Water as a record of final field conditions.
  - Related Sections:
    - 01 33 10 - Document Management
- **01 78 42 As-Built Drawings**
  This section includes the following:
  - Requirements for maintaining submittal documents produced by the Contractor and/or System Integrator during construction to match installed field conditions. This is for the purpose of DC Water inspection during construction.
  - Requirements to edit submittal documents produced by the Contractor and/or System Integrator during construction for final submission to DC Water as documentation of as-built conditions.
  - Related Sections:
    - 01 33 10 - Document Management
    - 01 33 00 - Submittals
- **01 79 00 Operation and Maintenance Training**
  This section includes the following:
  - Requirements for training needed to effectively understand and operate new functionality provided under a project.
  - Requirements for training needed to effectively maintain new products and systems provided under a project.
  - Related Sections:
    - 01 33 10 - Document Management
    - 01 33 00 - Submittals
    - 01 33 10 - Document Management
    - 01 75 20 - Service Manual
    - 01 78 39 - Project Record Documents
    - 01 78 42 - As-Built Drawings
- **01 91 00 Equipment System Commissioning**
  This section includes the following:
  - Requirements for testing products and systems provided under a project.
  - The designer must develop a comprehensive testing plan that demonstrates acceptable performance and response in all operating scenarios, both normal and failure mores.
  - Test results must be submitted to DC Water in writing upon successful completion of the testing.
  - Related Sections:
    - 01 76 00 - Testing Adjusting Balancing

The following shows the expected arrangement of Instrumentation & Control specifications. The Section numbers shall conform to the latest edition of the CSI MasterFormat. Request confirmation and comply with latest DC Water's specification writing standards.

The specification arrangement presented below is based on a subset of the specification sections listed in the July 2014 version of CSI MasterFormat Numbers & Titles originally obtained as a free download at:

http://www.csinet.org/numbersandtitles

Note that some of the CSI section titles are modified as needed to better reflect the needs of DC Water regarding SCADA design guidelines. Refer to the latest version of the CSI Master Format for sections not listed below and include sections not listed below where applicable. Section titles shown below that are marked with an asterisk (*) are not a part of the CSI MasterFormat.

- **40 01 00 Operation and Maintenance of Process Interconnections**
  - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
  - Related Sections:
    - 40 01 60 Operation and Maintenance of SCADA Systems
    - 40 01 70 Operation and Maintenance of Instrumentation for Process Systems
    - 40 01 90 Operation and Maintenance of Primary Control Devices
- **40 05 00 Common Work Results for Process Interconnections**
  - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
  - Related Sections:
    - 40 05 57 Actuators for Process Valves and Gates
    - 40 05 93 Common Motor Requirements for Process Equipment
- **40 06 00 Schedules for Process Interconnections**
  - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
  - Related Sections:
    - 40 06 60 Schedules for SCADA Systems
    - 40 06 70 Schedules of Instrumentation for Process Systems
    - 40 06 90 Schedules for Primary Control Devices
- **40 61 00 SCADA Process Control and Enterprise Management Systems General Provisions**
  - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
  - Related Sections:
    - 40 61 13 SCADA System General Provisions
    - 40 61 16 Enterprise Management System General Provisions
    - 40 61 21 SCADA System Testing
    - 40 61 26 SCADA System Training
    - 40 61 93 SCADA Input/Output List
    - 40 61 96Control Descriptions
- **40 62 00 Computer System Hardware and Ancillaries**
  - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
  - Related Sections:
    - 40 62 13 Server Computers
    - 40 62 16 Operator Workstation Computers

        - 40 62 19 Industrial Computers
        - 40 62 21 Desktop Computers
        - 40 62 26 Laptop Computers
        - 40 62 29 Tablet Computers and Mobile Devices
        - 40 62 33 Printers
        - 40 62 43 Large Display Screens
        - 40 62 63 Operator Interface Terminals (OIT)

- **40 63 00 Control System Equipment**
    - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
    - Related Sections:
        - 40 63 43 Programmable Logic Controllers
        - 40 63 99 Ethernet-Based Remote I/O *

- **40 66 00 Network and Communication Equipment**
    - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
    - Related Sections:
        - 40 66 13 Switches and Routers
        - 40 66 16 Firewall Hardware
        - 40 66 19 Media Converters
        - 40 66 23 Frame Relay Equipment
        - 40 66 26 Device Network Equipment
        - 40 66 33 Metallic and Fiber-Optic Communication Cabling and Connectors
        - 40 66 36 Process Instrumentation Networks
        - 40 66 43 Wireless Network Systems
        - 40 66 53 Multiple Address Radio Equipment
        - 40 66 56 Point-to-Point Radio Equipment
        - 40 66 63 Antennas
        - 40 66 66 Monopoles and Towers
        - 40 66 73 Satellite Communication Equipment
        - 40 66 99 Serial to Ethernet Converters *

- **40 67 00 Control System Equipment Panels and Racks**
    - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
    - Include a schedule at the end of each section to list distinct panels and racks to be provided.
    - Related Sections:
        - 40 67 13 Computer Equipment Racks
        - 40 67 16 Free-Standing Panels
        - 40 67 19 Wall-Mounted Panels
        - 40 67 23 Control System Consoles
        - 40 67 33 Panel Wiring
        - 40 67 63 Control Panel-Mounted Uninterruptible Power Supply
        - 40 67 99 Rack-Mounted Uninterruptible Power Supply *

- **40 68 00 SCADA Process Control Software**
    - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.

- Related Sections:
  - 40 68 13 SCADA Human Machine Interface (HMI) Software
  - 40 68 23 Reporting Software
  - 40 68 26 Online Performance Monitoring Systems Software
  - 40 68 33 Maintenance Management Software
  - 40 68 36 Laboratory Information System Software
  - 40 68 39 Energy Management Software
  - 40 68 43 Load Management Software
  - 40 68 63 Configuration of HMI Software
  - 40 68 66 Programming of Controller Software
  - 40 68 93 Computer Operating Systems Software
  - 40 68 99 Alarm Notification Software *

- **40 69 00 Packaged Control Systems**
  - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
  - Related Sections:
    - 40 69 98 Bar Screens *
    - 40 69 99 Odor Control Systems *

- **40 70 00 Instrumentation for Process Systems**
  - Include a master instrument schedule that uniquely identifies and completely defines each distinct instrument to be provided.

- **40 71 00 Flow Measurement**
  - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
  - Related Sections:
    - 40 71 13 Magnetic Flow Meters
    - 40 71 23 Differential Pressure-Type Flow Meters
    - 40 71 33 Propeller Flow Meters
    - 40 71 36 Turbine Flow Meters
    - 40 71 43 Variable Area Flow Meters
    - 40 71 46 Target Flow Meters
    - 40 71 49 Vortex-Shedding Flow Meters
    - 40 71 53 Positive Displacement Flow Meters
    - 40 71 63 Doppler Flow Meters
    - 40 71 66 Transit Time Flow Meters
    - 40 71 69 Open Channel Flow Meters
    - 40 71 73 Coriolis Flow Meters
    - 40 71 76 Thermal Flow Meters
    - 40 71 79 Flow Switches
    - 40 71 86 Flow Metering Weirs

- **40 72 00 Level Measurement**
  - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
  - Related Sections:
    - 40 72 13 Ultrasonic Level Meters (Continuous and Point-Type)
    - 40 72 33 Capacitance Type Level Meters (Continuous and Point Type)

    - 40 72 36 RF Admittance Level Meters (Continuous and Point Type)
    - 40 72 43 Pressure and Differential Pressure Type Level Meters
    - 40 72 46 Bubbler Systems
    - 40 72 63 Displacement-Type Level Meters
    - 40 72 73 Sight Level Gauges
    - 40 72 76 Level Switches
    - 40 72 83 Leak Detection Systems

- **40 73 00 Pressure, Strain, and Force Measurement**
  - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
  - Related Sections:
    - 40 73 13 Pressure and Differential Pressure Gauges
    - 40 73 16 Manometers
    - 40 73 23 Absolute-Pressure Transmitters
    - 40 73 26 Gauge-Pressure Transmitters
    - 40 73 29 Differential Pressure Transmitters
    - 40 73 36 Pressure and Differential Pressure Switches
    - 40 73 53 Torque Measurement Devices
    - 40 73 63 Diaphragm Seals
- **40 74 00 Temperature Measurement**
  - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
  - Related Sections:
    - 40 74 13 Resistance Temperature Devices
    - 40 74 16 Thermocouples
    - 40 74 63 Temperature Transmitters
    - 40 74 66 Temperature Switches
    - 40 74 69 Thermowells, Protection Tubes, and Test Thermowells
- **40 75 00 Process Liquid Analytical Measurement**
  - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
  - Related Sections:
    - 40 75 05 Multi-Parameter Analyzer Systems
    - 40 75 13 pH/oxygen reduction potential (ORP) Analyzers
    - 40 75 21 Chlorine Analyzers
    - 40 75 33 Fluoride Analyzers
    - 40 75 43 Dissolved Oxygen Analyzers
    - 40 75 53 Turbidity Analyzers
    - 40 75 66 Nitrogen Analyzers
    - 40 75 69 Phosphorous Analyzers
    - 40 75 73 Particle Counters
    - 40 75 83 Hardness Analyzers
    - 40 75 86 Alkalinity Analyzer
- **40 76 00 Process Gas Analytical Measurement**
  - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.

- Related Sections:
  - 40 76 13 Oxygen Gas Analyzers
  - 40 76 23 Combustible Gas Monitors
  - 40 76 26 Chlorine Gas Analyzers
  - 40 76 33 Hydrogen Sulfide Monitors
  - 40 76 39 Carbon Dioxide Analyzers

- **40 77 00 Position and Motion Measurement**
  - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
  - Related Sections:
    - 40 77 16 Proximity Measurement Devices
    - 40 77 23 Vibration Monitoring Systems
    - 40 77 26 Position, Speed, and Motion Measurement Devices

- **40 78 00 Panel Mounted Instruments**
  - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
  - Related Sections:
    - 40 78 13 Indicators and Meters
    - 40 78 16 Indicating Lights
    - 40 78 19 Switches and Push Buttons
    - 40 78 23 Potentiometers and Manual Controllers
    - 40 78 26 Chart Recorders
    - 40 78 33 Annunciators
    - 40 78 43 Single-Loop Controllers
    - 40 78 53 Relays
    - 40 78 56 Isolators, Intrinsically-Safe Barriers, and Surge Suppressors
    - 40 78 59 Power Supplies
    - 40 78 63 Alarm Dialers

- **40 79 00 Miscellaneous Instruments, Calibration Equipment, Instrument Valves, and Fittings**
  - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
  - Related Sections:
    - 40 79 23 Instrument Calibration Equipment
    - 40 79 26 Instrument Programming Equipment
    - 40 79 39 Signal Conditioners and Converters
    - 40 79 66 Instrument Valve Manifolds, Valves, and Fittings

- **40 80 00 Commissioning of SCADA Systems**

- **40 91 00 Primary Control Valves**
  - Where applicable, utilize the Sections listed below as distinct specifications. Refer to latest edition of CSI MasterFormat for Subsections not listed.
  - Related Sections:
    - 40 91 13 Electrically-Operated Primary Control Valves
    - 40 91 23 Solenoid Primary Control Valves

- **40 93 00 Analog Controllers/Recorders**

Do not use analog controllers and recorders without the prior written consent of DC Water.

8B.8 DESIGN REVIEW SET REQUIREMENTS

Provide progressively more complete drawings and specifications for each review cycle. General expectations for each review are indicated below:

8B.8.1 Drawing Overview

Table 2-8B-1. Design Drawing Deliverables

Drawing Deliverables	CFR	Prelim. Design	Intermediate Design	90% Design	Pre-Final Design	Final Review	SCADA Manual
Process and Instrumentation Drawings	70	80	90	100	100	100	100
Process Flow Diagram Drawings	70	80	90	100	100	100	100
Network and Communication Drawings	70	80	90	100	100	100	100
Software Architecture Drawings		50	70	90	100	100	100
Data Flow Drawings		50	70	90	100	100	100
Control Panel Drawings		50	70	90	100	100	100
Control Panel Layout Drawings		50	70	90	100	100	100
Control Panel Elementary Drawings		50	70	90	100	100	100
AC & DC Power Distribution Drawings		50	70	90	100	100	100
Single Line Diagram Drawing		50	70	90	100	100	100
Control and Equipment Room Layout Drawings		50	70	90	100	100	100
Area Classification Drawings		50	70	90	100	100	100
Field Interface Electrical Schematic Drawings			50	90	100	100	100
Motor Control Center Schematics			50	90	100	100	100
Variable Frequency Drive Schematics			50	90	100	100	100
Switchgear Schematics			50	90	100	100	100
Motorized Valve Schematics			50	90	100	100	100
Other Field Interface Schematics			50	90	100	100	100
Wire & Conduit Drawings			50	90	100	100	100
Ductbank Schedules & Detail Drawings			50	90	100	100	100
Instrument Mounting Detail Drawings			50	90	100	100	100
Loop Drawings			50	90	100	100	100

The table above is an overview of the drawings expected from a SCADA design project. The numbers in the **body** of table represent the percent complete each drawing should be at each deliverable stage.

8B.8.2 Specification Overview

Table 2-8B-2. I&C Specification Deliverables

I&C Specification Deliverables	CFR	Prelim. Design	Intermediate Design	90% Design	Pre-Final Design	Final Review	SCADA Manual
40 01 00 Operation and Maintenance of Process Interconnections		30	50	90	100	100	100
40 05 00 Common Work Results for Process Interconnections		30	50	90	100	100	100
40 06 00 Schedules for Process Interconnections		30	50	90	100	100	100
40 61 00 SCADA and Management Systems General Provisions		30	50	90	100	100	100
40 61 13 SCADA Process Control System General Provisions		30	50	90	100	100	100
40 61 16 Enterprise Management System General Provisions		30	50	90	100	100	100
40 61 21 SCADA Process Control System Testing		30	50	90	100	100	100
40 61 26 SCADA Process Control System Training		30	50	90	100	100	100
40 61 93 SCADA Process Control Input/Output List	70	80	90	100	100	100	100
40 61 96 Control Descriptions	70	80	90	100	100	100	100
40 62 00 Computer System Hardware and Ancillaries		30	50	90	100	100	100
40 62 13 Server Computers		30	50	90	100	100	100
40 62 16 Operator Workstation Computers		30	50	90	100	100	100
40 62 19 Industrial Computers		30	50	90	100	100	100
40 62 21 Desktop Computers		30	50	90	100	100	100
40 62 26 Laptop Computers		30	50	90	100	100	100
40 62 29 Tablet Computers and Mobile Devices		30	50	90	100	100	100
40 62 33 Printers		30	50	90	100	100	100
40 62 43 Large Display Screens		30	50	90	100	100	100
40 62 63 Operator Interface Terminals (OIT)		30	50	90	100	100	100
40 63 00 Control System Equipment		30	50	90	100	100	100
40 63 43 Programmable Logic Controllers		30	50	90	100	100	100
40 63 xx Ethernet-Based Remote I/O		30	50	90	100	100	100
40 66 00 Network and Communication Equipment		30	50	90	100	100	100
40 67 00 Control System Equipment Panels and Racks		30	50	90	100	100	100
40 68 00 SCADA Process Control Software		30	50	90	100	100	100
40 69 00 Packaged Control Systems		30	50	90	100	100	100
40 70 00 Instrumentation for Process Systems		30	50	90	100	100	100
40 80 00 Commissioning of Process Systems		30	50	90	100	100	100
40 93 00 Analog Controllers/Recorders		30	50	90	100	100	100

The table above is an overview of the specifications expected from a SCADA design project. The numbers in the **body** of table represent the percent complete each specification should be at each deliverable stage.

8B.8.3 Design Document Definitions

Three design levels are used in the following sections that describe design deliverables. These descriptions cover instrumentation and control. Requirements for other disciplines, general provisions, Division 00, and Division 01 are outside the scope of this section (8B).

Note that this is a high level overview. Each item listed may have multiple sub sections that also apply. For example, Control Panel Layout drawings are one of several drawings that fall under Control Panel Drawings. Also, a flow meter specification is one specification that would fall under 40 70 00 Instrumentation for Process Systems. Refer to Table 2-8B-1, Table 2-8B-2, and Section 8B.7 for more detailed outline information.

Level 1 Design Documents are defined as follows:

- Process and Instrumentation Drawings
- Process Flow Diagram Drawings
- Network and Communication Drawings
- 40 61 93 SCADA Process Control Input/Output List Specification
- 40 61 96 Control Descriptions Specification

Level 1 Design Documents are documents which lead and determine the content of other design documents.

Level 2 Design Documents are defined as follows:

- Software Architecture Drawings
- Data Flow Drawings
- Control Panel Drawings (multiple types)
- Single Line Diagram Drawing
- Control and Equipment Room Layout Drawings
- Area Classification Drawings

Level 2 Design Documents have a significant dependence on and therefore lag behind Level 1 Design Documents. Level 2 Design Documents have significantly more detail than Level 1 Design Documents.

Level 3 Design Documents are defined as follows:

- Field Interface Electrical Schematic Drawings (multiple types)
- Wire & Conduit Drawings
- Ductbank Schedules & Detail Drawings
- Instrument Mounting Detail Drawings
- Loop Drawings
- All specifications except Level 1 Input/Output List and Control Descriptions specifications

Level 3 Design Documents have a significant dependence on and therefore lag behind Level 2 Design Documents. Level 3 Design Documents have significantly more detail than Level 2 Design Documents.

8B.8.4 Preliminary Design

Level 1 Design Documents should be substantially complete. Substantially complete in this context means there is no missing content and the design documents describe the final project outcome expected by the Engineer at this point in the project. In addition, the documents are closely coordinated and conflicts are minimized.

Level 2 Design Documents are 50% complete for related drawings. These should be complete as possible with changes anticipated as the project progresses.

Level 3 Dependent Documents are 30% complete for related specifications. These may be standard or guideline specifications edited where necessary to apply to the project. Significant changes are expected as the project progresses.

Provide equipment and primary element sizing calculations that illustrate how the equipment will meet process control requirements.

8B.8.5 Intermediate Design

Level 1 Design Documents continue to progress to the 90% level based upon design refinement, review comments, and requested design changes. The design documents describe the final project outcome expected by the Engineer at this point in the project. Documents are closely coordinated and conflicts are minimized.

Level 2 Design Documents progress to the 70% level. These should be as complete as possible with changes anticipated as the project progresses.

Level 3 Dependent Documents progress to the 50% level. New detailed drawings are introduced. Specifications have been significantly modified based upon the needs of the project. Significant changes are still expected as the project progresses.

Provide updated or modified sizing calculations since the preliminary design.

8B.8.6 90% Design

Level 1 Design Documents continue to progress to the 100% level based upon design refinement, review comments, and requested design changes.

Level 2 and Level 3 Design Documents progress to the 90% level.

All design documents (Levels 1, 2, and 3) are substantially complete as defined under Preliminary Design. Subsequent changes should only be due to review comments and requested design changes. The design documents describe the final project outcome expected by the Engineer at this point in the project. The documents are closely coordinated such that conflicts and omissions are eliminated.

Provide updated or modified sizing calculations since the intermediate design.

8B.8.7 Pre-Final

The designer considers the design package ready for bid with internal quality control reviews completed prior to submission to DC Water. This is expected to be at 100% complete with only minor comments by DC Water after review. There should be no design/coordination between disciplines remaining.

8B.8.8 Final Review

Final review should only require a check against the comments from the pre-final design.

8B.8.9 SCADA Manual

The SCADA Manual is the entire design package as it was bid and conformed to addenda. The SCADA Manual shall be delivered to DC Water for use by SCADA personnel during construction and startup.

8B.9 GENERAL GUIDELINES

These guidelines apply to all work with the potential to affect the operation of the DDCS SCADA System. This includes traditional CIP projects, On-Call Support Services, and Internal DC Water Projects.

8B.9.1 Allowances

The procurement of computer hardware and software related to SCADA should be deferred relative to other purchases to ensure DC Water receives the most current product offerings from vendors and also longer useful asset life. This includes, but is not limited to: operator workstations, laptops, servers, operating systems, application software, programming software, support software, and other computer products. Coordinate all such purchases with DC Water to ensure selection of appropriate products.

8B.9.2 Coordination

The DC Water SCADA System serves a critical business function. Therefore, changes to the SCADA system shall be coordinated with a number of DC Water departments and other contractors, potentially. All work on the SCADA system shall be coordinated with appropriate DC Water departments and designated staff. Coordinate work through DC Water. Coordination includes, but is not limited to:

- Coordination of Wonderware programming/configuration, commissioning, testing, and startup with the DC Water SCADA Group.
- Coordination of work involving cyber security and SCADA communications with DC Water IT.
- Coordination of high voltage (i.e. 480 VAC and up) work with the DC Water High Voltage Group at the Blue Plains Plant.
- Coordination of work involving existing field instrumentation and remote SCADA site PLCs with the DC Water Department of Water and Sewer Pumping Maintenance (WSPM) and the DC Water SCADA Group.
- Coordination of work that could affect water distribution system, collection system, or stormwater collection system operation with DC Water Department of Distribution & Conveyance Systems.

Design work should state milestones expressed in days after the project start date that infer when relevant DC Water departments will need to provide resources. Construction work should include a schedule disseminated to all concerned parties once per month to permit management of staff scheduling and loading within DC Water; the construction schedule must show where DC Water involvement will be required (e.g., startup, testing, etc.).

Work involving SCADA shall follow DC Water change management practices.

8B.9.3 Project Meetings

Project progress meetings should be held for each project. The frequency of these meetings should not be less than monthly, but could be more frequent at the discretion of DC Water. An agenda should be provided to all concerned parties three days prior to each meeting. The meetings should include attendance by a representative of the DC Water SCADA Group and other departments with Coordination needs. Coordination with the DC Water SCADA Group and other contractors shall be a required agenda item at each meeting. Meeting minutes should be provided within 7 days after each meeting.

8B.9.4 Construction Schedule

Use a Gantt chart schedule to state implementation tasks, milestones, task durations, task dependencies and resources. Update the schedule and disseminate to all concerned parties on a monthly basis. Use this schedule as the primary basis for coordination.

8B.9.5 Submittals

Provide submittals for review by DC Water for work involving SCADA. Submittals include, but are not limited to:

- Project Management (e.g., coordination, schedules, etc.)
- SCADA HMI system components (e.g., workstations, servers, OITs, operating systems, application software, etc.)
- SCADA communication system components (e.g., routers, network interface devices, etc.)
- SCADA PLC system components (e.g., PLC products, UPS, Ethernet switches, panels, relays, surge suppressors, intrinsic safety barriers, terminal blocks, power supplies, etc.)
- Instruments (e.g., flow meters, level transmitters, pressure switches, etc.)
- Field mounted products (e.g., pushbutton stations, etc.)
- Supporting components (e.g., wire, cable, conduit, pull boxes, conduit fittings, etc.)
- Software development (e.g., PLC programming/configuration, Wonderware development, device configuration, etc.).
- Project close-out (e.g., training, record drawings, as-builts, service manuals, etc.)

8B.9.6 Document Management

Documents completed at the end of design or construction work shall be uploaded to DC Water's Oracle Primavera Contract Manager® document management system as part of the project work. This includes all documentation including but not limited to: CFRs, design documents, addenda, submittals, PLC program listing, HMI configuration, service manuals, etc.

8B.9.7 Quality Control

Design documents should include the requirement for certification by the instrument manufacturer. Instruments shall be certified by the manufacturer that each is installed and calibrated in conformance with both the contract specifications and the manufacturer's requirements. All certifications and calibration reports shall be submitted to DC Water and be incorporated into the operation and maintenance (O&M) manuals and commissioning reports.

8B.9.8 Service Manuals

Provide service manuals herein referred to as a "SCADA Manual" for all design and construction work. Two versions shall be provided.

The first version of the SCADA Manual is a preliminary manual. It will be provided by the designer and will include items denoted in the "Preliminary" column below. The manual will be made up of post-bid documents conformed to addenda. This version of the manual will be provided in individual portable document format (PDF) files and the original source files used to produce the material (e.g., MS Word, MS Excel, AutoCAD, etc.). This will be provided to DC Water on optical media. Hardcopies are not required for the preliminary manual.

The second version of the SCADA Manual will be the final service manual. It will be provided by the systems integrator and will include items denoted in the "Final" column below. The manual will be made up of design drawings updated throughout the construction process to reflect field conditions, otherwise known as Record Drawings. It will also include original documents from the systems integrator, otherwise known as As-Built documents. Note that control panel drawings produced during design will not be used in the final manual. Instead, control panel drawings approved during the submittal process and then updated to reflect as-built conditions will be used in the final manual.

Table 2-8B-3. SCADA Manual Requirements

Document Type	Preliminary	Final
Process and Instrumentation Diagram	Design	Record
Process Flow Diagrams	Design	Record
Network and Communication Drawings	Design	Record
Software Architecture Drawings	Design	Record
Data Flow Drawings	Design	Record
Control Panel Bill of Materials	-	Original
Control Panel Layout Drawings	Design	**Original**
Control Panel Elementary Drawings	Design	**Original**
Control Panel – AC & DC Power Distribution Drawings	Design	**Original**
Single Lines	Design	Record
Field Interface Electrical Schematics	Design	Record
Control & Equipment Room Layouts	Design	Record
Wire & Conduit Drawings	Design	Record
Ductbank Schedules	Design	Record
Instrument Mounting Details	Design	Record

Document Type	Preliminary	Final
SCADA Screens	-	Original
OIT Screens	-	Original
PLC & OIT Documentation [1]	-	Original
I/O Point List	Design	Record
Control Narrative – Operational Sequence Description	Design	Record
Factory Acceptance Test Results	-	Original
Site Acceptance Test Results	-	Original
Loop Drawings	-	Original

Note(s):

1. See 8B.14 PLC Configuration Guidelines for additional detail.

The original source files (e.g., AutoCAD, MS Word, MS Excel, etc.) used to create the preliminary and final manuals shall be provided to DC Water on read-only optical disk media [compact disc (CD) or digital video disc (DVD)].

For design projects, the Project Design Engineer (PDE) shall upload the preliminary service manual, and for construction projects, the Contractor shall upload the final service manual. Service manuals shall be uploaded in PDF format to DC Water's Oracle Primavera Contract Manager® document management system.

8B.10 TECHNICAL GUIDELINES

8B.10.1 Standards

Design work for DC Water projects must conform to the codes and regulations listed in this section. Reference materials may be obtained from the following professional societies:

ABBREVIATION	NAME
Fed. Spec.	Federal Specification
NEC	National Electric Code
ANSI	American National Standards Institute
ISA	International Society of Automation
IEEE	Institute of Electrical and Electronics Engineers
API	American Petroleum Institute
NEMA	National Electrical Manufacturers Association

Use the latest editions of following reference materials on the project:

- National Electric Code
- ISA, S5.4, Instrument Loop Diagrams, Standard.
- API, RP-550, Manual of Installation of Refinery Instruments and Control Systems.

- NEMA, Enclosure Type, Standards.

8B.10.2 Input/Output Point List

The I/O Point List is used for the computer system interface to the control system. The I/O Point List is developed in conjunction with the P&IDs. The I/O Point List permits the design engineer to keep track of the number of I/O signals at each location and will be used to determine the actual number of PLCs and I/O racks. If a contract involves modifications to existing systems with existing I/O points, those points (and dependent calculated PLC points) will require re-testing and must be included in the I/O Point List with a note in remarks column indicating that these are existing points. Prepare an I/O Point List in the most current release of Microsoft Excel with all design reviews compatible with Microsoft Office Suite. Update the I/O Point List during construction as and when changes are made.

Each design package shall include an I/O Point List that at contains the following minimum information. Conduct field research to ensure point information for existing points is accurate. The I/O Point List shall clearly denote new points, existing points to be retained, and existing points to be deleted or removed. Additional information can and should be added to accommodate the specific requirements of the designer's design methods. It is intended that the I/O Point List show all hardwired and data link points from devices such as PMTs, PLCs, Ethernet I/O, UPSs, etc. Use upper case for all entries with the exception of notes.

a. System Grouping - Field that corresponds to systems definitions for testing and control descriptions that tie multiple equipment items together (i.e., pumps, feeder breaker, priming valves, and discharge valves might be a system).

b. Equipment Grouping - Field that corresponds to all points associated with a piece of equipment (i.e., a valve might have 4 points associated with it, this grouping ties them together).

c. Wonderware objects and attributes.

d. ISA Tag - Based on P&IDs. Ties legacy work to Wonderware objects.

e. ISA Instrument - Examples: FI, LI, MN, etc. Useful for sorting with loop number.

f. ISA Loop Number - Useful for sorting with instrument.

g. Description shall be based on SCADA Naming Conventions described in this document.

h. Field Interface Location – the location in the field where an Input/Output point terminates.

i. Signal Type – values would include:

- DI - Discrete Input.
- DO - Discrete Output.
- AI - Analog Input.
- AO – Analog Output.

j. I/O Type – Further defines the point. Values would include:

- 4-20mA (for AIs and AOs)
- 1-5 VDC (for AIs and AOs)
- 0-10 VDC (for AIs and AOs)
- 24 VDC (for DIs and DOs)
- 120 VAC (for DIs and DOs)
- MO – N.O. (for momentary normally open contacts)

- MO – N.C. (for momentary normally closed contacts)
- MA – N.O. (for maintained normally open contacts)
- MA – N.C. (for maintained normally closed contacts)
- Serial
- Ethernet

k. Analog I/O Information:

- Analog Range - Calibrates signal range.
- Analog Units - MGD, GPM, GPH, PSI, etc.
- Loop Power - Field or PLC.
- Loop Ground - Field or PLC.

l. Discrete I/O Information:

- Set Value - Value when field contact is closed (i.e., Running, High Level, Low Level, etc.). Coordinate with electrical schematics.
- Reset Value - Value when field contact is open (i.e., Stopped, Normal, etc.). Coordinate with electrical schematics.
- Invert – States if a point should be or is inverted in the HMI database. This is uncommon, but may be set during startup to resolve a reverse condition regarding set/reset values. This will be useful when applying standards to existing remote sites.

m. Alarm – Indicates if the point is an alarm on the OIT and Wonderware SCADA system.

- Standardize the use of alarm contacts (NO/NC) and provide fail safe operation both in the field and SCADA.

n. IO Interface - Where field device is wired. Values might include:

- Remote input/output (RIO) name (hardwired).
- PMT name.
- PLC name.
- VFD name (for smart VFDs), where approved for use by DC Water.
- MCC name (for smart MCCs), where approved by DC Water.

o. Termination Information - Values for the fields below are to be assigned by the designer for new installations. For existing installation, this information is to be provided to designate spares to be used.

- PLC – The PLC the point is wired to
- Rack - The rack number identifier that contains the card that the point is wired to
- Slot - The slot number of the card that the point is wired to
- Point - The point number (in the card identified above) that the point is wired to
- PLC Address – The memory location in the PLC assigned to the point.

p. P&ID Reference – Include the P&ID page number that contains the point.

q. Miscellaneous design/construction coordination information.

- Surge and Intrinsic Safety requirements for each loop.
- DC Water or Contractor responsibility for equipment operation or upgrade.
- Alarm priority.

r. Miscellaneous requirements

- Use 24 VDC as the basis for discrete input points for all new installations.
- Use only one voltage system for discrete input points at a given facility.
- Exceptions are subject to the approval of DC Water.

Provide a complete I/O Point List for all new and existing I/O at a remote SCADA site. Provide separate and clearly labeled I/O Point Lists sorted as follows:

- Sort Version 1 – Sorted by loop number, signal type, ISA instrument. This presentation will be used for reviewing P&IDs and control descriptions.
- Sort Version 2 – Sorted by PLC identifier, rack, slot, point. This presentation will be used for reviewing elementary drawings, general fault tolerance, and risk distribution.

See Appendix B for "Sample I/O Point List."

8B.10.3 Control Descriptions

The control description section of the CFR and subsequent specifications, when used in conjunction with the process and instrumentation drawings (P&IDs) identifies the control philosophy. It is therefore critical that the P&IDs are completed before developing the control descriptions. Submit the control descriptions for review with completed P&IDs, together as a coordinated package.

Prepare Control Descriptions for all systems/equipment furnished in each design package as well as any equipment/processes that are existing that are being modified as part of the project.

The Control Description (CD) will be the means of communicating the methods of control to technical and non-technical people and supplement the P&IDs. The document will be created during the CFR and will be modified with each design submittal to reflect any changes or additions to the control system. The document will be an aid to design review and will form a basis to understand the control design intent.

The Systems Integrator will use the CD as a starting point for their documentation, enhance the document, and use the document as the basis for the Operations Manual. The document will be organized and include information so it can be stored and retrieved based on the control loop number, remote site identifier, and system.

Control Descriptions shall be arranged by system and subsystems and shall be coordinated with the "system test grouping" definition for testing as well as the I/O Point List. The "system test group" shall be as required for all the equipment within the test group to be operated automatically.

Control Descriptions shall be formatted and definitively identify what is occurring in the control system, what is hardwired, and what is provided in 3rd party controls.

Contractor shall be required to submit all modifications to control descriptions, schematics, and wiring during the submittal process as well as include as part of the "as-builts" and O&M manuals.

The document will include:

1. Title - Systems and/or Equipment.
2. Introduction - Brief overview of purpose.
3. Equipment Tags, description, and loop numbers that make up the system.

4. P&ID Sheet Numbers.
5. CD narrative at each hierarchical level of control as:
    - At the device.
    - At the motor control center (MCC) or the variable frequency drive (VFD).
    - At the local panels.
    - At the local OIT
    - At the SCADA workstation.

    The narrative would describe (at all levels including SCADA):
    - All automatic and manual functions.
    - All safety interlocks.
    - Interlocks to other process equipment.
    - Permissive conditions required for operation
    - Equipment protection.
    - Calculations and formulas.
    - Continuous control.
    - Sequential control.
    - Discrete (ladder logic) controls.
    - Set points for design conditions.
    - Equipment alternation schemes
    - Actual setpoints to be used initially during implementation.
    - Operator and engineer adjustable parameters
    - Describe all control mode options and the required process conditions for each mode.
    - Configuration states to be prevented.
    - Describe the operator Human Interface (HI) and controls available.
    - Describe HI to enable/disable control from each level of the control hierarchy.
    - Define where controls are provided.
    - Identify any PLC or other microprocessor control equipment.
    - Diagnostic monitoring.
    - Describe any signals sent/received to/from other unit process controls and include the references.
    - Describe the communication requirements between each level of the control hierarchy.
    - Indicate historian requirements for each historical data system.
    - Indicate alarming requirements and priorities.
    - Indicate action from SCADA and local controllers after a power outage or loss of control signals.
    - Describe manual or automatic stabilization methods for remote site operation upon loss of communications with SCADA. This could include holding last good value, system shutdown, etc.

Special requirements for failure conditions and equipment controllability checks need to be included by the designer. Examples include: hold last good value upon communications fail, force a control loop set point to certain values during certain faults, etc. All control modes and transitions between control modes needs to be clearly defined and explained – include requirements for bumpless transfer between all control modes.

Describe the control requirements regardless of equipment or control supplier. These narratives are required for all systems and associated equipment.

The control descriptions must include requirements for equipment protection (e.g., running pumps dry) and operational states that must be prevented based upon the operational needs of the system. The control descriptions should also define the minimum speed for pumps where a given pump begins to produce flow. Control must depend upon permissive conditions coordinated within a process train.

The control descriptions are commonly used as a scope document for System Integrators. Therefore, the control descriptions must completely describe the behavior of the Wonderware HMI and OIT, including: graphic displays, graphic controls, trends, alarm summaries, event summaries, alarm notifications, historian storage, reports, control hierarchy, internal logic, and calculations. The behavior of the HMI and OIT must match; this will help simplify control description development. Equipment interlocks at the HMI, PLC, and field wiring levels must be described. The control descriptions must describe PLC monitoring, control, derived points, internal points, and calculations.

The control descriptions are commonly used as the basis for acceptance testing. Therefore, the control descriptions must describe all possible control system states and expected operation to support testing during construction. Pass/fail test criteria must be clearly specified by the designer for use by the systems integrator during construction.

Include narrative to describe monitoring and control expectations regarding power fail and power restoration for all equipment that affects system operation.

The control descriptions should include a summary of the data needs of each department to permit confirmation that design submittals adequately meet those needs. This would include day-to-day operational needs, air permit needs, National Pollutant Discharge Elimination System (NPDES) reporting needs, consent decree needs, etc.

The control descriptions should confirm DC Water monitoring and control needs are addressed holistically for each project – look for additional needs that can be addressed that are beyond the initial objectives of a project. For example, add water pressure monitoring at strategic locations in projects focused on sewage collection sites.

All alarms shall be prioritized during design and documented in the control descriptions.

See Appendix Q for "Sample Control Description."

8B.10.4 PLC Equipment Layout, Sizing, and Naming Conventions

Programmable Logic Controllers (PLCs) are the primary interface to SCADA site processes. As the main control device, they form a single resource for almost all of the programmable monitoring and control functions at the remote sites. The Wonderware HMI provides a common database and communications interface for all devices connected to SCADA.

Sizing considerations are as follows:

- **a.** Design a system with enough PLC racks to accommodate a 30% future expansion of I/O card count and individual rack power supply systems that will accommodate this expansion. Size the rack power supply based on the I/O card with the most demanding power requirements.

b. Design a system with 20% spare analog inputs, 10% spare analog outputs, 30% spare digital inputs, and 10% digital outputs of each I/O type used in the design.

c. Specify PLC cabinets without windows. The cabinet shall have a 3-point latching hinge and a lockable handle.

d. Naming Conventions. PLC shall be named according to System, Site Class, and Site Identifier. Append manually assigned sequence number for each PLC. Example: SC_SPS_RCPS_PLC_1. Refer to SCADA Naming Conventions for more detail

e. I/O Card Modules.

8B.10.5 Hardwired Signal Interface

Typically, computer system I/O subsystems are designed to accept certain types of signals, both analog and digital. Standard interface signals are listed below. Any other special signals must be coordinated, through DC Water.

Although other cards are available from Schneider Electric, below are the standard I/O card modules utilized in the SCADA system. These cards should be used to minimize spare parts inventory to be maintained by DC Water:

- AI Cards - 8 isolated inputs, 4-20 ma, configurable for loop or field power, 250 ohm input
- AO Cards - 4 isolated outputs, 4-20 ma, into 750 ohms
- DI Cards - 16 inputs, isolated 120 VAC. * see below
- DI Cards - 16 inputs, isolated 24 VDC. * see below
- DO Cards - 16 outputs, form C, isolated relay contacts rated 120 VAC and 24 VDC.

All digital inputs will originate from dry, isolated contacts, which will be wetted by the PLC system. The wetting voltage will be 24 VDC for new installations and will be supplied directly from a redundant DC power supply that is UPS backed. The wetting voltage will be 120 VAC for expansions to an existing PLC input system that uses 120 VAC and will be supplied from the UPS; mixing 120 VAC inputs and 24 VDC inputs at a given facility is not allowed; exceptions shall be approved by DC Water.

If contacts are required in the 5- or 10-amp range, interposing relays will have to be furnished. Relays with DC coils shall also include a reverse biased diode across the coil for contact protection. Relays energized from PLC outputs shall be powered from the UPS.

8B.10.6 SCADA Connection to I/O and Field Devices

The following guidelines should be used in selection of connection types. Utilization of any connection other than hardwired should have a benefit/risk assessment for DC Water evaluation. Utilize hardwired I/O where reliability, availability, and security are essential to meeting DC Water operational objectives. Do not use anything other than hardwired I/O without specific permission from DC Water.

- Hardwired I/O. Utilize for all equipment where hardwired is available. Utilize where I/O signals could affect automatic or manual control. Utilize where I/O signals are used for billing or reporting to entities outside of DC Water. In some cases, additional information, reliability, or cost can contribute to utilizing the other methods below. All exceptions shall be approved by DC Water.

- I/O Via Ethernet Communications Links. Use Ethernet for non-essential monitoring-only connections to: OEM packaged autonomous systems (e.g., screens, odor scrubbers, etc.), PMTs, water quality analyzers, data loggers, and suitably equipped flow meters.
- I/O Via Serial Communication Links. Serial communications are not allowed regarding I/O. Replace existing serial products in the SCADA system with newer Ethernet-ready products whenever possible; when this is not possible use a serial-Ethernet bridge.
- Wireless I/O. Utilize in non-essential monitoring-only applications where a hardwired implementation would be cost prohibitive. Wireless I/O shall only be used with permission from DC Water. Wireless I/O must have 256 bit AES encryption.
- I/O Via Other Bus Technologies with permission from DC Water.

8B.10.7 SCADA Reliability and Layout

All remote SCADA sites shall be designed for high reliability, unmanned operation, and remote monitoring/control. Design documents shall specify performance metrics to define what high reliability means for a given project. The design documents shall specify how the performance metrics will be tracked over an acceptance period, pass/fail criteria, and how unacceptable performance is resolved and reevaluated.

Design work shall specify firm capacity requirements of relevant remote SCADA sites. The PLC system design shall not include a single point of failure that violates the firm capacity constraints of relevant remote SCADA sites.

The PLC design shall not include a single point of failure that results in the loss of monitoring/control of more than one field asset or process train. The table below generally summarizes the desired fault tolerance required at remote SCADA sites capable of directly affecting the water distribution, sewage collection, and stormwater collection systems. NOTE: Redundant I/O cards and redundant field wiring shall not be used.

Table 2-8B-4. SCADA Basic Contingency Planning

Failure	Backup, Effect on Process
SCADA Workstation	Local monitoring via OIT, no immediate effect
Verizon System	Local monitoring via OIT, no immediate effect
Verizon Primary Comm	Backup communication path takes over, no effect
PLC Processor	Backup processor takes over, no effect
Ethernet Switch	Backup switch takes over, no effect
Ethernet Cable	Redundant cable takes over, no effect
AC Power Feed	UPS batteries supply power, no immediate effect
DC Power Supply	Backup power supply takes over, no effect
UPS	Automatic UPS bypass, no effect
PLC Rack Power Supply	None, loss of monitoring/control limited to TWO process trains
I/O Card	None, loss of monitoring/control limited to ONE process train
I/O Fuse (Discrete Input)	None, loss of monitoring/control limited to ONE field asset
I/O Fuse (Analog Input)	None, loss of monitoring/control limited to ONE field asset
Instrument (for Control)	Backup instrument used for control, no effect after control transferred

Use redundant PLC processors in separate racks in a typical hot backup (automatic failover) arrangement offered by Schneider. Use a dedicated communications link between the redundant processors solely for the management of hot backup functionality. Synchronize critical operating information between the processors to achieve bumpless failover (no change in system operation) and to prevent data corruption. Ensure the HMI communicates directly with the active PLC processor in normal and failover modes.

> EXAMPLE: Setpoints, tuning parameters, and other control-related data are mirrored between the processors. The process is unaffected when the backup processor assumes control and also when the primary resumes control.

> EXAMPLE: Runtimes and flow totals are mirrored between the processors. Data is not corrupted and reports are not affected when the backup processor assumes control and also when the primary resumes control.

Assign PLC/rack/slot/point designations for all I/O (including spares) during design using the I/O Point List. **The objective is to assign I/O across racks and cards as needed to minimize loss of monitoring/control of field assets and process trains as a result of any single rack or I/O card failure.**

Use the minimum number of racks needed to meet spares and future expansion requirements defined elsewhere.

> EXAMPLE: The I/O for a pump station design can fit within one rack. However, to meet spares and future expansion requirements, the designer decides two racks will be needed. The decision is further supported by the need for redundant processors in separate racks.

Where multiple PLC racks are used, distribute I/O for similar field assets as evenly as possible between the racks. Do not assign I/O for any given field asset to more than one rack.

> EXAMPLE: In a three rack PLC system, all of Pump 1 I/O is assigned to Rack 1, all of Pump 2 I/O is assigned to Rack 2, and all of Pump 3 I/O is assigned to Rack 3.

Where multiple I/O cards of the same type are used, distribute I/O for similar field assets as evenly as possible between the cards. Do not assign I/O for any given field asset to more than one card of each type (i.e., AI, AO, DI, DO) required.

A process train is a collection of sequentially-connected field assets with a mutual dependency that performs a similar function to other parallel collections of like assets. As an example, a pump station with three pumps would have three pumping process trains; each train consisting primarily of a suction valve, pump, motor, VFD, and discharge valve. Use similar risk management techniques as described above for field asset racks and cards also to process trains. In other words, distribute I/O for similar process trains as evenly as possible between multiple racks; do not assign I/O for any given process train to more than one rack. Also, distribute I/O for similar process trains as evenly as possible between the cards; do not assign I/O for any given process train to more than the absolute minimum number of cards required. Lastly, distribute I/O between cards as needed to limit the loss of control to only one process train if any single card fails.

Use a separate fuse to wet contacts for each group of discrete inputs for a given field asset such that a single blown fuse does not result in the loss of monitoring/control of more than one field asset. Use fused disconnect type terminal blocks to isolate the wetting voltage for a given field asset to facilitate equipment shutdown or maintenance; opening a fused disconnect type terminal shall not result in the loss of monitoring/control of more than one field asset.

Use redundant Ethernet communication devices, interfaces, and cabling to eliminate single points of failure in the communication system. Redundant Ethernet communications is not required where it is not feasible (e.g., certain existing PMTs, flow meters, small brick-style PLCs, etc.).

Automatic control shall be based on hardwired I/O signals only and not depend upon communications between intelligent end devices (IEDs); exceptions must be specifically approved by DC Water.

Conduct field testing to ensure consistently adequate signal strength of wireless remote site connections. Do not use CDMA for remote site communications where timeliness of data and reliability are important for successful distribution or collection system operation.

Use diagnostic I/O points to monitor the health of the PLC system and control system. For example, failsafe alarm monitoring of PLC system components that affect controllability. Also, for example, pressure switches on the common discharge of dual seal water pump systems.

Use microprocessor-based diagnostic information to monitor the health of the PLC system. This includes but is not limited to: components that affect controllability, PLC processor diagnostics, I/O card diagnostics, UPS diagnostics, etc.

Design a diagnostic sub-system that supports unmanned operation and allows operations and maintenance staff to remotely monitor the operational health of the remote facility.

Historize PLC system health and diagnostic information for near-realtime and historical analysis. Include complete health and diagnostic monitoring description in control descriptions. Ensure the health and diagnostic information is an integral part of the HMI and OIT systems.

Use redundant instrumentation where failure of a single instrument would preclude control. One example is wetwell level control. Another example is discharge pressure control. Wire redundant instruments to the PLC. Use a software switch inside the PLC (accessible via Wonderware or OIT) to select which device will be used for control. Program a discrepancy alarm into the PLC when the readings disagree by more than five (5) percent; monitor this alarm in both Wonderware and the OIT.

Utilize PLC Panel UPS-backed power (AC or DC) to power critical instruments (e.g., those used for control, billing, safety, reporting to outside agencies, etc.). For all other 4-wire instruments powered directly from 120 VAC panelboards, provide separate circuit breakers for each. 2-wire transmitters shall be powered from the PLC system using a redundant DC power supply that is UPS backed. 2-wire transmitters shall be individually fused in the PLC panel. In general, for each instrument, provide separate overcurrent protection with integral disconnect means.

For discrete alarm inputs, use a normally open contact that is held closed under normal conditions and opens when there is an alarm. Under normal conditions, the input to the PLC will be turned on. This type of failsafe wiring is more reliable because it also detects loose wires, blown fuses, pulled relays, poorly fitting edge card connectors, and other “open wire” type conditions. This failsafe wiring and “open-wire” detection is essential to alarm integrity; otherwise, alarm conditions could go undetected. Note that an “open wire” condition will result in a false positive alarm that can be correctly diagnosed and addressed by maintenance staff. Wire discrete alarm inputs directly to the originating field device; do not use interposing relays.

Use a limit or proximity switch for positive confirmation of movement for field equipment (e.g., screens, conveyors, etc.) that use belts, chains, and mechanical over-torque protection (e.g., shear pins). The limit switch will prevent a false positive run status indication form a motor starter when a mechanical failure in the field occurs.

Size the PLC system UPS for four (4) hours of backup power under normal remote SCADA site operation. Provide a UPS Maintenance/Bypass disconnect switch for each UPS over 1 KVA. Provide an automatic transfer switch (ATS) for the UPS to switch to line power when the UPS fails.

Provide a maintenance bypass disconnect switch for all UPSs except smaller footprint UPSs dedicated to a local workstation. The maintenance bypass disconnect switch should be a standard product offered by the UPS vendor. The position of the maintenance bypass disconnect switch should be monitored by the SCADA System.

At sites without multiple power feeds or an on-site backup generator, provide an externally mounted receptacle and internally mounted manual transfer switch for the connection of a small gas powered portable generator to power the PLC system.

Use products with conformal coatings where a corrosive environment exits within the facility. This includes PLC components, OITs, instruments, communication devices, and other products containing a printed circuit board.

Ensure all drawings clearly identify classified areas and design work adequately addresses relevant risks.

Use conduit seals as needed to meet applicable codes regarding classified areas. In addition, use conduit seals on conduit originating or passing through a corrosive area as needed to protect wiring terminations and products containing a printed circuit board. All conduit connections to an enclosure must enter from the bottom of the enclosure; this is to avoid potential water entry into enclosure.

Cellular (e.g., CDMA, 3G, 4G, etc.) should not be used for SCADA communication where reliability and timeliness of data are important. Cellular should not be used for control purposes. Cellular is not deemed to be a high reliability communications method; DC Water should expect outages. These outages may occur at critical times and affect operations for an indefinite period of time. If cellular is proposed, the designer should consult the SCADA group to quantify past Cellular communication availability statistics and assess this communications methodology against project performance requirements. Use of Cellular should comply with DC Water IT guidelines developed as part of the DC Water SCADA Communications System Design. Contact DC Water IT for additional information. Use of cellular should include verification that adequate signal strength will be available using the products (wireless modem, cable, antenna, etc.) to be installed during implementation.

8B.10.8 SCADA Configuration and Programming

All designs and programming shall accommodate the requirements in these technical guidelines.

8B.10.8.1 Workstations

Unstaffed remote SCADA sites should not be equipped with Wonderware workstations.

Power all workstation from a local UPS separate from the PLC system UPS.

Install workstations only in physically secure locations which preclude access by unauthorized individuals.

Workstations should be provided with minimal software installed. Workstations should not include PLC programming software.

The aspect ratio used in the final implementation of graphics (HMI, workstations, OITs, etc.) should be coordinated and stated during design to ensure development by an integrator on an appropriate system.

8B.10.8.2 Operator Interface Terminal (OIT)

Ideally, an OIT would be directly connected to a remote site PLC using a crossover Ethernet cable. This provides an independent communications path to the PLC that cannot easily be disrupted from the remote site control network or remotely across the wide area network. This presents a serious maintenance challenge as this approach requires an onsite presence for OIT updates. As a result, DC Water has decided to use the Wonderware configuration for remote sites for two purposes: HMI and OIT. This will greatly reduce development, support, and maintenance labor, but increases risk to some degree.

An OIT with strong password security at unstaffed remote SCADA sites is acceptable provided OIT monitoring and control is limited to that site only. Ensure strong password security is required to access OIT graphics and configuration.

Power the OIT from the PLC system UPS.

OITs must be able to operate independent of WAN availability.

Ensure the local UPS is monitored by the OIT.

The aspect ratio used in the final implementation of graphics (HMI, workstations, OITs, etc.) should be coordinated and stated during design to ensure development by an integrator on an appropriate system.

8B.10.8.3 Remote Site Password Security

All SCADA components with the capability to support password security must be configured with strong passwords established and documented by DC Water. This includes but is not limited to PLCs, PMTs, OITs, communication equipment, operating systems, computers, laptops, etc. All default passwords must be changed before any work commences. All passwords when established or changed must be performed by a member of DC Water’s SCADA Group.

Legacy OITs might not have password security capability. If not, use a Personal Identification Number (PIN) approach to secure the OIT to the extent possible. Make the OIT default to a PIN entry screen after 10 minutes of no data entry/navigation activity. Use separate and unique PIN numbers for each person that DC Water wants to have access to a given OIT. Store valid PINs in the local PLC. Use the PLC to validate entries. Activate an alarm on the SCADA system when more than two invalid PINs are entered over a 5 minute period. Legacy OITs should be replaced as part of design and construction work at a given facility.

8B.10.8.4 Anti-Virus Software

The standard anti-virus software used by the SCADA System should be installed on all servers, workstations, and OITs. Consult with DC Water SCADA Group for software details.

8B.10.9 OEM PLC Applications and Requirements

PLCs included as part of an OEM packaged system (e.g., screens, etc.) shall meet the requirements of these guidelines. Ethernet communications is permissible for monitoring purposes and remote setpoint adjustments of OEM control algorithms. Hardwired I/O shall be used for interlocks and interfaces with other systems where loss of Ethernet communications would have an adverse effect on operations.

8B.10.10 Control and Monitoring Guidelines

The first section below ("General Monitoring") states general objectives for use in determining which functions should be monitored and which should be controlled.

Subsequent sections (Constant Speed Motor I/O through ATS I/O) describe I/O requirements for equipment commonly found in small to medium sized pump stations. Use the I/O as the starting point for I/O selection and add/subtract I/O based on the specific needs of each project. Ultimately, it is the responsibility of the design engineer to choose the I/O that will best meet the needs of DC Water for any given project.

8B.10.10.1 General Monitoring

Provide a "RUN" status input to SCADA for all motors; exceptions may include HVAC equipment deemed inconsequential. Be careful to provide run status of the driven equipment and not just the motor, in cases where equipment run status and motor run status may be different. For example, if a chain is used to drive a piece of equipment and the chain fails, the motor will be indicated as running but the driven equipment will not be.

The following processes and equipment should be monitored:

- Major process variables such as temperature, flows, levels, and pressures.
- Status of major process equipment such as pumps, and compressors. Include as a minimum run status and availability (disconnect switch and/or breaker).
- Status of process variables or equipment controlled by the PLC system.
- Flow, motor amperes and power (watts) for all pumps, blowers, compressors and fans 75 HP and larger.
- For variable speed driven equipment monitor speed input/output. For motors that operate continuously, monitor motor current and power (watts).
- Gas flows to be pressure, temperature, relative humidity compensated.
- Switchgear breaker status and microprocessor breaker monitor.
- Limit switches and torque/overload on valves and gates.
- Status of motors and speed of variable speed devices that are larger than 1/3 HP except for HVAC equipment.
- Flow and electric utility signals that can be used to verify jurisdictional billing and electrical billing
- Safety indicators (e.g., fire alarm, physical security alarm, gasses such as H_2S, CH_4, etc.).

DC Water has standardized the monitoring of protective devices to be provided for large equipment. Provide SCADA monitoring of rotating assemblies for backspin, vibration (xyz), and temperature (windings and bearings) for large motors (75 HP and above) in addition to the hardwired interlocks with the equipment. Analog monitoring of temperature is preferred over discrete inputs to SCADA. The items above are minimum monitoring points; evaluate if other points are beneficial for continuous monitoring.

Alarms must also be monitored. Install alarm sensors in equipment that will generate alarm signals for major process equipment problems, process variables, and controlled device failure-to-respond signals. Furnish alarm sensors in equipment to indicate pending problems (i.e., preparatory alarm), such as impending torque overload for a bar screen. These alarms are intended to alert the operator of pending problems. Evaluate and discuss with DC Water requirements for manually resetting alarms separate from SCADA.

The Consent Decree requires operations to report on availability of remote site equipment. Monitor availability (disconnect switch and/or breaker) as needed to support this reporting requirement. Consult DC Water operations for which equipment must be monitored.

Refer to Appendix P for "Sample Object Definitions" for additional control and monitoring needs.

8B.10.10.2 Constant Speed Motor I/O

Monitor the following points.

- MF Motor Overload Alarm DI From starter
- MN Motor Run Status DI From starter
- QN Motor Available Status DI From starter and/or local disconnect
- TH Motor High Temp Alarm DI From motor winding
- XF Seal Water Fail Alarm DI From pressure switch

Where control is desired include the following additional points.

- YN Motor In Remote Status DI From starter circuit switch

For maintained control outputs (< 20 hp motor):

- MD Motor Start/Stop Command DO N.O. contact to starter

For momentary control outputs (> or = 20 hp motor):

- MD Motor Start Command DO N.O. contact to starter
- MB Motor Stop Command DO N.C. contact to starter

8B.10.10.3 Two-Speed Speed Motor I/O

Monitor the following points.

- MF Motor Overload Alarm DI From starter
- MNH Motor Run Status High Speed Status DI From starter
- MNL Motor Run Status Low Speed Status DI From starter
- QN Motor Available Status DI From starter and/or local disconnect
- TH Motor High Temp Alarm DI From motor winding

Where control is desired include the following additional points.

- YN Motor In Remote Status DI From starter circuit switch
- MDH Motor Start High Command DO N.O. contact to starter
- MDL Motor Start Low Command DO N.O. contact to starter
- MB Motor Stop Command DO N.C. contact to starter

8B.10.10.4 Variable Speed Motor I/O

Variable speed drives (VSDs) shall be designed with separate Hand-Off-Remote controls/switches for start/stop and local/remote switches for speed control. All VSD speed input signals shall be designed for 4ma = 0 speed and 20 ma = 100% speed. All variable speed drives shall be programmed with a minimum speed to prevent equipment damage regardless of control mode. In cases where VSDs are used with pumps to control sewage wetwell level, the variable speed drives shall be programmed with a minimum speed corresponding to the point on the system pump curve where discharge flow into the collection system begins.

Monitor the following points.

- SI VFD Speed Feedback AI From VFD
- MF VFD Fail Alarm DI From VFD
- MN VFD Run Status DI From VFD
- QN VFD Available Status DI From VFD and/or local disconnect
- TH Motor High Temp Alarm DI From motor winding
- XF Seal Water Fail Alarm DI From pressure switch

Where control is desired include the following additional points.

- SC VFD Speed Command AO To VFD
- YN VFD Start/Stop in Remote Status DI From VFD
- YN VFD Speed in Remote Status DI From VFD
- MD Motor Start Command DO N.O. contact to VFD
- MB Motor Stop Command DO N.C. contact to VFD

8B.10.10.5 Valve or Gate Actuator I/O

Open/Close valves and gates should be designed for separate momentary open and close outputs from SCADA.

Modulating or positioning valves or gates should be designed to utilize isolated 4-20 ma input and output signals with SCADA with backup discrete signals for monitoring full open and full close positions.

All valves and gates should have discrete inputs to SCADA for full open and full close position.

Pump discharge valves should be directly interlocked with pump and not controlled through SCADA. SCADA will only monitor these valves.

Design should clearly specify what is to happen to actuator on loss of control signal.

Monitor the following points.

- ZI Valve Position AI From position sensor
- QN Valve Available Status DI From VFD and/or local disconnect
- WH Valve High Torque Alarm DI From motor operator
- ZH Valve Opened Status DI From limit switch
- ZL Valve Closed Status DI From limit switch

Where control is desired include the following additional points.

- YN Valve in Remote Status DI From operator
- VD Valve Open Command DO N.O. contact to operator
- VB Valve Closed Command DO N.O. contact to operator

8B.10.10.6 Pump Check Valve I/O

Pump check valves should be directly interlocked with pump and not controlled through SCADA. SCADA will only monitor these valves.

Design should clearly specify what is to happen to actuator on loss of control signal.

Monitor the following points.

- QN Valve Available Status DI From VFD and/or local disconnect
- WH Valve High Torque Alarm DI From motor operator
- ZH Valve Opened Status DI From limit switch
- ZL Valve Closed Status DI From limit switch

8B.10.10.7 Belt, Chain, Gear Driven Load I/O

Where a mechanical failure could provide a false positive run indication, monitor the following points. Examples of mechanical failure include but are not limited to: shear pin failure, chain disengagement, belt break, etc. The solution could include a proximity switch to sense driven load movement.

- MX Positive Confirmation Status DI

8B.10.10.8 Seal Water System I/O

Monitor the following points.

- PL Seal Water System Pressure Low Alarm DI

For each pump:

- MF Motor Overload Alarm DI From starter
- MN Motor Run Status DI From starter
- QN Motor Available Status DI From starter and/or local disconnect

8B.10.10.9 Air Compressor System I/O

Monitor the following points.

- PL Air Pressure Low Alarm DI

For each compressor:

- MF Motor Overload Alarm DI From starter
- MN Motor Run Status DI From starter
- QN Motor Available Status DI From starter and/or local disconnect

8B.10.10.10 Uninterruptible Power Supply I/O

Monitor the following points.

• XN	Battery Volts	AI	From UPS, via Ethernet
• XN	Input Volts	AI	From UPS, via Ethernet
• XN	Output Amps	AI	From UPS, via Ethernet
• XN	Battery Temperature	AI	From UPS, via Ethernet
• XN	UPS Communication Status	AI	From UPS, via Ethernet
• XN	Remaining Battery Runtime	AI	From UPS, via Ethernet
• XN	UPS Normal Status	DI	From UPS, hardwired or Ethernet
• XF	UPS Failure Alarm	DI	From UPS, hardwired or Ethernet
• XA	UPS on Battery Power Alarm	DI	From UPS, hardwired or Ethernet
• XL	UPS Battery Low Alarm	DI	From UPS, hardwired or Ethernet
• ZA	UPS in Bypass Mode Alarm	DI	From maintenance/bypass switch

8B.10.10.11 Hazardous Gas Monitoring I/O

Use hazardous gas detection (e.g., combustible gas, hydrogen sulfide, carbon dioxide, etc.) products with both analog signal and discrete alarm outputs. DDCS wants analog monitoring in order to detect and respond to rising gas levels before alarms are generated. Incorporate analog and discrete signals into the remote SCADA sites. Use contacts that are held closed under normal conditions and open when there is an alarm.

Monitor the following points for CO, CO2, H2S, LEL, O2 and other gases:

• XI	Gas Concentration	AI
• XA	Gas High (or Low) Level Alarm	DI

8B.10.10.12 PLC Panel I/O

Monitor the following points.

• ZA	PLC Panel Intrusion Alarm	DI
• JN	24 VDC Primary Power Supply In Use Status	DI
• JN	24 VDC Primary Power Supply Fail Alarm	DI
• JA	24 VDC Backup Power Supply In Use Alarm	DI
• JN	24 VDC Primary Power Supply Fail Alarm	DI

8B.10.10.13 Fire Alarm I/O

SCADA is not intended to monitor fire alarm systems/equipment which should be on a separate and dedicated system from SCADA. SCADA should monitor the fire alarm system at remote SCADA sites for informational purposes only. Use a contact that is held closed under normal conditions and opens when there is an alarm.

Monitor the following points.

• ZA	Fire Alarm System Common Alarm	DI

8B.10.10.14 Physical Security I/O

SCADA is not intended to monitor physical security alarm systems/equipment which should be on a separate and dedicated system from SCADA. SCADA should monitor the security alarm system at remote SCADA sites for informational purposes only. Use a contact that is held closed under normal conditions and opens when there is an alarm.

Monitor the following points.

- ZA Security System Common Alarm DI

8B.10.10.15 Facility HVAC I/O

Facility systems such as HVAC are not anticipated or desired to be on SCADA at this time. SCADA should only monitor this type of signal where there are specific hardwired interlocks to process equipment and DC Water Operations needs to know the reason for shutdown. Exceptions could include environmental monitoring of temperature or air quality.

Consult with DC Water Operations to determine if monitoring environmental conditions (e.g., ambient temperature) at a given remote site through SCADA would be beneficial.

8B.10.10.16 Power Monitoring I/O

Power monitoring transmitters shall be provided and connected to SCADA for the following power distribution locations:

- Incoming utility feeders.
- Primary and secondary sides of transformers
- Feeders to MCCs.
- Large equipment 75 hp and above.

The power monitor interface shall be an Ethernet-based connection/protocol that can be directly polled from Wonderware, another Schneider PLC, or an OIT without the need for additional hardware/software products.

Power monitors interface to SCADA shall provide current and voltage on each phase (RMS), power factor (set up to show negative on lagging PF), KW, KWH, and KVAR for each device.

Power monitors shall provide the I/O interface for breaker position status and alarm points such that SCADA will pick up these points through the power monitor rather than have separate hardwired connections to SCADA.

SCADA will also monitor 5KV and above transformers for alarms such as leak detection, oil level, cooling fan operation, high temp, high/low pressure and transformer monitor fail.

Power monitors shall be completely prewired and tested during the factory test prior to shipment to the jobsite and shall be included in the factory test results submission. Note that DC Water has standardized on “Shark 200” or later PMTs models.

8B.10.10.17 Automatic Transfer Switch I/O

Remote sites with a dual utility feed or on site generator shall require an ATS.

Monitor the following points.

- QN Normal Power Available Status DI
- JN Normal Power Connected Status DI
- QN Emergency Power Available Status DI
- JA Emergency Power Connected Alarm DI
- JF ATS Failure DI

8B.10.11 Control Hierarchy Guidelines

Equipment shall be designed such that control is only from one location at a time (i.e., Local at driven equipment, control from OIT in PLC panel, control from SCADA, or control from the equipment starter/local control panel.

Control at driven equipment or field will always take precedence from SCADA and disable SCADA control.

Safety for both personnel and equipment shall have priority over SCADA control.

All devices that transfer or allow control from SCADA shall be monitored by SCADA such that SCADA knows when it has control of the equipment. In some cases, such as control of chemical metering pumps or variable speed drives, separate hand switches will need to be provided for these signals.

Control Switches shall have the designation Hand-Off-Remote or Local-Remote, if control by SCADA. **Do not utilize Hand-Off-Auto nomenclature.**

For variable speed equipment provide separate control mode switches for start/stop and speed. No VFD speed control is required at the driven equipment.

In general, control outputs to driven equipment 20 hp and larger shall utilize separate momentary start and stop commands from SCADA. For equipment, smaller than 20 hp the designer may utilize either maintained outputs or momentary outputs to meet process and budgetary constraints.

Provide manual and automatic controls in accordance with the guidelines below:

Manual. Provide manual control as part of the prepackage equipment or at local control/backup panels. Provide start/stop lockout pushbuttons or switch at driven equipment if local/remote switch is remote from driven equipment. Provide an input to SCADA that indicates that SCADA has control of the equipment. This input must include status of all local/remote selector switches, the stop/lockout pushbutton, status of the breaker in the MCC or switchgear which feeds the equipment, and disconnect switch status. The interface to the PLC must be designed so that local controls are locked out when the L/R switch is in the remote position, and the PLC is locked out when the L/R switch is in the local position.

Automatic. Full automatic control is to be provided by the PLC and not duplicated in the field. Design device controls to be as simple and straightforward as possible.

Design the PLC and instrumentation systems for "fail-safe" control. If a PLC fails, all outputs are to remain unchanged, allowing the flows to be hydraulically self-regulated, and thereby maintaining process stability.

8B.10.11.1 Interlocks

Protective interlocks shall be hardwired into the electric circuit of equipment. Signals from protective sensors can be either discrete (contacts) or continuous signals and will have no controllable operator interface. All protective interlocks are to be wholly independent of all location modes of control signals. Equipment and personnel safety signals and interlocks should be hardwired between equipment and field devices.

Any signals that will shut down or alarm equipment should also be sent to SCADA so that SCADA knows the specific cause of the shutdown or alarm. Common alarms should be avoided, but if required, the designer should obtain specific approval from DC Water for using a common alarm to SCADA. DC Water may, at their discretion, approve common alarms separated by discipline (e.g., electrical, mechanical, instrumentation, etc.). Submit a list to DC Water that defines which equipment is latched and must be manually reset and what is not. Anything that causes shutdown should be latched.

8B.10.11.2 Local Control

Local control is accomplished at or in close proximity to a piece of equipment. Local control functions will include emergency shut-off as required by code; sufficient control for start-up, testing, maintenance and repair functions; and adequate provisions for manual operation in the absence of any higher-level control components. Emergency shut-off functions (e.g., mushroom pushbuttons, etc.) shall be hardwired directly to equipment starter circuits and monitored by the PLC system using separate contacts; ensure emergency shut-off functions and monitoring functions are failsafe.

Local/off/remote or start/stop control shall be provided within 25 feet of all motors controlled through SCADA. If the driven equipment is not in the same area as the motor, a stop/lockout switch shall be provided at the driven equipment. Open/close controls shall be provided in conjunction with all local/off/remote control for remotely operable gates and valves.

Panel lights shall incorporate a two-light system and red shall depict "run" or "open" flowing or energized function (assume ISA standard). Lights should only be provided for equipment whose run status cannot be verified visually, such as a submerged pump. Both the open and closed indicating lights will be lit when a motor operator gate or valve is in travel.

8B.10.12 Instrumentation and Control Valves

8B.10.12.1 General Instrumentation Requirements

It is beyond the scope of this document to list complete requirements for instrumentation and control valves. Reference material regarding best-practices is widely available from reputable organizations. The designer is expected to design and specify instrumentation that ensures accuracy, reliability, a long service life, and maintainability.

Always follow manufacturer application and installation recommendations for instrumentation and control valves.

Confirm that process contact materials are compatible with the process contact fluid. Confirm that devices are rated appropriately for the environment in which it will be installed.

8B.10.12.2 Equipment Selection and Sizing Calculation Requirements

See subsection 1.3, Calculation Requirements, in Section 1, General, of this volume. Basic requirements specific to the instrumentation discipline follow. The quality of a control system's operation depends on the proper application and sizing of the primary elements and process equipment.

Size the elements properly to provide a reliable system operation over the operating range. Calculations for flow meters, control valves, variable-speed controlled equipment, chemical feed equipment, and other pertinent equipment shall be done for minimum, average, and maximum operating conditions. In addition, these calculations (min/avg/max) must be done and presented for start-up flows and conditions as well as the ultimate design flows and conditions. Specifically, equipment needs to be sized for a range that is bounded by minimum condition at start-up and maximum or peak condition at ultimate design. As much of the equipment operates in a range of minimum to average conditions, DC Water requires equipment to be sized to be economically and accurately operated in this range. Peak conditions generally occur with storm events, which are experienced a small percentage of the time.

Evaluate whether to make provisions for future replacement/upgrade of the equipment (upsizing when design conditions are met), provide more units that can total up to the future peak requirements, or operate at reduced accuracy and control. The evaluation and impacts to DC Water will be specifically discussed and agreed to with DC Water. The evaluation shall include operating costs such as energy and chemical consumption when equipment is oversized and can’t provide the turn-down needed for minimum conditions at start-up.

8B.10.12.3 Instrument Locations

Instruments should be located in an accessible, dry location not exposed to corrosive elements. The proper location of instruments will allow a long, useful life and will greatly assist in the routine maintenance of the instruments.

Locate instruments such that the instrument is protected from adverse conditions and not exposed to corrosion. Avoid installations where an instrument could accidentally be submerged, damaged by passing vehicles, or dripped upon. Provide for installation of instruments in areas adjacent to normal operator travel to allow casual viewing of the local indicator to confirm proper operation. Use intrinsically safe instruments in a potentially explosive environment. Control panels and cabinets shall be NEMA 4X 316 stainless steel (fiberglass for chemical resistance is appropriate). Control panels and cabinets shall not be installed in hazardous areas. Use sun shields on all outdoor enclosures (e.g., control panels, cabinets, and instruments, etc.) with direct exposure to the sun.

8B.10.12.4 Flow Meters

Perform standard sizing calculations for flow meters and provide design criteria. The calculations will verify Reynolds Number, differential at minimum and maximum flows, and the head loss for venturi meters. Calculate velocities at minimum and maximum flows for both start-up conditions and ultimate design conditions.

Piping and flow meter placement shall be designed to maintain a full pipe under all conditions; whenever possible, flow meters should be installed in a vertical pipe. Flow meters shall be installed in the main pipe, not in a bypass to avoid inaccuracies and additional head loss associated with tees and elbows associated with the bypass.

Magnetic flow meters may be used for water. Size magnetic flow meters to maintain a minimum velocity of 3 feet per second. Maximum velocity shall not exceed 25 feet per second. The meter should be a DC type with a 4-20mA output for input to SCADA.

Venturi meters may be used for water lines. Venturi flow meters should be installed in a horizontal pipe and provided with an auxiliary set of taps for a manometer. Venturis used in other than potable water or air service must have sealed pressure sensors.

All flow meters wetted parts shall be compatible with fluid being measured.

For differential pressure devices used in flow applications, provide integral square root extraction at the meter for non-compressible fluids. For compressible fluids such as air, square root extraction will occur within SCADA. Designer is responsible for specifying instrument specific formulas for converting differential pressure to actual flow when conversion is performed within SCADA.

8B.10.12.5 Level Measurement

Use ultrasonic level transmitters for wetwell level measurement. For open channel level measurement, use acoustic transmitters or submerged pressure sensors. Design level transmitters such that any transmitter faults such as loss of echo or near zone alarm conditions cause the transmitter output and any associated alarms to fail to an alarm condition. All alarms shall be transmitted to SCADA and follow the alarm priorities identified in these guidelines. For example, an ultrasonic level transmitter and associated high level associated with a tank should fail high and the high level alarm actuate on loss of echo.

Bubbler systems may be used for level measurement in indoor applications only. In the installation, include provisions for rodding out the tube through the clean out tee and for blowing out the tube with a 40-psig-air source. The tube should be fabricated of 1/2-inch 316 stainless steel tubing and cut with a v-notch at the base. The tube should extend into the wet well to a depth of 6 inches above the bottom.

For level measurement applications, where high-high or low-low level could result in equipment damage, a permit violation or endanger personnel safety, provide an independent backup, such as a float switch for the equipment, protective interlocks, and redundant alarm functions as required.

8B.10.12.6 Analytical Measurements

When installing probes in tanks, provide enough interconnecting cable to allow removal of the probe for calibration and for positioning the probe in different locations within the tank. Discuss maintenance requirements and probe mounting details with DC Water.

8B.10.12.7 Temperature Measurement

For temperature measurements, use resistance thermal devices (RTDs) whenever possible. All temperature elements shall be installed in wells. Provide a simple means for removal of RTD for calibration and maintenance. Convert resistance to a 4-20 mA dc signal as near to the sensor as practical. Use 4-20 mA dc local indication and input to the computer system.

Provide analog temperature monitors in all facility electrical rooms for input to SCADA.

8B.10.12.8 Pressure Measurement

Use strain gage, resonant wire or capacitance-type pressure transducers. Output signals shall be 4-20 mA dc. Provide block and bleed manifolds with manometer taps for calibration and maintenance. Wherever possible, use flange-mounted units with a large area diaphragm. Provide a flushing connection, if suitable.

8B.10.12.9 Control Valves

Check all modulating control valves for the following criteria for both start-up conditions and ultimate design conditions, during design:

- Position at low flow (maximum required head loss).
- Position at maximum flow (minimum required head loss).
- Verification that cavitation is not present during operational range.
- Motor operator size.
- Performance when close-coupled to a venturi flow meter.
- Wiring and communication requirements.

Most applications for modulating control valves can be performed with butterfly valves. If a tight shut-off is required on a sewage line, use a plug valve. Large control ranges may require specialty valves. Whenever possible, mount the valve at floor level, or as a minimum, provide remote-mounted electric pushbutton stations and maintenance platforms for maintenance.

Coordinate with instrumentation which could affect control valve operation.

8B.10.12.10 Actuators

Define which valves and gates will be motor operated, location/requirement for remote control stations, and interface to SCADA. Actuators shall be designed and rated for the expected service (i.e., continuous modulating). All controls shall be accessible and viewable without climbing over anything or requiring special equipment such as harnesses or ladders.

8B.10.13 Control Areas and Environments

DC Water has very high corrosion rates in areas of the water distribution and collection systems. The design shall include suitable protection for instruments and equipment such as:

- Place all electronic equipment inside a control room where possible.
- Conformal Coating of circuit boards.
- Sealed or encapsulated enclosures.
- H2S scrubbers and air conditioners on sealed cabinets. Desiccants are not an alternative for purifying air.
- Tinned copper wires for control wiring.
- Equipment shall be located above flood levels for the site, where possible.

Each project should include a review of exiting site conditions as well as an interview with DC Water operations staff to determine if there are ongoing environmental issues (e.g., high room temperatures, flooding, gases, etc.) that could result in an operational failure. Issues and proposed solutions should be presented to DC Water to determine if a change of scope is warranted.

Construction sequencing shall be specified to require that environmental controls are operational in SCADA equipment areas prior to equipment arriving on site. SCADA equipment shall be stored in environmentally controlled areas that meet the requirements of this section.

The control centers and SCADA equipment rooms will contain computer equipment. To protect the hardware from corrosion damage due to sulfide and chloride exposure, temperature stress, and humidity-related problems, the conditions indicated in the Tables 2-8-5 through 2-8-6 will be required:

Table 2-8B-5. Requirements for Rooms Containing Control Equipment

Type Of Exposure	Rate
Sulfide Exposure	
Average	1.0 ppm
Maximum	10.0 ppm for 1 hour
Chloride Exposure	
Average	1.0 ppm
Maximum	10.0 ppm for 1 hour
Temperature	
Average	80°F
Maximum	85°F
Minimum	75°F
Maximum rate of change	10°F per hour

Table 2-8B-6. Required Room Air Quality Environment

Temperature: 65-75 degrees F <5 percent rate of change per hour.
Relative Humidity: 40-60 percent, non-condensing <6 percent rate of change per hour.

Contaminant	Concentration	Class/ Severity*
Liquid Aerosols:		
Oils	<5 g/kg	LB1
Solids: Particle Size		
> 1 mm	$<100/m^3$	SA1
100 to 1000	$<100/m^3$	SB1
1 to 100	$<100/m^3$	SC1
< 1	$<100/m^3$	SD1
Gases: Mild	<300 angstroms film formation on copper coupon after one month exposure	G1
H_2S	$<3mm^3/m^3$	G1
SO_2, SO_3	$<10mm^3/m^3$	G1
Cl_2	$<1mm^3/m^3$	G1
NOx	$<50mm^3/m^3$	G1
Mercaptans	$<10mm^3/m^3$	G1

Contaminant	Concentration	Class/ Severity*

Notes:
< is defined as "less than"
> is defined as "more than"
≥ is defined as "greater than or equal to"
1.0 g/kg = 1.0 part per billion ($p/10^9$)
mm^3/m^3 = cubic millimeters per cubic meter
* See ISA Standard S71.04-1985

8B.10.14 Power Monitoring

Use DC Water standard devices for power monitoring (obtain from DC Water Program Manager and/or DC Water DETS. Standard devices are compatible with SCADA without additional programming.

8B.10.15 Reliable Power

At Water & Sewer Pumping Stations, power shall be supplied to the control and communications equipment including PLCs using battery powered UPS. In all cases UPS shall provide 4 hour backup minimum, include static bypass and network management card.

As directed by DC Water, new designs shall include dual facility power feeds connected through an ATS switch. All remote SCADA sites not equipped with dual power feeds or an onsite backup generator shall have a connection for a portable generator and appropriate manual transfer switch for emergency power to critical local equipment, including all SCADA equipment. Ensure that the generator/transfer switches are configured to power the SCADA UPS and that the UPS provides conditioned/regulated 120VAC power to the SCADA equipment regardless of generator line voltage/frequency. The manual transfer switch shall include an approved mechanical interlock to prevent back-feeding the utility feeder. Ensure all applicable safety standards are addressed.

Coordination with electrical designer regarding dual power feeds and ATS shall be performed, as well as, consultation with owner for UPS manufacturer preferences.

8B.10.16 Wiring

Splicing is not allowed for any type of control, signal, or communications cabling.

For analog instrumentation wiring, use stranded, tinned copper conductors, size no. 16 American Wire Gauge (AWG) minimum twisted shielded pair (TSP). Generally, TSP wiring should have 300V insulation unless there is a special need to use higher voltage insulation. TSP wiring with 600V insulation should be used in motor control centers and VFDs, as needed.

For power and control wiring, use 600-volt, type cross-linked polyethylene high heat-resistant water resistant (XHHW). For conductors, use stranded copper rated not smaller than size no. 12 AWG for power wiring and not smaller than 14 AWG for control wiring.

Signal shields for a control loop shall be grounded at one location only. In general, the signal shields shall be grounded at the PLC/RIO cabinet.

PLC control panels shall include an isolated bus bar for instrument ground isolation.

See Section 9, Electrical, for additional details.

8B.10.17 Surge Protection

Surge protection for power, communication, and I/O shall be required on any wiring extending beyond the confines of a building, exposed outdoors, or in underground duct banks. Size PLC panels as needed to account for the additional space needed for surge protection devices.

8B.10.18 Analog Loop Isolators

Do not use analog loop isolators unless absolutely required. If loop isolators are required, only use loop powered isolators where loop power is supplied from a UPS-backed DC power supply in the PLC cabinet. Use 1-5VDC signals tapped from existing inputs to avoid ground loops where two device inputs share a grounded (-) terminal; for example, a chart recorder and PLC in close proximity. Do not use voltage signals where the cable length will exceed 25 feet.

Valid uses of analog loop isolators include:

- Solve a ground loop issue.
- Convert 4-20 mA to a non-standard format for legacy field equipment (e.g. 0-10 VDC for VFDs, etc.).

All other uses must be approved by DC Water.

8B.10.19 Interposing Relays

Do not use interposing relays unless absolutely required. Use available dry contacts in field equipment and enclosures to the extent possible. Add new contacts to existing devices wherever possible.

If interposing relays are required, they shall only be installed in the field panel where the signal source originates and should be powered from the same voltage source as the device being monitored. For example:

- A relay installed across a pilot light in a field panel to monitor a certain process condition
- A relay installed (for run status monitoring) across a legacy motor starter with no available run contacts and no way to add more run contacts.

Do not use interposing relays where a power loss in the field would cause the relay to produce a false-positive or false-negative signal relative to the originating contact directly monitoring the process.

Do not use interposing relays for inputs to the SCADA system to be used for alarming. Ensure all alarm inputs are normally-opened held-closed (NOHC) under normal process conditions.

Include a surge suppression diode across all DC relay coils.

8B.10.20 Instrument and Control Panel Lineups

Locate PLC panels in areas, such as electrical rooms, that meet the environmental guidelines of this section.

Coordinate environmental requirements with the HVAC engineer.

Provide large enough openings to buildings and rooms to allow equipment access after buildings are constructed.

Coordinate with the electrical engineer for proper power conditioning requirements.

Coordinate with the structural and architectural engineer for raised floors in control centers.

Coordinate with the mechanical engineer if special fire protection is required in area control centers.

Permit future expansion by allowing for at least a 25% percent increase in PLC panel space requirements.

8B.10.21 SCADA System Control Panel Ratings

There are three basic requirements for control panel selection:

- Do not install control panels in environments that will cause corrosive damage (for whatever reason) to internal components.
- Use NEMA 4X stainless steel enclosures for control panels. Do not install control panels in environments where another NEMA rating would be more suitable (e.g., submersion, etc.).
- NEMA 12 enclosures may be used instead of NEMA 4X in control room environments that are clean and environmentally controlled.

Where these conditions cannot be met, make a recommendation to DC Water on how to proceed; do not proceed without the approval of DC Water.

8B.10.22 Field Testing

Take the following into account in developing the contract documents and construction/testing sequence.

a. Specifications shall require that all equipment be calibrated; communications testing completed, and have point to point testing completed prior to performing Witnessed Combined Loop Test (WCLT).

b. Point to Point tests shall show that data is properly transferred between the field device and the PLC memory.

c. Communications test reports shall show confirmation that PLC interfaces to OITs, PMTS, and other electronic devices properly transfer values to and from the correct PLC memory locations.

d. Field Calibration Reports that meet the requirements under Maintenance and Calibration. Field Calibration Reports shall be in accordance with sample calibration sheet in Appendix O.

e. Witnessed combined loop testing shall be provided to show proper operation between field device and graphics (on both the OIT and SCADA). Witnessed Combined Loop testing shall be for complete “Systems” as defined by the contract “systems test grouping.” Communications test reports, and Point-to-Point test results shall be submitted with the WCLT request. WCLT request shall include a list of I/O points to actually be tested and shall be submitted at least one week prior to requested test date. If any part of the “system test grouping” fails that requires rewiring of controls or PLC programming, then the entire “system test group” WCLT shall be retested. Specifications shall define system test grouping and testing details.

Design documents shall specify all testing requirements needed for each project as determined by the Engineer. General guidelines are provided below.

All tests should include DC Water representatives from relevant departments (e.g., engineering, operations, maintenance, etc.). All tests should include a sign-off to indicate these representatives have witnessed the test and accept (or reject) the results.

The designer shall take the following into account in developing the contract documents and construction/testing sequence.

a. Specifications shall require that all equipment be calibrated; communications testing completed, and have point to point testing completed prior to performing Witnessed Combined Loop Test (WCLT).
b. Point to Point tests shall show that data is properly transferred between the field device, PLC, HMI, and OIT.
c. Communications test reports shall show confirmation that PLC interfaces to OITs, PMTS, and other electronic devices properly transfer values to and from the correct PLC/HMI/OIT locations.
d. Field Calibration Reports that meet the requirements under Maintenance and Calibration. Field Calibration Reports shall be in accordance with sample calibration sheet in Appendix O.
e. Witnessed combined loop testing shall be provided to show proper operation between field device and graphics (on both the OIT and SCADA). Witnessed Combined Loop testing shall be for complete "Systems" as defined by the contract "systems test grouping." Communications test reports, and Point-to-Point test results shall be submitted with the WCLT request. WCLT request shall include a list of I/O points to actually be tested and shall be submitted at least one week prior to requested test date. If any part of the "system test grouping" fails that requires rewiring of controls or PLC programming, then the entire "system test group" WCLT shall be retested. Specifications shall define system test grouping and testing details.

See Appendix O for "Sample Testing Documents."

8B.10.22.1 Factory Acceptance Testing (FAT)

The System Integrator shall demonstrate the following during the FAT:

- The power, communication, and I/O in control panels are wired according to approved submittals.
- All equipment is connected in the same manner it will be at startup.
- The equipment works and performs in accordance with the design documents
- The HMI (e.g., graphics, alarms, trends, alarm notification, etc.) for the SCADA system and OIT are configured correctly.
- Inputs manipulated at PLC panel field terminal strips result in the correct changes in the HMI and OIT.
- Outputs manipulated in the HMI and OIT result in expected changes at the PLC field terminal strip.
- Signal continuity between the HMI, PLC memory, and field terminal strip performs in a predictable and repeatable manner.
- Control strategies programmed into the PLC/HMI perform according to specification.
- The system is ready for installation in the field. Therefore, all issues encountered at startup will most likely be field wiring issues.

The demonstration shall be observed by DC Water. The FAT shall be conducted using the same products to be installed in the field as part of the project; substituting equipment is prohibited.

8B.10.22.2 Site Acceptance Testing (WCLT)

The System Integrator shall demonstrate the following during the Witness Combined Loop Test (WCLT):

- The power, communication, and I/O to/from control panels are wired according to approved submittals and the contract documents.
- The equipment is installed, functions, and performs in accordance with the contract documents.
- HMI, OIT, and PLC monitoring matches verified field conditions when process equipment is manipulated in the field.
- HMI, OIT, and PLC outputs control target field equipment as required when manipulated from the HMI, OIT, and PLC.
- Control strategies programmed into the PLC/HMI perform in accordance with the specifications.
- The SCADA System additions (e.g., graphics, alarms, trends, alarm notification, historian, reports, communications, UPS, etc.) are proven to be working correctly.
- The system is ready for reliable operational use by DC Water.

The demonstration shall be observed by DC Water. The Systems Integrator shall perform pretesting to ensure readiness for the WCLT. Upon completion of pretesting, the Systems integrator shall send a request for WCLT to DC Water. The Systems Integrator shall complete a WCLT Report upon completion of the WCLT. See Appendix O for examples of WCLT Request and WCLT Report documents.

8B.10.23 Maintenance and Calibration

Locate instruments such that routine maintenance does not require ladders or placement of personnel outside of protective handrails. As much as possible, locate transmitters inside to allow calibration during inclement weather. Gate and valve design documents shall specifically identify where remote mounted controls and indication are required and how oriented.

Instruments should be specified to be certified by the manufacturer as being installed and calibrated in conformance with both the design specifications and the manufacturer's requirements. All certifications and calibration reports shall be submitted to DC Water and be part of the O&M manuals and as part of commissioning reports.

8B.10.23.1 Calibration Reports

Field calibration or confirmation shall be provided that show proper calibration over the full range of the instrument or equipment with values at 4 ma and 20 ma or actual instrument output. In addition, test over (101%) and under range (-1%) and document results on the Calibration Report. Calibration reports shall show both the direct measured variable as well as corresponding process variable in process units (i.e., show differential pressure input as well as corresponding flow for differential range or actual pump speed corresponding to the 0-100% speed range). Calibration report shall show calculated readings as well as actual feedback and calculate the error. All flow meters using differential pressure measurement shall show anticipated dp reading to flow charts. Calibration reports for discrete points shall show action in both the rising and falling directions as well as set and reset characteristics of the instrument. All calibration reports shall be provided as part of the submittal process prior to WCLT. This will tie into the commissioning specification and construction sequencing. Specifications shall indicate minimum list of requirements that is required in loop test. Specifications shall state that all work must be completed before loop test and no changes are allowed during the loop test.

Refer to Appendix O for sample Calibration Reports.

8B.10.23.2 Loop Drawings and Electrical Wiring

Specifications shall include requirements for complete loop drawings to be provided for all equipment. The drawings shall be complete from final field instrument to PLC panel terminations or control panel terminations including routing through all panels on one loop drawing. See sample loop drawing in Appendix N.

Specifications shall require complete documentation of all wiring for control systems; modification of the documentation to reflect as-built conditions; and verification of the documentation in the field.

A copy of the final as-built PLC panel schematics and wiring diagrams shall be specified to be provided in pockets in each panel with a sign that indicates “Do Not Remove” within the panel. An electronic copy of loop drawing shall be inserted in the SCADA service manuals provided by the Contractor.

Specify that all documentation be provided in a searchable, electronic format meeting the requirements for DC Water document management system.

8B.10.23.3 Test Connections and Bypasses

All instruments that require routine calibration testing, such as pressure transmitters, will be furnished with suitable manifolds, fittings and valves such that a test gage can be easily installed without requiring the shutdown of the process or interruption of the measurement and its transmission to other process instruments. To perform routine maintenance, it should not be necessary to break any permanent piping or electrical connections.

8B.10.23.4 Pressure and Differential Pressure Transmitters

Provide all differential pressure transmitters with a minimum of a three-valve manifold to allow zeroing of the transmitter. Provide manometer taps and isolation valves for all differential pressure transmitters used for flow applications.

Provide all pressure transducers with manifold, shutoff valves and a fitting to which a pressure gage can be attached.

Provide suitable pulsation dampers and isolation seals for the test point.

8B.10.23.5 Current Loops

Provide all current loops with an easily accessible point at which a signal simulator can be placed into the loop.

8B.10.23.6 Analyzers

All analyzers shall be removable from the process lines without disruption of process.

Note that the SCADA system currently measures one or more of the following parameters at several water distribution sites: Chlorine, pH, Temperature, Turbidity, ORP, and Conductivity. Instrumentation is connected to a Honeywell Multi-Trend Paperless Recorder as the interface to SCADA.

Consult with DC Water operations for project specific monitoring requirements.

8B.11 SCADA NAMING CONVENTIONS

The purpose of naming conventions is to promote the consistent implementation of vendor hardware and software products throughout the DC Water SCADA System. Consistent use of naming conventions within the Wonderware HMI will result in a more user-friendly and understandable SCADA interface for DC Water operations staff. This consistency is also the key to significantly expanding the SCADA system with minimal effect on operations.

Three naming conventions are provided at the end of this section: I/O Point Naming, Site Naming, and PLC Naming. Each naming convention is a unique combination of certain consistently applied naming convention components (i.e., abbreviations and descriptions). There are six naming convention components presented in this section: Systems, Site Class, Site Name, Asset, Loop Number, and Attribute.

The following I/O point naming example is provided as an introductory high level overview of the naming convention components and general approach that will be used with all naming conventions.

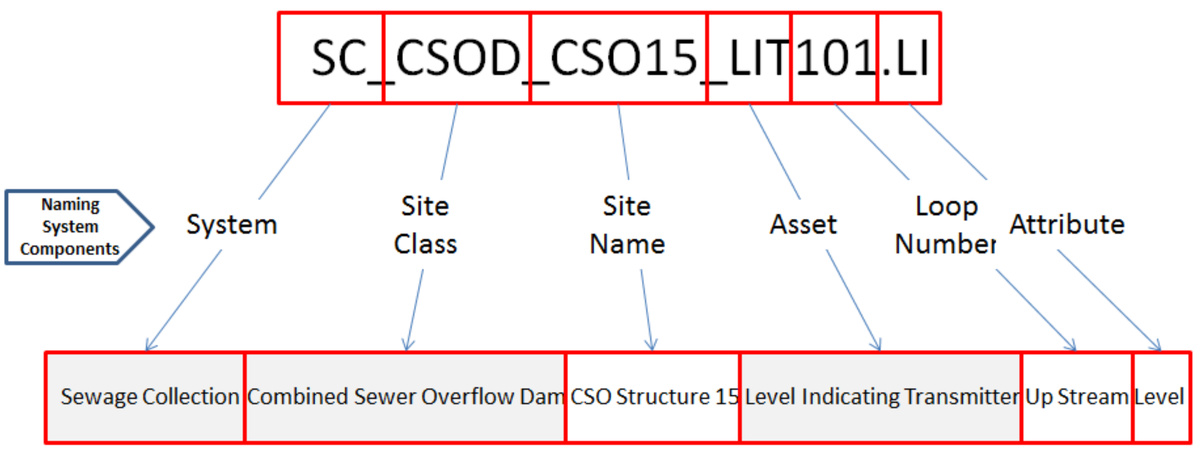

Figure 2-8B-2. I/O Naming Convention Example

There is a practical limit to the length of descriptions used in the Wonderware SCADA system because long descriptions are difficult to fit on reports and difficult to read on alarm screens. As a result, the I/O point description used in the Wonderware SCADA system includes only the Site Name, Loop Number, and Attribute, as shown below. The description at the bottom is what an operator will see in the Wonderware SCADA system.

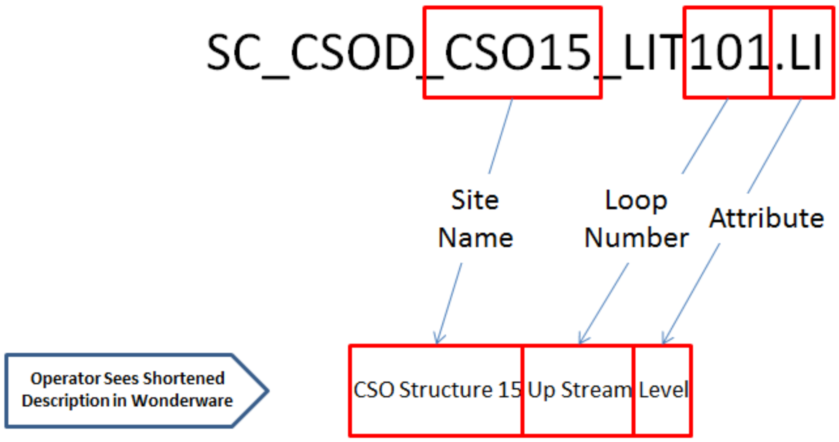

Figure 2-8B-3. I/O Naming Convention Example, Shows Wonderware Description

The remainder of this section describes and defines or provides examples of each naming convention component.

8B.11.1 Component 1 – Systems

System Abbreviation – The System Abbreviation is used to assign a tag to one of three high level DC Water organizational areas served by the SCADA System.

System Description – The System Description is used to describe the System Abbreviation.

These are both coordinated with the DC Water Asset Management Program.

Table 2-8B-7. System Prefixes and Descriptions

System Abbreviation	System Description
SC	Sewage Collection
SW	Stormwater
WD	Water Distribution

8B.11.2 Component 2 – Site Classes

Site Class Abbreviation – The Site Class Abbreviation is used to assign a tag to a collection or distribution site function.

Site Class Description – The Site Class Description is used to describe the Site Class Abbreviation.

These are unique to SCADA and NOT coordinated with the DC Water Asset Management Program. Most of these are consistent with existing documents related to SCADA.

Table 2-8B-8. Site Class Prefixes and Descriptions

System Abbreviation	Site Class Abbreviation	Site Class Description
SC	CSO	Combined Sewer Overflow
SC	CSOD	Combined Sewer Overflow Dam
SC	OCF	Odor Control Facility
SC	RL	River Lights
SC	SMS	Sewage Metering Station
SC	SPS	Sewage Pump Station
SC	SSF	Sewage Swirl Facility
SW	SWPS	Stormwater Pump Station
WD	WET	Water Elevated Tank
WD	WPM	Water Pressure Monitor
WD	WPS	Water Pump Station
WD	WR	Water Reservoir

8B.11.3 Component 3 – Site Names

Site Abbreviation – The Site Abbreviation is a unique mnemonic assigned to each SCADA site

Site Abbreviation Description – The Site Abbreviation Description is used to describe the Site Abbreviation.

These are both coordinated with the DC Water Asset Management Program.

Table 2-8B-9. Site Abbreviations and Descriptions

System Abbreviation	Site Class Abbreviation	Site Abbreviation	Site Abbreviation Description
SC	CSO	CSO2	CSO Structure 02
SC	CSOD	CSO14	CSO Structure 14
SC	CSOD	CSO15	CSO Structure 15
SC	CSOD	CSO15A	CSO Structure 15A
SC	CSOD	CSO16	CSO Structure 16
SC	CSOD	CSO24	CSO Structure 24
SC	CSOD	CSO34	CSO Structure 34
SC	CSOD	CSO35	CSO Structure 35
SC	CSOD	CSO52	CSO Structure 52
SC	OCF	PI27	Potomac Interceptor Site 27
SC	OCF	PI95	Potomac Interceptor Site 1995
SC	RL	FM35	River Lights Flow Meter 35
SC	RL	FM9	River Lights Flow Meter 9

System Abbreviation	Site Class Abbreviation	Site Abbreviation	Site Abbreviation Description
SC	SMS	BCF	8th & Chesapeake Flume
SC	SMS	BRF	Belt Road Flume
SC	SMS	IHF	Indian Head Flume
SC	SMS	ORF	Oxon Run Flume
SC	SMS	OXF	Oxon Run Flume
SC	SMS	SPF	Suitland Parkway Flume
SC	SMS	VDF	Valley Drive Flume
SC	SMS	WBF	Watts Branch Flume
SC	SPS	3C	3rd & Constitution Pump Station
SC	SPS	EP	Earl Place Pump Station
SC	SPS	ES	East Side Pump Station
SC	SPS	MP	Main Pump Station
SC	SPS	OS	O Street Pump Station
SC	SPS	PO	Potomac Pump Station
SC	SPS	PP	Poplar Point Pump Station
SC	SPS	RC	Rock Creek Pump Station
SC	SPS	UA	Upper Anacostia
SC	SSF	NB	Northeast Boundary Swirl Facility
SW	SWPS	1C	1st & Canal Street Southwest Pump Station
SW	SWPS	1D	1st & D Street Southwest Pump Station
SW	SWPS	9D	9th & D Street Southwest Pump Station
SW	SWPS	9M	9th & Madison Avenue Northwest Pump Station
SW	SWPS	BR	14th Street Bridge Pump Station
SW	SWPS	CP	12th & Constitution Stormwater Pump Station
SW	SWPS	DA	Deane Avenue Pump Station
SW	SWPS	EA	Eastern Avenue Pump Station
SW	SWPS	KA	Kenilworth Ave Pump Station
SW	SWPS	KS	26th & K Street Northwest Pump Station
SW	SWPS	MS	12th & Maine Avenue Pump Station
SW	SWPS	NH	New Hampshire & Virginia Avenue Pump Station
SW	SWPS	PS	Portland Street Pump Station
SW	SWPS	SC	Scott Circle Pump Station
SW	SWPS	TC	Thomas Circle Pump Station
SW	SWPS	VA	23rd & Virginia Avenue Northwest Pump Station
WD	WET	AT1	Anacostia Elevated Tank 1
WD	WET	AT2	Anacostia Elevated Tank 2
WD	WPM	RPOS	Remote Pressure Monitoring O Street Pumping Station

System Abbreviation	Site Class Abbreviation	Site Abbreviation	Site Abbreviation Description
WD	WPM	RPPO	Remote Pressure Monitoring Potomac Pumping Station
WD	WPS	AL	16th & Alaska Pump Station
WD	WPS	AP	Anacostia Pump Station
WD	WPS	BS	Bryant Street Pump Station
WD	WPS	FR	Fort Reno Pump Station
WD	WR	FRR2	Fort Reno Reservoir 2
WD	WR	FSR1	Fort Stanton Reservoir 1
WD	WR	FSR2	Fort Stanton Reservoir 2
WD	WR	SHR	Soldiers Home Reservoir

8B.11.4 Component 4 – Assets

Asset Abbreviation (Device) – The Asset Abbreviation is (ideally) obtained from the P&ID drawings. It is the physical field device itself (not the I/O) where a SCADA input signal originates or an output signal terminates. The physical field device usually has multiple monitoring and control I/O points. For example, a "motor asset" commonly has Motor Run, Motor Fail, Motor C/L, Motor Start, and Motor Stop discrete I/O.

This asset abbreviation must adhere to common ISA practices to the extent possible. In cases where no such designation exists, one must be created; see entries with an asterisk below. Creation of all new abbreviations must be approved by the DC Water SCADA Group. The abbreviation must be added to the table below and periodically disseminated to all concerned parties by the DC Water department maintaining these guidelines.

Asset Abbreviation Description – The Asset Abbreviation Description is used to describe the Asset Abbreviation.

Table 2-8B-10. Asset Examples and Descriptions

Asset Abbreviation (ISA Device)	Asset Abbreviation (Other Device)	Asset Abbreviation Description
	24VDC *	DC Power Supply
AIT		Analytical Indicating Transmitter
	ATS *	Automatic Transfer Switch
	C *	Compressor
	COMM *	Communication System
FIT		Flow Indicating Transmitter
FSL		Low Flow Switch
	G *	Generator
LIT		Level Indicating Transmitter

Asset Abbreviation (ISA Device)	Asset Abbreviation (Other Device)	Asset Abbreviation Description
LSH		High Level Switch
LSHH		High High Level Switch
	M *	Motor
	MCC *	Motor Control Center
	P *	Pump
PIT		Pressure Indicating Transmitter
	PLC *	Programmable Logic Controller
	PMT *	Power Monitoring Transmitter
PSH		High Pressure Switch
PSLL		Low Low Pressure Switch
	S *	Drainage Sump
	SCN *	Screen
	SEC *	Physical Security System
TSH		High Temperature Switch
TSL		Low Temperature Switch
	UPS *	Uninterruptible Power Supply
	V *	Valve
	VFD *	Variable Frequency Drive
ZIT		Position Indicating Transmitter

8B.11.5 Component 5 – Loop Number

NOTE: This section (8B.11.5) contains material that needs to be verified/updated by DC Water prior to use.

Loop Number – The Loop Number is the ISA Loop Number obtained from the I/O Point List. It is the right-most numerical part of a typical ISA tag (e.g. 100 for A1LI100, 101 for A1MN101, 102 for A1MF102, etc.). The Loop Number is unique to a sub-system, physical field device, or process measurement point at a SCADA site. The Loop Number may also be obtained from P&IDs, loop drawings, and control panel I/O drawings in a well-coordinated design and implementation.

Some **EXAMPLE Loop Numbers** are given in the table below. Note that these vary widely in the existing system. The table below does not imply these loop numbers are part of an existing standard.

NOTE: The **"Loop Number"** together with the **"Asset"** (described in the previous section) form what Wonderware regards as the "Object" in the **"Object.Attribute"** approach used by the ArchestrA platform. So, "M101" would be a fully developed **Object** representing the motor associated with Pump 1, based on the table below.

Loop Number Description – The Loop Number Description is used to describe the unique sub-system, physical field device, or process measurement point.

Table 2-8B-11. Loop Number Examples and Descriptions

EXAMPLE Loop Number	EXAMPLE Loop Number Description
100	Wetwell
101	Pump 1
102	Pump 2
103	Pump 3
200	Seal Water System
201	Seal Water Pump 1
202	Seal Water Pump 2
300	Air Compressor System
301	Air Compressor 1
302	Air Compressor 2
400	Sump Pump System
401	Sump Pump 1
402	Sump Pump 2
501	Switchgear Feeder 1 Breaker
502	Switchgear Feeder 2 Breaker
540	Automatic Transfer Switch
575	UPS
901	PLC System
950	Communication System

8B.11.6 Component 6 – Attributes

Attribute Abbreviation – The Attribute Abbreviation is the ISA Instrument Abbreviation obtained from the I/O Point List. It is the 2-3 character abbreviation middle part of a typical ISA tag (e.g., LI for A1LI100, MN for A1MN101, MF for A1MF102, etc.). The ISA Instrument Abbreviation may also be obtained from P&IDs, loop drawings, and control panel I/O drawings in a well-coordinated design and implementation.

Some **EXAMPLE Attribute Abbreviations** are given in the table below. Note that these vary widely in the existing system. The table below does not imply these instrument abbreviations are part of an existing standard.

NOTE: The **"Loop Number"** together with the **"Asset"** (described in the previous section) form what Wonderware regards as the "Object" in the **"Object.Attribute"** approach used by the ArchestrA platform. The Attribute Abbreviation (or ISA Instrument Abbreviation) described above is the **Attribute** part of the **"Object.Attribute"** approach used by the ArchestrA platform. So, "M101.MN" would be a fully developed object.attribute representing the run status of the motor associated with Pump 1, based on the table below and the example in the previous section.

Attribute Description – The Attribute Description is used to describe the Attribute Abbreviation.

Table 2-8B-12. Attribute Examples and Descriptions

EXAMPLE Attribute Abbreviation	EXAMPLE Attribute Description
FI	Flow Rate
FQ	Flow Total
LI	Level
MBF	Fail To Stop
MDF	Fail To Start
MF	Motor Fail
MN	Motor Run
PI	Pressure
PL	Pressure Low
TH	Temperature High
TL	Temperature Low
YN	In Computer

8B.11.7 I/O Point Naming Convention

In Wonderware, an I/O point "tag" is the combination of System, Site Class, Site Abbreviation, Asset Abbreviation, Loop Number, and Attribute naming components described previously. The I/O point tag description is the combination of Site Abbreviation, Loop Number, and Attribute descriptions associated with the naming component abbreviations.

This naming convention coordinates with the DC Water Asset Management program to the extent that is practical. It also takes into account that the existing system (e.g., instrument engravings, wire labels, PLC programming, OIT programming, record drawings, as-built documentation, etc.) makes heavy use of common ISA tagging conventions and this naming convention includes a way to link the Wonderware object.attribute model to the existing ISA tagging convention used throughout the SCADA system. It also takes into account that ISA tagging is expected to continue indefinitely as engineers develop new P&IDs and I/O Point Lists. In other words, it is a way to make Wonderware conform to long standing control system engineering practices that are unlikely to change, nor should they.

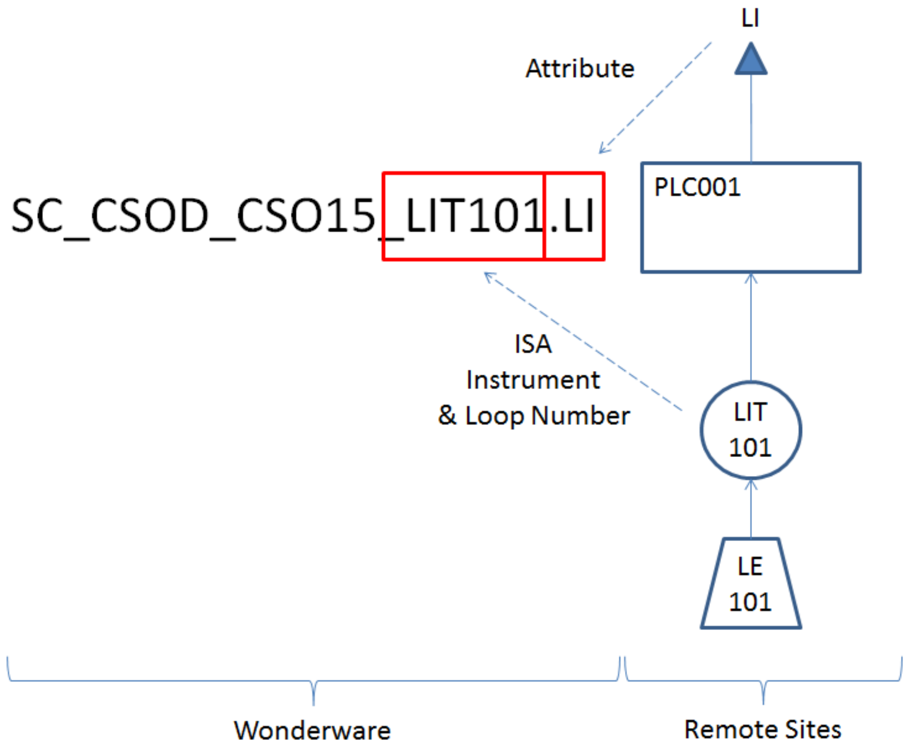

Figure 2-8B-4. I/O Point Naming Convention Links Wonderware to Existing SCADA

This approach also provides an organized way to sort large quantities of information when the data is sorted by "tag." This will make searching through and finding information easier. A good example of this is a Wonderware Historian Client ad hoc query that uses wild card characters to filter search results.

Two fully developed examples are provided below that illustrate the I/O point naming convention and relevant Wonderware configuration information.

Table 2-8B-13. Example I/O Point Naming A

EXAMPLE Component Category	EXAMPLE Component	EXAMPLE Component Description
System	SC	Sewage Collection
Site Class	CSOD	Combined Sewer Overflow Dam
Site Abbreviation	CSO15	CSO Structure 15
Asset Abbreviation	LIT	Level Indicating Transmitter
Loop Number	101	Upstream
Attribute	.LI	Level

What an operator sees in Wonderware . . .	
Object.Attribute	SC_CSOD_CSO15_LIT101.LI
Description	CSO Structure 15 Upstream Level

Table 2-8B-14. Example I/O Point Naming B

EXAMPLE Component Category	EXAMPLE Tag Name Component	EXAMPLE Tag Name Component Description
System	WD	Water Distribution
Site Class	WET	Water Elevated Tank
Site Abbreviation	AT1	Anacostia Tank 1
Asset Abbreviation	LIT	Level Indicating Transmitter
Loop Number	101	Tank
Attribute	.LI	Level

What an operator sees in Wonderware . . .	
Object.Attribute	WD_WET_AT1_LIT101.LI
Description	Anacostia Tank 1 Tank Level

8B.11.8 Site Naming Convention

A site tag is the combination of System, Site Class, and Site Abbreviation naming components described previously. The site tag description is the Site Abbreviation description associated with the naming component abbreviation.

Table 2-8B-15. Example Site Naming A

EXAMPLE Component Category	EXAMPLE Component	EXAMPLE Component Description
System	SC	Sewage Collection
Site Class	CSOD	Combined Sewer Overflow Dam
Site Abbreviation	CSO15	CSO Structure 15

What an operator sees in Wonderware . . .	
Object	SC_CSOD_CSO15
Description	CSO Structure 15

Table 2-8B-16. Example Site Naming B

EXAMPLE Component Category	EXAMPLE Tag Name Component	EXAMPLE Tag Name Component Description
System	WD	Water Distribution
Site Class	WET	Water Elevated Tank
Site Abbreviation	AT1	Anacostia Tank 1

What an operator sees in Wonderware . . .	
Object	WD_WET_AT1
Description	Anacostia Tank 1

8B.11.9 PLC Naming Convention

A PLC tag is the combination of System, Site Class, Site Abbreviation, Asset Abbreviation, and Loop Number naming components described previously. The PLC tag description is the combination of Site Abbreviation and Loop Number descriptions associated with the naming component abbreviations.

Table 2-8B-17. Example PLC Naming A

EXAMPLE Component Category	EXAMPLE Component	EXAMPLE Component Description
System	SC	Sewage Collection
Site Class	CSOD	Combined Sewer Overflow Dam
Site Abbreviation	CSO15	CSO Structure 15
Asset Abbreviation	PLC	Programmable Logic Controller
Loop Number	001	PLC 1

What an operator sees in Wonderware . . .	
Object	SC_CSOD_CSO15_PLC001
Description	CSO Structure 15 PLC 1

Table 2-8B-18. Example PLC Naming B

EXAMPLE Component Category	EXAMPLE Tag Name Component	EXAMPLE Tag Name Component Description
System	WD	Water Distribution
Site Class	WET	Water Elevated Tank
Site Abbreviation	AT1	Anacostia Tank 1
Asset Abbreviation	PLC	Programmable Logic Controller
Loop Number	001	PLC 1

What an operator sees in Wonderware . . .	
Object	WD_WET_AT1_PLC001
Description	Anacostia Tank 1 PLC 1

8B.12 WONDERWARE CONFIGURATION GUIDELINES

NOTE: This section (8B.12) contains material that needs to be verified/updated by DC Water prior to use.

The System Platform software architecture is designed to use areas, templates, and objects to model the overall plant environment. Unlike traditional SCADA architectures based on a flat tag naming structure, the System Platform architecture will be developed to model the physical process to create a hierarchy of equipment which resembles the actual plant. For instance, objects that represent tanks, pumps, and valves could be grouped together to make a pump station. Each of those objects would be based on a reusable template created in the System Platform software. The templates contain all of the information, such as

PLC I/O references, security, alarming, and history, which the SCADA system requires for that type of equipment. In this way, the entire process system can be modeled using templates and built into an overall SCADA system that closely resembles the actual process.

8B.12.1 Application Software Design

In developing the SCADA architecture, the following approach will be used to design the system:

- Identify field devices and functional requirements
- Define naming conventions
- Define the area model
- Plan the templates
- Define the security model
- Define the deployment model

8B.12.2 Object Templates

NOTE: This section (8B.12.2) contains material that needs to be verified/updated by DC Water prior to use.

All components of the SCADA system are built from reusable templates. Templates will be created in a hierarchical structure to allow easy navigation through the template structure. In addition, the template structure allows for global changes to be made at a "Master Template Level", site specific changes to be made at a "Site Template Level", and unit changes at the "Unit Template Level."

The object template structure will be designed to adhere to the following practices:

- Templates will be derived from base templates to create a logical hierarchy. These will follow, at minimum, a Base/Master/Site/Unit hierarchy.
- Instances will use propagation locking to allow changes and or additions to the template to propagate to the object instances to maintain consistency.
- Create templates such that derived instances do not require editing of scripting, history, alarms, or attributes.
- Field Attributes and User Defined Attributes will be used to reduce the number of contained objects as much as possible.
- All scripts used in templates will contain documentation that describes the template name, revision number, change log, and comments.

See Appendix P for "Sample Object Definitions." Objects and Attributes have been developed for Upper Anacostia and Eastside Sewage Pump Stations based upon the existing I/O at these sites.

DC Water would like for the Asset ID from the Maximo work management system to be included as an attribute in each object. This will require a significant amount of coordination between Maximo and Wonderware.

8B.12.3 PLC and Field Device Interfaces

The SCADA system must interface with many different types of PLC and third-party systems. The communications infrastructure to these devices is critical to providing operators with reliable data. As a result, redundant communications interfaces will be implemented within the SCADA system to provide both hardware and software redundancy in the SCADA architecture.

The communicated device data in the PLC or field device must be referenced to SCADA objects to provide data to the overall plant model. The device references, such as PLC tags or field device memory addresses, will be directly related to SCADA objects using an alias table in the SCADA system (resident within each object's instance). The alias table provides a standard location to manage the I/O references from field devices. The alias tag will be based on a standard naming convention that relates to the SCADA object attribute.

8B.12.4 Graphic Symbol Templates

In addition to data modeling in templates, the System Platform software allows for standardized graphic symbols to be developed as part of the object template. This creates a fully standardized and consistent object model from the communications, naming, referencing, control, alarming, and history through to the visualization environment of the HMI.

The development of the template graphics will follow all display principals and philosophies discussed in other sections. The graphics will be developed to incorporate all the objects basic graphical functions in the template. These reusable graphics will force standardization among graphic objects and will allow for change propagation between the template and each instance on the HMI.

The following graphic template development methods will be utilized:

- Graphics will utilize standardized colors, text, and line size, as defined in the following sections.
- Graphics will be developed to depict data quality and status information utilizing standard colors and indicators.
- All scripts used in graphic templates will contain documentation that describes the graphic name, revision number, change log, and comments.

8B.12.5 HMI Principals and Attributes

The goal of an operator graphic display is to provide operators with information in a clear and intuitive format and minimize the possibility of mistakes. To achieve this goal, the following three primary principals should be followed when creating operator graphic displays.

Clarity:

- Operator graphics should be intuitive and easy to understand Graphics should clearly show process state and conditions
- Graphic elements used to control the process are clearly distinguishable and consistently implemented
- Graphics do not contain unnecessary detail or clutter Graphics convey relevant information to operators
- Process information has prominence based upon relative importance
- Alarms and indications of abnormal situations are clear, prominent, and consistently distinguishable

Consistency:

- Graphic functions are standardized, intuitive, straightforward, and involve minimal keystrokes or pointer manipulations
- Graphic display navigations is logical, hierarchical, and performance-oriented

Feedback:

- Graphics elements and control objects must behave and function consistently on all graphics in all situations
- Important operator actions with significant consequences will have confirmation mechanisms to avoid inadvertent activation
- Operator graphics will be designed to minimize user fatigue for operations staff that constantly use these displays

These principals will be used to develop operator graphic displays with the following attributes:

- The operator's attention is drawn to the most critical information
- The HMI is designed to eliminate confusion and mistakes by providing consistent, easy to read, intuitive information with the proper feedback
- Operator reaction time is optimized by providing needed information in a simple, logically progressive, performance-oriented display structure

8B.12.6 HMI Hierarchy

8B.12.6.1 General

Operator graphics are designed in a hierarchy for progressive disclosure of process detail to handle specific tasks. The purpose of hierarchical displays is twofold:

- Provide different amounts of operating detail to aid the operator in performing different tasks
- Allow for easier navigation

The hierarchy for process graphic displays is dependent on operator location and responsibility is listed below. These levels of display represent increasing levels of complexity and detail to the operator. The hierarchy operates like a tree structure, where lower-level displays are associated with higher-level displays.

- Level 1: This system overview will include pump stations, odor control, flow monitoring sites and other SCADA remote sites. This display will include high level KPIs, Important Facility Parameters and Conditions, and Major Equipment Status. All SCADA remote sites can be accessed from this level.
- Level 2: These displays will include geographic and facility summary level displays. This display will include subsystem KPIs, Important Subsystem Parameters and Conditions, Equipment Status, and Alarms. The user will be able to access site equipment status and trend pop-up displays from this level.
- Level 3: Site SCADA graphic displays, controllers, alarms, values, equipment status, and SCADA trends are presented at this level. Users can access PID controller, equipment control, and trend pop-up displays from displays at this level. This level includes individual process equipment, such as the individual equipment and instruments associated with a site.

Level 1, 2, and 3 graphics should include left and right navigation buttons to allow operators to make "virtual rounds" by sequentially stepping through each remote site at the same level.

8B.12.6.2 Summary Displays

Summary Displays should be implemented that group like information together for a system perspective, including:

- Communications Summary Graphic – All remote site SCADA communications statuses including Watchdog Timers.
- Flow Summary Graphic – All flow rates, current day totals, and previous day totals.
- Level Summary Graphic – All tank levels and current volume.
- Power Summary Graphic – All key power measurements (e.g., estimated cost, energy, demand, power factor, etc.).

Include links to historical data for priority points determined by end users.

8B.12.6.3 Departmental Displays

Develop and organized graphic display systems specifically tailored to the needs of Operations, Electrical, Maintenance, and Engineering. Work with each department to understand what needs to be included for each set of graphics.

8B.12.7 Displays

Graphic displays will have a consistent look and feel. Wonderware InTouch and System Platform objects (provided by Invensys), navigation abilities (methods), and programmable key features should be used as much as possible. This will maximize the use of built-in capabilities.

8B.12.7.1 Layout

Graphic displays will have a consistent layout. Full screen and windowed graphics will have a similar look and feel. Pop-up displays will be unique to each application.

- Process flow will be shown as left to right and match the process layout at the remote sites. Well thought out layout will minimize crossing lines. Include a "North Arrow" on each graphic.
- Logical and consistent navigation shall be utilized with a hierarchy of progressive exposure of process details
- Displays should be "clean" and "uncluttered"
- Standard display templates will be developed and used as guides for each level of display.
- Templates will show common items for each type and level of display

Full Screen process graphic displays (overlays) will include a Navigation Bar at the top of the display and an Alarm Banner at the bottom of the display. By default, the navigation bar will not be visible. A mouse click on a preconfigured icon will make the navigation bar visible. A new un-acknowledged alarm indication will appear on each process graphic display as a major, minor, or informational priority alarm object. This new object will be displayed in the lower right hand corner, just above the alarm banner.

Pop-up displays are displayed on top of existing displays. Pop-ups can be any rectangular size. They will appear in a default location but can be moved anywhere on the display.

8B.12.7.2 Navigation

Multiple levels of navigation will be utilized. The operator will be able to go up and down through the hierarchy using a navigation bar, side to side through the process, and call related details, trends, and control displays from any graphic. The system will be configured so it is never necessary for the operator to type a point name or graphic name.

The ability to get to any graphic without knowing the hierarchy will be available for users. This will be accomplished using an overall display menu. Maintenance displays will be included in this menu. Forward and back navigation buttons will be provided to move to adjacent displays in the process flow. A "last display" button will be provided to navigate to the previous display.

8B.12.7.3 Characteristics

All displays will be constructed with a common theme. The characteristics of the process graphic displays are described as follows:

- Display layouts will be consistent with the operator's mental model of the process. Some displays may be arranged based on physical layout rather than the layout shown on P&ID's.
- Process equipment will be depicted in a simple two-dimensional low contrast manner for Level 1 displays, Level 2 and 3 displays may use three-dimensional low contrast elements.
- Muted color backgrounds are used to minimize glare and will be used with generally low contrast process equipment depictions.
- Display elements will have consistent visual and color coding.
- There will be limited use of color. Alarm colors will be used for alarms only. An alarm color will not be used for a text label, line color, border, or any non-alarm related element.
- Dark gray or black lines will be used to depict the process, with major process lines shown slightly thicker than minor process lines.
- There will be no gratuitous animation such as splashing liquids and spinning agitators. Animation will primarily be used to highlight abnormal situations. Some animation may be used to indicate equipment running.
- If used, measurement units will be shown in low contrast lettering.
- Display access will be accomplished with a minimum number of keystroke actions.
- Techniques will be used to minimize the possibility of operator mistakes and provide validation and security measures such as access to control displays or displaying control elements based upon security level.
- Screen control elements and alarm acknowledgement operation shall be governed by role-based security.
- Graphic element will be present to notify operations of new un-acknowledged alarms.

8B.12.8 Use of Color

Color usage is restricted, achieving display consistency and drawing attention to important situations. Color choices and their use in graphics are applied consistently throughout the display hierarchy. Color should never be the sole differentiator of important information. Color differences will be combined with shapes to convey state or condition.

Background Color – A muted color background has been shown to effectively address problems of glare, contrast, color interference, and fatigue on the eye. The same background color will be used for all graphic displays.

Foreground Colors – A minimum number of colors should be used. Foreground color should be used to draw an operator's attention to an abnormal situation or alarm. Bright, intense, saturated colors are used to quickly draw the operator's attention to abnormal conditions or alarms.

If the process is running correctly, the process graphic should display little or no color.

All use of color will be standardized (hue and saturation) and rigorously followed. Each color will be used to indicate only one condition. For example, if Red is used for an alarm color, it will not be used for any process graphic objects, text, or elements.

Process lines and outlines of vessels and equipment should be dark gray or black. Emphasis will be provided by using varying line thickness, (not color) with primary process flow using the heaviest line.

Color will not be used to indicate the type of material, e.g., natural gas, potable water, etc. It is difficult to apply consistently on all displays and provides a distraction to the operator. Material type will be identified with text.

Color Blindness – Colorblindness is a common phenomenon. The most problematic color pairs are red-green, green-yellow, and white-cyan. Therefore, foreground colors used to indicate abnormal conditions will be used in conjunction with text, shape, filled or unfilled status, texture, or similar distinguishing characteristics. Some animation will also be used.

8B.12.9 Lines, Vessels and Static Equipment

Process Lines:

- Process lines should be dark gray or black.
- Thickness should be used to differentiate their significance.
- There will be two different line types, solid (existing process flow and equipment) and dashed (future process flow and equipment).

Process Vessels:

- Vessels should be depicted as two or three dimensional depending on the display level.
- The interior of the vessel should be uniformly shaded without gradients and be the same color as the background color.
- The vessel should be outlined in a thin line of black or dark gray. The vessel's shape should be shown, but without much detail.
- The size of the vessel should be relative to the process importance of the vessel and, when practical, related to the physical size.

Process Flow:

- Process flow should be depicted consistently.
- Process flows should be from left to right.
- Vapors generally flow up and liquids flow down unless directly associated with a pump or compressor.
- Process lines should enter and leave the screen in consistent ways. Entry and exit points used as navigation targets should be presented and differentiated from non-navigation points.

8B.12.10 Text

The display of static text on process graphics and other displays will follow the following principals:

- The amount of text should be minimized but not eliminated. Text will be used to identify items when their placement or shape does not make their identity obvious.
- Text on process graphics will be dark gray.
- Text on alarm or event displays will be the color associated with the priority.
- All display lettering should in non-serif fonts, e.g., Arial, Tahoma, Verdana, or Calibri.
- For isolated words, titles, short labels, and equipment designations, use all uppercase. For all other instances, use mixed case lettering to improve legibility.
- Text size will be standardized for operator console displays. Text size for control center large screen displays may vary to improve readability from the console.
- Ensure consistency with abbreviations. A glossary of abbreviations will be included with operator's reference manual.

8B.12.11 Values (Dynamic Text)

The display of live values should be shown differently than static text. The following rules will be followed.

- Bold dark blue will be used for live values.
- Bold dark green for values that can be adjusted by the operator.
- Leading zeros will not be displayed except for fractional values.
- In tables, numbers will be aligned by decimal points. Extensive use of tables is discouraged.
- When needed, the units of measure will be displayed in lower contrast gray text adjacent to the value.
- Tagnames will not be shown on graphic displays by default. Tagnames may appear as the pointer hovers over a value or be displayed for clarity in a control pop-up.
- When a value has the focus of the pointing device, the status should be indicated by a white rectangle surrounding the value.
- For levels – display level relative to tank bottom, display datum level, and display percent full.

8B.12.12 Moving Analog Indicators

Moving analog indicators provide users with a means of quickly ascertaining if a process variable is in a normal operating range, approaching an alarm state, or in an alarm condition. Figure 6-5 shows two examples of a vertical analog indicator at two operating conditions.

8B.12.13 Objects and Symbols

Standard shapes and sizes for vessels, pumps, heaters, blowers, etc. will be developed. The Invensys System Platform objects and symbols will be used to the greatest extent possible. Their use will be governed by the standards described in this section.

All objects and symbols will be consistent so they can be recognized without the use of labels. If labeling is required, text will be low contrast. To reduce display clutter, tagnames will routinely not be displayed. They may be displayed with a "mouse-over" by the operator.

8B.12.13.1 Vessel Level

Vessel levels will be shown with a level bar filling the vessel. The overall height of the level will correspond to the range of the instrument installed on the vessel. The full part of the level range will be shown in blue. The unfilled part of the level range will be shown in dark gray.

8B.12.13.2 Control Valves

Open - close control valves will be shown in white or dark gray. Valves with lengthy transition times will be shown as dark gray and white. Valve not ready, failed, locked indications, fail to open and fail to close alarms will follow consistent colors and alarm response.

Modulating valves will be shown in dark gray when closed. When the valve is open, it will be shown with a white body and the percent open indication.

8B.12.13.3 Pumps

Pump status will be shown in white or dark gray. Variable speed pumps will be shown in white with the percent speed shown below the pump. Pump not ready indication, fail to start, and fail to stop will follow consistent colors and alarm response. Animation may be used to indicate equipment running.

8B.12.14 Controllers

Process control is accomplished in PLCs. The SCADA system will provide operators with a depiction of controller elements operators need to monitor and control the process. Detailed controller configuration displays will be available through the operator interface.

Two levels of process controller objects will be available for graphic displays. A simplified controller object will display the controller Process Variable (P), Setpoint (S), Output (O), and controller mode (Auto, Manual, or Cascade).

A controller pop-up will also be available. This pop-up display will resemble a typical controller faceplate. This pop-up will be presented to the operator after clicking on the simplified controller object. The pop-up will allow operators to adjust the controller setpoint and change the controller mode.

8B.12.15 Trending

Real-time and historical trending is available from many levels in the display hierarchy. Pre-configured real-time trends and ad-hoc historical trend capabilities are defined in the following sections. Historical trends should be used instead of real-time trends because real-time trends take time to populate. Trending requirements for each project should be defined during design with detailed input from DC Water operations.

8B.12.15.1 Process Trends

Process Trends are created to provide users with preconfigured trends of two to eight process variables. These full-screen displays are selectable from the navigation bar and include the following characteristics:

- Fixed preconfigured process variables

- Fixed preconfigured time and value scales
- Adjustable time and value axis
- Adjustable time axis provides digital values for the time selected by the axis
- Fixed preconfigured list of process variables by tag and color
- Process variables can be removed from the display
- Pre-configured trend background and border colors

8B.12.15.2 Pop-Up Trends

Pop-Up Trends are created to provide users with preconfigured trends of a single process variable. The pop-up displays are selectable from the process graphic or other control pop-up displays. These displays include the following characteristics:

- A title bar with the process variable name to allow the pop-up to be moved
- The pop-up will not be sizable
- Fixed pre-configured process variable
- Fixed pre-configured time and value scale
- Adjustable time and value axis
- Adjustable Time axis provides digital values for the time selected by the axis
- Preconfigured trend background and border colors

8B.12.15.3 OIT Trending

Trending on a remote site OIT should not be dependent upon WAN communications to display realtime and historical data.

8B.12.15.4 Ad-Hoc Trends

Ad-hoc Trends are full-screen displays selectable from the navigation bar. These displays will include the following characteristics:

- Selectable process variables using the Historian Client “Tag Picker” function
- Selectable time period and scale using Historian Client “Time Picker” function
- Adjustable time and value axis
- Adjustable time axis provides digital values for the time selected by the axis
- Selectable process variables by tag and color up to eight variables
- Process variables can be removed from the display
- Historical trend can be switched to real-time
- Pre-configured trend background and border colors
- Ad-hoc trend configuration can be saved and recalled at a later date
- Trend information can be saved to a file for retrieval at a later date

8B.12.16 Alarms

The purpose of the alarm system is to direct the operator’s attention to the facility conditions requiring timely assessment or action. Each alarm should alert, inform, and guide the operator, have a defined response, and allow the operator adequate time to carry out the response.

Alarms should be prioritized based on severity of consequence taking into account safety, environmental, economic factors, and the time available to take corrective action.

Handle events separate from alarms. Use the I/O Point List and control descriptions to clearly indicate alarms and events; both hardwired and those derived from software.

Three alarm priorities will be used. The proposed priorities and their general definitions are as follows:

- **Major** – Immediate operator action required (e.g., process shutdown, severe equipment damage, health, safety, or environmental violation imminent, or costly economic impact)
- **Minor** – Rapid operator action required (e.g., process shutdown possible, off-spec process condition, emergency level alarm or violation imminent)
- **Information** – Operator action is required, but the process is still in steady state operation. The following sections will discuss the philosophy of how alarms are presented to operators.

8B.12.16.1 Alarm Behavior and Indications

Any system value in alarm should be shown clearly and consistently. The methods used to for this standard are defined in the following sections.

- Color is related to alarm priority.
- Every alarm will have a unique color that will not be used for any other purpose on any graphic display.
- Unacknowledged alarms will be distinguished from acknowledged alarms.
- Unacknowledged alarms will blink.
- If more than one alarm is in effect on a value, only the highest priority alarm should be indicated.

A combination of visual indications, audible indications, or both, shall be used to distinguish the following required alarm states:

- normal
- unacknowledged alarm
- acknowledged alarm

Normal State Indication: The normal state should not use an audible indication. The normal state visual indication should be the same as indications without alarms.

Unacknowledged Alarm State Indication: The unacknowledged alarm state should use an audible and visual indication. The audible indication should be silenced with a silence action or acknowledge action by the operator. The visual indication should be clearly distinguishable from the normal state indication by using colors and symbols (e.g., shape or text). The visual indication for an unacknowledged alarm should include a blinking element.

Acknowledged Alarm State Indication: The acknowledged alarm state should not use an audible indicator. The acknowledged alarm state visual indication should be clearly distinguishable from the normal state indication by using symbols (e.g., shape or text), and should be identical in color to the unacknowledged alarm indication. A blinking element should not be used in the visual indication for an acknowledged alarm.

8B.12.16.2 Graphic Display Indication Method

On process graphic displays, alarms will be indicted by unique colors, text, and shape. For the proposed three alarms priorities, the following indication methods will be used:

- **Major** – A yellow filled rectangle with a black 1 in the rectangle will indicate an acknowledged alarm. The same symbol, blinking, will indicate the alarm is unacknowledged.
- **Minor** – A magenta filled triangle with a black 2 in the triangle will indicate an acknowledged alarm. The same symbol, blinking, will indicate the alarm is unacknowledged.
- **Informational** – An orange filled diamond with a black 3 in the diamond will indicate an acknowledged alarm. The same symbol, blinking will indicate the alarm is unacknowledged.

8B.12.16.3 Alarm Banner

For single HMI displays, an alarm banner will provide the operator with a four line alarm list with buttons to select alarm acknowledgement, alarm summary, alarm history and to scroll the list up or down. By default, the most current alarms grouped by operator area of responsibility will be displayed in the banner.

8B.12.16.4 Alarm Summary Display

At least one alarm summary display is required for HMI. The alarm summary provides a list of active alarms within the alarm system. The alarm summary display shall list only alarm information. The display shall provide the following information for each alarm:

- name and description of the tag in alarm
- alarm state (including acknowledged status)
- alarm priority
- time/date the alarm became active
- alarm type

The recommended list of additional parameters recommended by ISA Standard ANSI/ISA 18.02- 2009 follows. Some of these parameters may be implemented if supported by InTouch and System Platform:

- process value (supported)
- alarm setpoint
- process area
- alarm group (supported)
- alarm message
- The alarm summary display will provide the following functions:
- sorting of alarms by chronological order
- sorting of alarms by priority
- individual acknowledgment of each alarm
- buttons configured to allow filtering alarms by priority
- buttons configured to allow grouping alarms by process area

8B.12.16.5 Alarm History Display

The alarm history will be archived within the Historian. Alarms and events will be logged as alarm states change. Alarms and events will be displayed in their unique colors. The alarm history display will have the following functions:

- buttons configured to allow filtering alarms by priority buttons
- buttons configured to allow grouping alarms by process area
- capability to query the alarm history between two instances in time

8B.12.16.6 Alarm Notification

Local annunciation will be performed within System Platform. Alarm objects, current summary objects, history alarm objects, and local audible annunciation will be configured and delivered to operations personnel.

Remote response objects will be developed to provide operations with the ability to be notified in the event of an alarm and the ability to respond to alarms using SMS texting and email. Alarm notification escalation, staff calendars, and call groups will provide operations with the notification flexibility. Alarm notifications with System Platform will provide:

- ***SMS Texting Out:*** Alarm system notification to cell phones
- ***Email Out:*** Alarm system notification to email recipients
- ***SMS Texting In:*** Alarm acknowledgement from mobile operators
- ***Email In:*** Email response from remote operations personnel for alarm acknowledgement
- ***PIN for Alarm Acknowledgement:*** Security for remote alarm acknowledgement
- ***Call Groups:*** Group response configuration
- ***Contact Scheduling:*** Response personnel scheduling for on-shift or off-shift operator response

8B.12.16.7 Alarm Management

Alarm Acknowledgement – Ability to acknowledge alarms will be based upon security level of the operator.

Alarm Shelving – Current operation relies on InTouch alarm shelving within the SCADA application. Limited sustainability features due to the limitation of requiring the alarm objects to be a focus within displays for continuous operation.

8B.13 HISTORIAN CONFIGURATION GUIDELINES

8B.13.1 Data Acquisition Type

The data acquisition types are IOServer or Manual. A brief description of each acquisition type follows.

- IOServer: Wonderware-compatible software application that reads values from PLCs and other factory devices and forwards the real-time data on to Wonderware applications.
- Manual: Forced storage of values from an HMI or from client applications.

The majority of data collected by Historians will be acquired using the IOServer. Process variable information required for daily or monthly reporting that is not connected to SCADA will be manually forced into Historians. The methods used for forcing data will be direct data entry from an InTouch display or by data import from Excel generated CSV files.

8B.13.2 Data Collected

Data can be collected as one of four tag types: analog, discrete, string, and event. A brief definition of each tag type follows:

- Analog: An analog value is a variable that measures a continuous physical quantity. For example, the level of a wetwell would be measured as an analog value. Totalized values are also analog tag.
- Discrete: A discrete value is a variable which only has two states: '1' (True, On) or '0' (False, Off).
- String: A string value is a text expression treated as a single data item. A string does not require a special format or syntax.
- Event: An event tag is a name for an event definition in the system. For example, if you wanted to detect when the temperature of tank reached 100 degrees, you might define an event tag and name it "TankAt100."

Currently Analog, Discrete, and String data is collected. The data collection standards will be applied as follows:

- Analog: All SCADA Real and Integer data types
- Discrete: All Discrete data

Note: The definition of actual data collected will be defined in the application software specifications for each project.

8B.13.3 Storage Method

The methods used to collect data are cyclic, delta, and forced. A brief description of each method follows:

- Cyclic: Cyclic storage is the storing of analog data based on a time interval. This method of storage writes a record to history at the specified interval only if a data change occurred during the time interval. For example, the value of an analog tag could be stored every five seconds.
- Delta: Delta storage is the storing of data based on a change in a value. This method of storage writes a record to history only if the current value has changed greater than the previous value +/- the specified deadband or a time dead band is exceeded, or rate of change dead band has been exceeded. This is also called "storage by exception." It is typically used for storing discrete values, string values, and analog values that remain constant for long periods of time.
- Forced: Forced storage is the storage of each value as it comes in from an HMI or from a client application with no filtering applied.

The data collection method standards applied will be as follows:

- Cyclic: This method will not be used as a standard method of collecting data. It may be used for specialty cases.
- Delta: This method will be used for all discrete, analog, and string data.
  - For discrete and string data, any change in state will be recorded.

- For analog data, the value deadband is the percentage of difference between the minimum and maximum engineering units for the tag. The value deadband will be set as required by the process for stable alarm initiation. The time deadband will be set to 0.
- For all data, store one value per hour as an integrity checkpoint.

8B.13.4 Aggregation

Aggregation (e.g., maximum, minimum, average, total, etc.) must be performed at the remote sites by the local PLC. Aggregation using stored historical data is subject to error during periods where communications is compromised.

8B.13.5 Point Grouping

Utilize historian "groups" to consolidate similar points for easier point recall. Groups are very flexible and need to be defined by DC Water. Groups could include any of the following point collection examples:

- All Sewer Flows
- All Water Flows
- All Water Tank Levels
- All Water Electrical Monitoring
- Fabridam 15 points
- Upper Anacostia Points
- Engineering Points
- Maintenance Points

8B.13.6 Reports

Reports shall include the following information:

- The DC Water Logo.
- The name of the system the report covers (Water Distribution, Collection, or Stormwater).
- The start and end date/times of the reporting period.
- The date/time the report was executed.
- The Object/Attribute Description at the top of each column. The description may be abbreviated to address space constraint provided it is still clear what the data below represents.
- The Object/Attribute at the top of each column.
- The engineering units for the data, placed below the Object/Attribute at the top of a column.
- Maximum, minimum, average, and total at the bottom of each column of data, where appropriate. For example, total for pH should be left blank.

The requirements above describe a typical monthly report with a landscape orientation. A wide variety of other options exist. Ensure that the general intent (readability) is achieved for all reports.

Reports to be provided under a project should include a mock-up (as part of the design documents) using Microsoft Excel to confirm acceptability by DC Water departments that will use the reports.

8B.14 PLC CONFIGURATION GUIDELINES

8B.14.1 Background

Most of the PLCs connected to the Wonderware SCADA System were provided over many years under capital improvement projects designed and implemented by numerous companies. Some PLCs were implemented through internal DC Water projects. As a result, the PLCs vary widely in terms of programming philosophy, vendor, model, communication protocol, interface hardware, spare parts, support, documentation, etc.

8B.14.2 Coordination

DC Water shall, upon request, provide all IP addresses for new equipment. Provide a control system configuration drawing depicting all network nodes that require an IP address. The drawing will be provided to DC Water prior to control system related submittals. DC Water shall return the drawing complete with IP addresses assigned within two weeks of receipt. The control system supplier will include the IP address information with control system submittals.

8B.14.3 Communications

This section documents existing interface methods which connect the Wonderware SCADA System. Note that the standard for communication for all new work is MODBUS TCP. Deviations from this standard must be approved by DC Water with supporting engineering rationale for the deviation. For example, a project may result in a new remote site that needs to communicate peer-to-peer with an existing Allen Bradley PLC.

New interfaces shall be consistent with the existing interfaces having many of the following common features:

Communication between the Wonderware SCADA system and PLCs is achieved with either MODBUS or Allen Bradley communication protocols. MODBUS protocols use either Ethernet (IEEE 802.3) or Serial (RS-485 or RS-232). Allen Bradley protocols (AB CSP/PC, AB EIP, and AB EIP/PCCC) use Ethernet.

Control related commands (e.g., start/stop, open/close, auto/manual, etc.) issued to a PLC from the Wonderware SCADA system shall be transmitted with momentary or maintained bit values. For momentary bits, the PLC logic must latch the momentary bits from Wonderware and hold the equipment in the intended operational state until a momentary bit is received from Wonderware to reverse the previous action. Based on past experience, the preferred interface approach is to use momentary bits because it is less disruptive to the process during fault conditions (e.g., PLC power issue, communication outages, primary/secondary server failover, etc.). The decision to use momentary/maintained outputs for hardwired PLC outputs is up to the designer based on the needs of the project.

Some protocols, depending upon desired functionality, require special network switches and switch configurations. For example, some Allen Bradley protocols have special switch requirements related to the following: VLAN, full duplex capability on all ports, auto-negotiation and manually configurable speed/duplex, IGMP snooping, port mirroring, STP, QoS, and SNMP. The designer is expected to design a robust industrial network appropriate for their project.

Some communication protocols such as CIP over EtherNet/IP are designed to be tag based, not register based. This particular protocol driver may require validation of tags upon startup or after a communications outage. The duration of the validation phase can be significant for large I/O point counts and must be considered by the designer from reliability, controllability, and general system performance perspectives.

Some communication protocols handle higher resolution 32-bit data types differently (e.g., double precision, real, float, etc.). The designer and system integrator shall coordinate PLC memory and communication drivers to directly map memory in to Wonderware object/attributes. This will be done to avoid having to swap words and/or bytes to link the Wonderware tag to PLC memory. Some examples of how tags can be read by drivers include: "high byte first high word first", "high byte first low word first", "low byte first high word first", "low byte first low word first", etc. If this is not managed carefully, three (3) or more tags may be needed to rearrange byte/word order into a final destination tag. This can drastically affect systems with tag based licensing. If this byte/word cannot be managed, use 16-bit registers to transmit integers with a shifted decimal place (e.g., x10 transmits 12.4 as 124 x100 transmits 124.5 as 12450, etc.) – note that this approach drastically reduces resolution and accuracy. However, if high resolution and/or accuracy is needed to use the multiple tag approach only as a last resort.

The number of PLCs, registers, bits, tags, etc. supported by these links depends upon numerous requirements including: network speed, port speed, communication payload (number of bits/registers), protocol, and update rate. The designer is expected to design an interface that meets or exceeds performance requirements specific to their project. This will require research beyond the scope of this document.

8B.14.4 Polling Methodology

There are generally two schools of thought regarding polling: memory mapping, and direct polling.

Memory mapping uses move commands in the PLC logic to align registers into contiguous registers to achieve the fewest communications messages with a remote SCADA site. The benefits of this method are more efficient communications, improved graphic update rates, and reduced remote site communication bandwidth needs. The disadvantage is more planning and coordination prior to programming, more complex PLC programming, and less flexibility after initial implementation. This method was popular when low bandwidth links were the only option.

Direct polling does not use an intermediate area of PLC memory to consolidate PLC data to be exchanged with polling devices. Instead, Wonderware manages all of the polling and tag information is exchanged directly with PLC registers distributed across the PLC memory. This has the advantage of simplified communication configuration and easier polling modifications after implementation. It has the disadvantage of requiring more communication messages per remote site. There is also an increased probability of latency issues on graphics or conditional programming within the Wonderware system.

The approach preferred by DC Water DDCS is direct polling. The memory mapping approach should not be used unless there is a compelling reason to do so.

Note that there can be adverse results (e.g., confusing graphic displays, nuisance alarms, controllability) if PLC data exchanged with a Wonderware server or centralized controller arrive at different times because multiple messages are used. Therefore, messages should be minimized and control logic needs to account for potential data latency.

8B.14.5 PLC Program Organization

8B.14.5.1 Defined Function Blocks

All programming in PLCs shall be accomplished using defined function blocks. Relay ladder logic or any other programming language shall not be used where defined function blocks could be used instead.

8B.14.5.2 Defined Function Blocks

The PLC program shall be organized into group of logic using the following sequence.

1.	Input Scanning	Occurs by default in PLC
2.	Input Conditioning	Custom code by Systems Integrator
3.	Strategy Logic	Custom code by Systems Integrator
4.	Output Conditioning	Custom code by Systems Integrator
5.	Output Scanning	Occurs by default in PLC

8B.14.6 Time Synchronization

Where practical, utilize PLCs that support NTP (Network Time Protocol) for automated synchronization with a dedicated network time server. Otherwise, use the following approach described below for PLC time synchronization.

At 12:00 noon, each day, the Wonderware SCADA system will send a bit to each remote site PLC to reset and synchronize the PLC clocks. The PLC will perform all necessary logic to reset the PLC clock. The Wonderware SCADA system will only send the synchronization bit once per day at noon.

The time synchronization function will ensure that calculated daily values throughout the PLC (if any) are performed during the same time interval. It also addresses coordination of daylight saving time.

8B.14.7 Communication Status Monitoring

One of the most important functions the Wonderware SCADA system performs is to monitor the health of the distribution and collection systems. The remote site communications sub-system is an important overall part of this monitoring. DDCS needs to know when the communications system is not functioning normally. The Wonderware system will use watchdog timers programmed into the Wonderware system and remote site PLCs to monitor communication system health.

The PLC utilizes a watchdog timer from the Wonderware SCADA system to verify that the SCADA system is communicating correctly and is capable of generating control commands (set points, etc.). If the PLC determines that watchdog timer is not functioning, then the PLC should generate an alarm in the local OIT. This will alert local staff to the communication malfunction that may be able to resolve the issue.

Similarly, the Wonderware SCADA system will utilize a watchdog timer from the PLC to verify that the PLC is communicating correctly and that the application program is running. If the Wonderware SCADA system determines that the watchdog timer is not functioning, the SCADA system should generate an alarm.

The actual response (e.g., alter control mode, hold last good value, etc.) in the PLC and for any given fault situation needs to be determined by the designer and documented in the Control Descriptions.

The preferred way to generate a Watchdog Timer is to have an incrementing analog value. This value will be the PLC clock seconds value. One possible scenario is described below:

- The PLC generates a watchdog timer value that changes often (e.g., PLC clock seconds) and writes it to a register in the PLC.
- The Wonderware SCADA system reads this value at least every 10 seconds and monitors it to insure that it is changing.
- If this value does not change within a specified number of seconds (10 seconds, for example), then an alarm is generated and the Wonderware SCADA.
- The Wonderware SCADA system also generates a watchdog timer value and writes it to a register in the PLC.
- The PLC reads this value and monitors it to insure that it is changing.
- If this value does not change within a specified number of seconds (10 seconds, for example), then an alarm is generated on the local OIT.

8B.14.8 Analog Conditioning

8B.14.8.1 Analog Input Scaling

Analog inputs are acquired from analog input modules and placed into registers as raw un-scaled 'counts' (typically ranged 0-4095, 0-32767, etc.) The PLC program logic shall scale inputs to their engineering ranges and convert them to real numbers. Once the analog inputs have been scaled, all further references shall be in engineering units and used as real number values.

8B.14.8.2 Analog Input Out of Range Alarms

The PLC programming shall generate an alarm if an analog input value is less than 3.9 mA or greater than 20.1 mA; include a 5 second timer to filter out nuisance alarms.

The PLC shall clamp values less than 4 mA at the 4 mA value to prevent miscalculations (e.g., negative flow accumulation). Similarly, the PLC shall clamp values greater than 20 mA at the 20 mA level. This example used a signal with a 4-20 mA input. This concept shall be applied to other types of signals as well (e.g. 0-10 VDC, 1-5 VDC, etc.).

8B.14.8.3 Analog Outputs

Analog output values represented in engineering units must be scaled to the appropriate raw count range and converted to the appropriate word type before they can be sent to an analog output module.

All process related variables and calculated points in the PLC are to remain as real numbers throughout the PLC programming. Analog output scaling is only performed as a final step before data is sent to the analog output module.

8B.14.9 Control Modes

NOTE: This section (8B.14.9 and subsections) contain material that needs to be verified/updated by DC Water prior to use.

Several levels and modes of operational control will exist for SCADA equipment and systems. Operators must have the ability to monitor and control equipment via local manual controls, via the local operator interface, or through remote SCADA control. The selection of these modes of operation will be made available through the use of hardwired field switches and software selector switches. All transitions between control modes should be bumpless (no effect on process) to the extent possible.

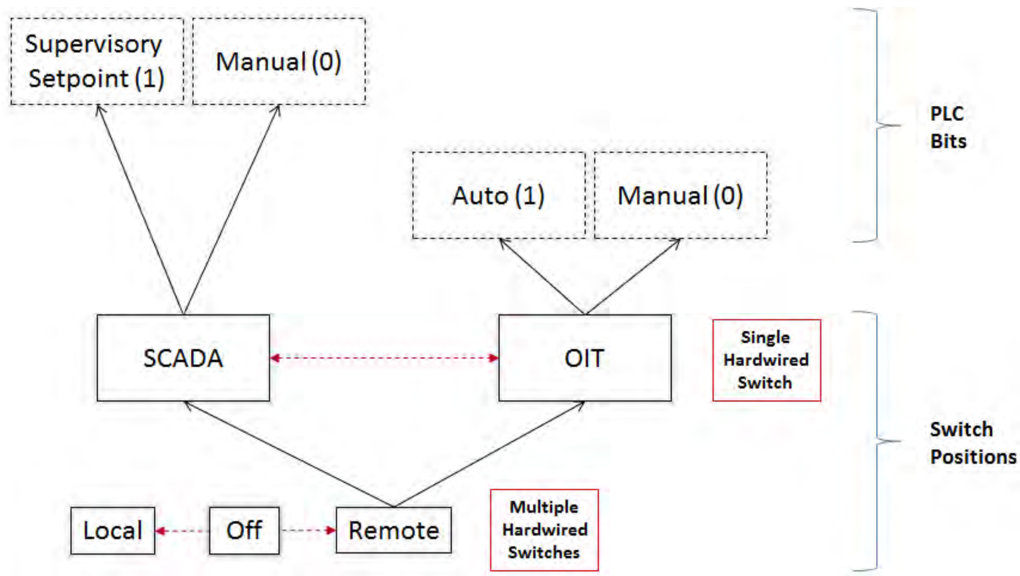

Figure 2-8B-5. SCADA Control Hierarchy

Note that the lines in the figure above do not denote electrical wiring or software connections, but rather control hierarchy.

8B.14.9.1 Local/Off/Remote Switches

At the lowest level in the control hierarchy, Local/Off/Remote (LOR) switches are physically hardwired into equipment control circuits in motor control center cubicles, VFDs, valve operators, local control panels, etc. The LOR switches are used to electrically isolate all equipment controlled through the PLC system from local backup controls (e.g., selector switches, pushbutton, speed pots, etc.). This is intended for use primarily during maintenance functions and is not intended for normal operation.

All equipment controlled through the PLC system must be provided with local backup controls.

LOR "remote" switch status is monitored through SCADA and the local OIT.

(a) Local Control Mode

When the LOR switch is in the "Local" position, equipment is locally controlled by an operator independent of the PLC.

(b) Remote Control Mode

When the LOR switch is placed in the "Remote" position, equipment will be controlled by the PLC in either of the OIT modes (PLC or Manual) or either of the SCADA modes (Supervisory Setpoint or Manual).

8B.14.9.2 SCADA/OIT Switch

Remote sites with an OIT shall be equipped with a single SCADA/OIT selector switch mounted on the local PLC control panel, near the Operator Interface Terminal (OIT). A hardwired switch is recommended because an OIT failure would preclude access and limit controllability.

(a) Remote Control, OIT Mode

When the SCADA/OIT switch is in the "OIT" position, the operator will control equipment from the local OIT graphic screens. While in OIT mode, the operator can select Auto or Manual operation via a software switch on the OIT screens. These modes are described below:

- Manual - Operator will control equipment manually via the OIT interface.
- Auto - Automatic control and sequencing is accomplished via the PLC's program logic.

While in OIT mode, operators will be prohibited from invoking commands and manipulating SCADA set points at the Wonderware graphic screens.

(b) Remote Control, SCADA Mode

When the SCADA/OIT switch is in the "SCADA" position, the operator will control equipment from the Wonderware graphic screens. While in SCADA mode, the operator can select automatic or manual operation via a software switch on the Wonderware graphic screens. These modes are described below:

- Manual - Operator will control equipment manually via the Wonderware graphics.
- Auto - Automatic setpoints and sequencing parameters are transferred to the remote site PLC. Automatic control and sequencing is accomplished via the PLC's program logic

While in SCADA mode, operators will be prohibited from invoking commands and manipulating SCADA set points at the local OIT graphic screen.

8B.14.10 Calculated Values

All calculated values shall be calculated in the local PLC at the remote sites and not in the Wonderware SCADA system. Examples of calculated values include aggregation (e.g., max, min, avg, total, etc.).

Performing calculations locally ensures that errors due to Wonderware communications outages are eliminated (e.g., flat-lined data, etc.). This is especially important when the calculated data affects permit data, billing, and other uses sensitive to accuracy; for sensitive data, store one week of values in the PLC for manual retrieval by DC Water.

The contractor shall coordinate calculation data types with DC Water.

8B.14.10.1 Analog and Digital Input Calculation Overview

Program the PLC to perform the calculations described below. For each, accumulate or adjust the current day value. Store the previous day final value for each in a separate register. Display both of these values on the Wonderware and OIT graphics. Also, historize both of these values. For each calculation, store seven (7) days of previous values in adjacent registers for manual retrieval by SCADA support staff.

Flow Rate Inputs – Calculate total, maximum, minimum, average, and total.

Level Inputs – Calculate maximum, minimum, and average.

Pressure Inputs – Calculate maximum, minimum, and average.

Speed Inputs – Calculate maximum, minimum, and average.

Run Status Inputs – Calculate runtime, number of starts, and average duty cycle.

Available Status Inputs – Calculate accumulated time equipment is available similar to runtime.

Computer/Local Inputs – Calculate time in computer.

8B.14.10.2 Runtime Calculation

Calculate runtimes for all equipment whose run statuses are monitored by the PLC. Two separate runtimes will be calculated; Daily Runtime and Accumulated Runtime.

These calculations will use double precision (i.e. 32 bit) integer data types. The current day runtime register will increment each second the associated equipment is running. At midnight, the current day runtime register will be added to the accumulated runtime register associated with that piece of equipment. The total runtime (in hours) will be calculated by the Wonderware SCADA system though scaling system before display. The current day value will then be reset to zero once. A 32 bit unsigned integer has a maximum value of 4,294,967,295 (i.e., FFFF FFFF in hexadecimal). This run timer has a maximum value that slightly exceeds 136 years.

The accumulated runtime register is reset automatically by the PLC when the maximum value is reached. The operator will not have the ability to reset these accumulator values. It is expected that the values will only be reset through a programming laptop by qualified personnel.

8B.14.10.3 Flow Totalization

Calculate flow total for all process flows that are monitored by the PLC. The following example illustrates a typical flow totalization calculation:

Each second the following calculation is performed in PLC logic.

Totalized flow: (Flow Value (MDG) / 86400) + Total accumulated flow.

In this example, the flow rate is expressed in MGD and the Total accumulated flow is expressed in MG. This calculation, executed once a second by the PLC, adds an increment of flow to the total accumulated flow each time the calculation is performed. Since the calculation is performed once per second, the flow rate is divided by 86400 (i.e., the number of seconds in a day.) The result is the total accumulated flow in millions of gallons. If the flow is represented in engineering units other than MGD, the appropriate conversion constants will need to be substituted into the calculation.

At the end of each day, the program shall take the current day's totalized values, move them to a different register storage area for yesterday's data and reset the new current day's value to zero. Current daily totals and yesterday's accumulated values shall be monitored by the Wonderware SCADA System.

8B.14.10.4 Minimum, Maximum and Average Calculations

In addition to calculating totalized process values, it is important for the PLC to capture and calculate minimum, maximum and average daily values. Current day and previous day values shall be monitored by the Wonderware SCADA System. One week of these values shall be stored in contiguous registers for later retrieval by SCADA technical support staff in the event of an extended communication outage.

8B.14.10.5 Minimum Value Calculation

PLC programming shall be implemented to calculate the minimum daily value for analog process I/O points. This is achieved in PLC logic by performing the following:

- At the beginning of each day, reset the minimum value holding register to the maximum value. For example, if a particular flow rate's upper range limit is 4.00 MGD, then move a value of 65535.00 into the holding register.
- On the first scan of the logic, the PLC will compare the process value to the holding register. If the process value is less than the holding register, then move the current process value into the holding register. If the process value is greater than or equal to the holding register value, then the last value will remain until a process value less than the holding register is evaluated.
- This routine is performed continuously though out the day, and yields the minimum value.
- At the day's end, today's minimum value is moved to yesterday's minimum value and the current day's value is set.
- The current day's minimum value is set to a maximum permissible value in order to ensure that the PLC's first scan will move a valid process value into the holding register.

8B.14.10.6 Maximum Value Calculation

PLC programming shall be implemented to calculate the maximum daily value for analog process I/O points. This is achieved in PLC logic by performing the following:

- At the beginning of each day, reset the maximum value holding register to zero. For example, if a particular flow rate lower range limit is 0.00 MGD, then move a value of 0.00 into the holding register.
- On the first scan of the logic, the PLC will compare the process value to the holding register. If the process value is greater than the holding register, then move the current process value into the holding register. If the process value is less than or equal to holding register value, then the last value will remain until a process value less than the holding register is evaluated.
- This routine is performed continuously though out the day, and yields the maximum value.

- At the day's end, today's maximum value is moved to yesterday's maximum value and the current day's value is reset.
- The current day's maximum value is set to a minimum permissible value in order to ensure that the PLC's first scan will move a valid process value into the holding register.

8B.14.10.7 Average Value Calculation

PLC programming shall be implemented to calculate the average daily value for the required process I/O points. This is achieved in PLC logic by performing the following:

- At the beginning of each day, the PLC will begin to count a predefined sample rate to capture data. In this example the sample rate will be 5 seconds.
- Every 5 seconds the PLC will increment the count, capture the current process value and perform this calculation:
  Daily Average = (Current process value + Accumulated process value) / count
- This routine is performed continuously though out the day, and yields the average value.
- At the day's end, today's average value is moved to yesterday's average value and the current day's value is reset to zero. The PLC will also reset the number of counts to zero.

8B.14.11 PLC Alarms

Alarming is primarily an HMI function. While the HMI obtains its process data from the PLC, the PLC is not to be used to manage alarm activity. This means that all of the latching and acknowledgement functions are handled exclusively on the remote OIT alarm screens (if provided) and the Wonderware SCADA alarm screens. Alarms viewed and acknowledged at the remote site OIT screens will be handled independently of the alarms processed and managed by operations at the Wonderware SCADA workstations. To clarify, alarms acknowledged at the remote site OIT will not serve as an acknowledgment to alarms displayed by the Wonderware SCADA system and vice-versa. Wonderware Workstations implemented using an OIT device is considered Wonderware workstations within this context.

8B.14.11.1 Discrete Input Alarms

These alarms are sent directly to Wonderware SCADA system. These DI alarms may also be used by the PLC logic as software interlocks for process control. These DI's remain energized as long as the process condition remains in alarm.

8B.14.11.2 Discrete Derived Alarms

Discrete Derived Alarms are generated by the PLC based on process conditions, or a combination of process conditions. The PLC generates alarms if equipment fails to perform as expected. These alarms remain on in the PLC while the alarm condition exists. Some of these alarms might require a manual reset by the operator. The Wonderware SCADA system manages alarm reporting and acknowledgment within the HMI. Acknowledging and resetting are separate, independent operator functions.

(a) Fail to Start, Stop, Open, or Close

When a PLC sends a command output to the field, a timer is energized. The corresponding status feedback for the field device is used to reset the timer when the device status matches the output request. If the status feedback is not received within an operator adjustable period of time, the timer will expire and generate a failure alarm in the PLC; use a default value of 5 seconds. This alarm will be displayed on the local OIT and on the Wonderware graphics and alarm summary.

If the output is a Start command, a Fail To Start alarm will be generated.

If the output is a Stop command, a Fail To Stop alarm will be generated.

If the output is an Open command, a Fail To Open alarm will be generated.

If the output is a Close command, a Fail To Close alarm will be generated.

8B.14.11.3 Analog Derived Alarms

Analog Derived Alarms are generated based on logic applied to analog input values and/or other analog derived values. The PLCs process each analog input value to detect specified signal levels for Low-Low, Low, High, and High-High condition. Since these alarms are used by the OIT and Wonderware SCADA system, they are generated in PLC logic. Out of range alarms will be generated in PLC logic.

Provide alarm conditioning as a standard method of limiting nuisance alarms (i.e., dead band, dead band with minimum duration timers, etc.). Adjust alarm conditioning settings to ensure only valid alarms are received by the Wonderware SCADA system.

8B.14.12 Diagnostic Monitoring

Use the SCADA system to monitor the following conditions in each remote SCADA site PLC.

- RIO and I/O cards for alarm and/or fault conditions.
- PLC processors for alarm and/or fault conditions.
- Hot-backup configurations for alarm and/or fault conditions.
- Communication processors for alarm and/or fault conditions.

Provide control logic as needed to combine each of these alarms into a single common alarm bit, per category, per PLC (i.e., four bits total per remote SCADA site PLC). Historize these diagnostic conditions for long-term review from the Wonderware SCADA system. Show the status of these diagnostic conditions on the local OIT and on Wonderware graphics. Alarm these diagnostic conditions in the OIT and on the Wonderware system. Use graphics to present this diagnostic information for each remote site; condense the information on to just a few graphic screens to speed status review by operators.

8B.14.13 PLC & OIT Documentation

After PLC programming and/or OIT configuration is accepted and tested, provide the following documentation and software. Include this information as part of the ***PLC & OIT Documentation*** listed in the SCADA Manual requirements in section ***8B.9 GENERAL GUIDELINES*** under ***8B.9.8 Service Manuals.***

- PLC Program Listing – Provide a readable document that depicts the PLC control logic in a traditional fashion (e.g., ladder logic, function block programming, etc.). Must include logic element labels and rung comments that describe the operation of the logic. Rung comments must be coordinated with and reflect the requirements established in the control descriptions.

- PLC Logic Elements Labels – Provide a listing of all control elements used in a PLC application (e.g., coils, contacts, function blocks, etc.).
- PLC Memory Contents – Provide the contents of each memory location. This memory includes values for totalization, tuning, control that are typically lost when a new processor is installed, an existing processor is reset, or operational settings are not initialized to known values on program startup.
- PLC and OIT Programming Software and Licenses – Where programming software is purchased as part of project implementation, provide the original software media purchased to program the equipment and applications.
- PLC Program Source Code – Provide the application logic and configuration specific to a particular installation (e.g., Filter Backwash Control, etc.).
- Password Listing – Provide usernames and passwords for all equipment, applications, and software. Updates shall be provided whenever this information changes, so DC Water has access to all systems in production.

8B.15 VENDOR HARDWARE & SOFTWARE PREFERRED PRODUCTS GUIDELINES

8B.15.1 General

This document should be reviewed by DC Water every six (6) months to determine if any products are nearing the end of their lifecycle. If so, newer replacement products must be identified and relevant updates made to this document. This will help to avoid product availability issues during implementation where a significant time lag exists between product selection and purchase. It will also help to ensure replacement products are readily available in case repairs are needed after implementation.

8B.15.2 HMI Hardware & Software

8B.15.2.1 Wonderware SCADA Server Hardware

Given the rate at which server technology changes, consult DC Water for specifications regarding Wonderware server hardware.

8B.15.2.2 Wonderware SCADA Software (as of Sept 2014)

- Wonderware System Platform 2012.
  - Historian
    - Wonderware Historian 10,0,101,0112
    - Wonderware Historian Client Trend 10.0.200, 0595.0168.0067.0005
  - Wonderware InfoServer
  - Wonderware Application Servers
    - Protocols
      - ABTCP
      - ABCIP
      - OPC (for UPS communications)
      - Modbus/TCP
  - HMI
    - InTouch WindowMaker 10.5.001 1626.0723.0119.0100
  - Integrated Development Environment (IDE)
    - ArchestrA IDE 3.5.001 3413.0001.0120.0000, Build Date May 3, 2012

- Operator Workstation
  - Linux Operating System
  - Terminal Services Session Client
- Terminal Server
  - Wonderware InTouch 10
  - Windows Server 2008 R2

8B.15.2.3 OITs

DC Water wishes to move away from traditional Operator Interface Terminals (OITs). The goal going forward will be to develop one set of graphics that can be used for SCADA and also for the OIT at the remote sites. DC Water is looking into Wonderware Standalone Edition running on an Arista Personal Computer to satisfy this need.

8B.15.3 Communications Equipment

8B.15.3.1 Communications Hardware

See Appendix R for "DC Water IT Communications Hardware Standards." Information in this appendix is current as of November 2014.

8B.15.3.2 Cyber-Security and Communications

Refer to DC Water cyber-security and communications guidelines.

Designs should be reviewed by DC Water IT to confirm that cyber-security and communications needs are adequately addressed.

8B.15.4 PLC Hardware & Software

8B.15.4.1 Schneider-Electric (Modicon) Quantum

The following table is an inventory of products used at Anacostia, Earl Place, Eastside, Main, O Street, Potomac, Rock Creek, Upper Anacostia sewage pumping stations. Components for all new work should use the more frequently used products whenever possible to minimize spare parts inventory.

Table 2-8B-19. SCADA Quantum Inventory

Component	Model Number	Quantity	Description
CPU	CPU-113-03	4	CPU 1xMB+
CPU	CPU-434-12	6	CPU 2MB 1xMB+ 2xModbus
RIO	CRA-931-00	10	RIO Drop
RIO	CRP-931-00	6	RIO Head S908
RIO	XBE-100-00	6	Backplane Extender & Cable
COMM	NOE-771-01	10	ENET 10/100 TCP/IP I/O Scanner
HSB	CHS-110-00	4	Hot Standby Module
PS	CPS-114-20	23	AC PS 115V/230 8A, CPS114-10
PS	CPS-124-20	5	AC Redundant PS 115/230V 10A

Component	Model Number	Quantity	Description
AI	ACI-030-00	8	Analog Input 8 Channel Unipolar
AI	ACI-040-00	9	Analog Input 16 Channel Current
AI	AVI-030-00	6	Analog Input 8 Channel Isolated
AO	ACO-020-00	8	Analog Output 4 Channel Current
AO	ACO-130-00	5	Analog Output 8 Channel Current
DI	DAI-540-00	53	AC Input 115V (Isolated)
DI	DAI-543-00	27	AC Input 115V (Non-Isolated)
DI	DDI-841-00	28	DC Input 10-60V
DO	DAO-840-10	2	AC Output 24-115V
DO	DRA-840-00	42	Relay Output
CPU	~~CPU-113-02~~ *	1	CPU 1xMB+
DI	~~DAI-553-00~~ *	1	AC Input 115V 32 Point
DO	~~DAO-842-10~~ *	1	AC Output 100-230V

* Do not use. Choose another product from the list.

All PLC components must be provided with a conformal coating.

Use a Quantum system where hot standby is deemed necessary. The Schneider M340 may also be used as an alternative the Quantum at locations where hot standby capability is not required.

The SCADA System includes a variety of Allen Bradley products. However, Allen Bradley should not be used unless explicit permission is provided by DC Water.

8B.15.4.2 Programming Software

Use Unity Pro programming software available from Schneider-Electric for all new work. Use of Concept programming software maybe required at certain existing installations; consult with DC Water regarding existing installation programming requirements and software version requirements.

8B.15.5 Uninterruptible Power Supply

8B.15.5.1 500 KVA

Consult DC Water.

8B.15.5.2 2KVA

Consult DC Water.

8B.15.6 Instrumentation

Consult DC Water.

Appendix A
Sample Process & Instrumentation Drawings

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INSTRUMENT IDENTIFICATION TABLE

ISA–S5.1–1984

LETTER	FIRST LETTER: MEASURED OR INITIATING VARIABLE	FIRST LETTER: MODIFIER	SUCCEEDING LETTERS: READOUT OR PASSIVE FUNCTION	SUCCEEDING LETTERS: OUTPUT FUNCTION	SUCCEEDING LETTERS: MODIFIER
A	ANALYSIS (2)		ALARM		
B	BURNER, COMBUSTION			CLOSE, STOP, DECREASE (1)	
C				CONTROL	
D		DIFFERENTIAL		OPEN, START, INCREASE (1)	
E	VOLTAGE		SENSOR (PRIMARY ELEMENT)		
F	FLOW RATE	RATIO (FRACTION)			FAIL (1)
G			GLASS, VIEWING DEVICE		
H	HAND				HIGH (OPENED)
I	CURRENT (ELECTRICAL)		INDICATE		
J	POWER	SCAN			
K	TIME, TIME SCHEDULE	TIME RATE OF CHANGE		CONTROL STATION	
L	LEVEL		LIGHT		LOW (CLOSED)
M	MOTOR, MOTION (1)	MOMENTARY		MOTOR (1)	MIDDLE OR INTERMEDIATE
N					ON OR OPERATE (1)
O			ORIFICE, RESTRICTION		OVERLOAD (1)
P	PRESSURE, VACUUM		POINT (TEST) CONNECTION	PUMP (1)	
Q	EVENT, QUANTITY (2)	INTEGRATE, TOTALIZE			
R	RADIATION		RECORD		
S	SPEED, FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMIT	
U	MULTIVARIABLE (2)		MULTIFUNCTION (2)	MULTIFUNCTION (2)	MULTIFUNCTION (2)
V	VIBRATION, MECHANICAL ANALYSIS			VALVE, DAMPER, LOUVER	
W	WEIGHT, FORCE		WELL		
X	UNCLASSIFIED (2)		UNCLASSIFIED (2)	UNCLASSIFIED (2)	UNCLASSIFIED (2)
Y	STATE, PRESENCE			RELAY, COMPUTE, CONVERT	
Z	POSITION, DIMENSION			DRIVER, ACTUATOR, UNCLASSIFIED FINAL CONTROL ELEMENT	

(1) USER'S CHOICE

(2) WHEN USED, SYMBOL OR SIGNAL LINE IS ANNOTATED.

FLOW STREAM IDENTIFICATION*

AHP	AIR, HIGH PRESSURE PROCESS
AIS	AIR, INSTRUMENT SUPPLY
ALM	ALUM
ALP	AIR,LOW PRESSURE PROCESS
ASH	ASH
BFE	BIO–FILTER EFFLUENT
BFR	BIO–FILTER RECYCLE
BLS	BLENDED SLUDGE
BR	BRINE
BRS	BRINE SLUDGE
BRSP	BRINE, SPENT
BYP	BYPASS
CA	COOLING AIR
CDG	CARBON DIOXIDE GAS
CDL	CARBON DIOXIDE LIQUID
CEN	CENTRATE
CH	CHEMICAL
CLG	CHLORINE GAS
CLL	CHLORINE LIQUID
CLS	CHLORINE SOLUTION
CSL	CARBON SLURRY
CWR	COOLING WATER RETURN
CWS	COOLING WATER SUPPLY
CI	CORROSION INHIBITOR
DCT	DECANT
DG	DIGESTER GAS
DRN	DRAIN
DS	DIGESTED SLUDGE
DWE	DEWATERING STATION EFFLUENT
DWS	DEWATERED SLUDGE
EFF	EFFLUENT
EXG	EXHAUST GAS
FBW	FILTER BACKWASH
FC	FERRIC CHLORIDE
FCPL	PICKLE LIQUOR
FES	FERROUS SULFATE
FIW	FINISHED WATER
FL	FLUORIDE
FLE	FILTER EFFLUENT(FILTERED WATER)
FLT	FILTRATE
FLW	FILTER WASH WATER
FOR	FUEL OIL RETURN
FOS	FUEL OIL SUPPLY
GR	GRIT
GRS	GREASE
H2O2	HYDROGEN PEROXIDE
HC	HYPOCHLORITE
HG	HYDROGEN GAS
HL	LIQUID HYDROGEN
HPC	HIGH PRESSURE CONDENSATE
HPS	HIGH PRESSURE STEAM
HWR	HEATING WATER RETURN
HWS	HEATING WATER SUPPLY
INF	INFLUENT
LM	LIME, DRY
LMS	LIME SLURRY
LMSD	LIME SLUDGE
LO	LUBRICATION OIL
LPC	LOW PRESSURE CONDENSATE
LPS	LOW PRESSURE STEAM
MG	METHANE GAS
ML	MIXED LIQUOR
MW	MIXED WATER
NAC	SODIUM HYPOCHLORITE
NAH	SODIUM HYDROXIDE
NG	NITROGEN GAS
NL	NITROGEN LIQUID
OF	OVERFLOW
OG	OXYGEN GAS
OL	LIQUID OXYGEN
ORL	OXYGEN RICH LIQUID
PG	PROPANE GAS
PRE	PRIMARY EFFLUENT
PLI	PLANT INFLUENT
PRI	PRIMARY INFLUENT
PRS	PRIMARY SLUDGE
PYD	POLYMER DRY
PYL	POLYMER LIQUID
PYS	POLYMER SOLUTION
RAS	RETURN ACTIVATED SLUDGE
RAW	RAW WATER
RCY	RECYCLE
RWS	RAW WATER SAMPLE
SA	SODA ASH
SAS	SODA ASH SOLUTION
SCM	SCUM
SDG	SULFUR DIOXIDE GAS
SDL	SULFUR DIOXIDE LIQUID
SDS	SULFUR DIOXIDE SOLUTION
SE	SECONDARY EFFLUENT
SEW	SETTLED WATER
SFSW	SPENT FILTER & SCRUBBER WATER
SLG	SLUDGE
SMP	SAMPLE
SPTG	SEPTAGE
SSL	SECONDARY SLUDGE
STW	STORM WATER
SUP	SUPERNATANT
SWW	SURFACE WASHWATER
TAS	THICKENED ACTIVATED SLUDGE
TBS	THICKENER BOTTOM SLUDGE
TE	THICKENER EFFLUENT
TO	THICKENER OVERFLOW
TPS	THICKENED PRIMARY SLUDGE
TR	THICKENER RECYCLE
TS	THICKENED SLUDGE
TUF	THICKENED UNDERFLOW
UD	UNDERDRAIN
VT	VENT
WAW	WASH WATER
WAS	WASTE ACTIVATED SLUDGE
WCL	WATER, CHLORINATED PLANT EFFLUENT
WD	WATER, DISTILLED
WML	WASTE MIXED LIQUOR
WO	WATER, OZONATED
WP	WATER, POTABLE
WPS	WATER, PLANT SERVICE
WN	WATER, NON–POTABLE
WSE	WATER, SCREENED EFFLUENT
WW	WELL WATER

*IDENTIFICATION MAY BE FOLLOWED BY A NUMBER TO DIFFERENTIATE AMONG SIMILAR FLOW STREAMS. FOR EXAMPLE, CH1 & CH2 WOULD REPRESENT TWO DIFFERENT CHEMICAL FLOW STREAMS.

Figure A-1. P&ID ISA Abbreviations

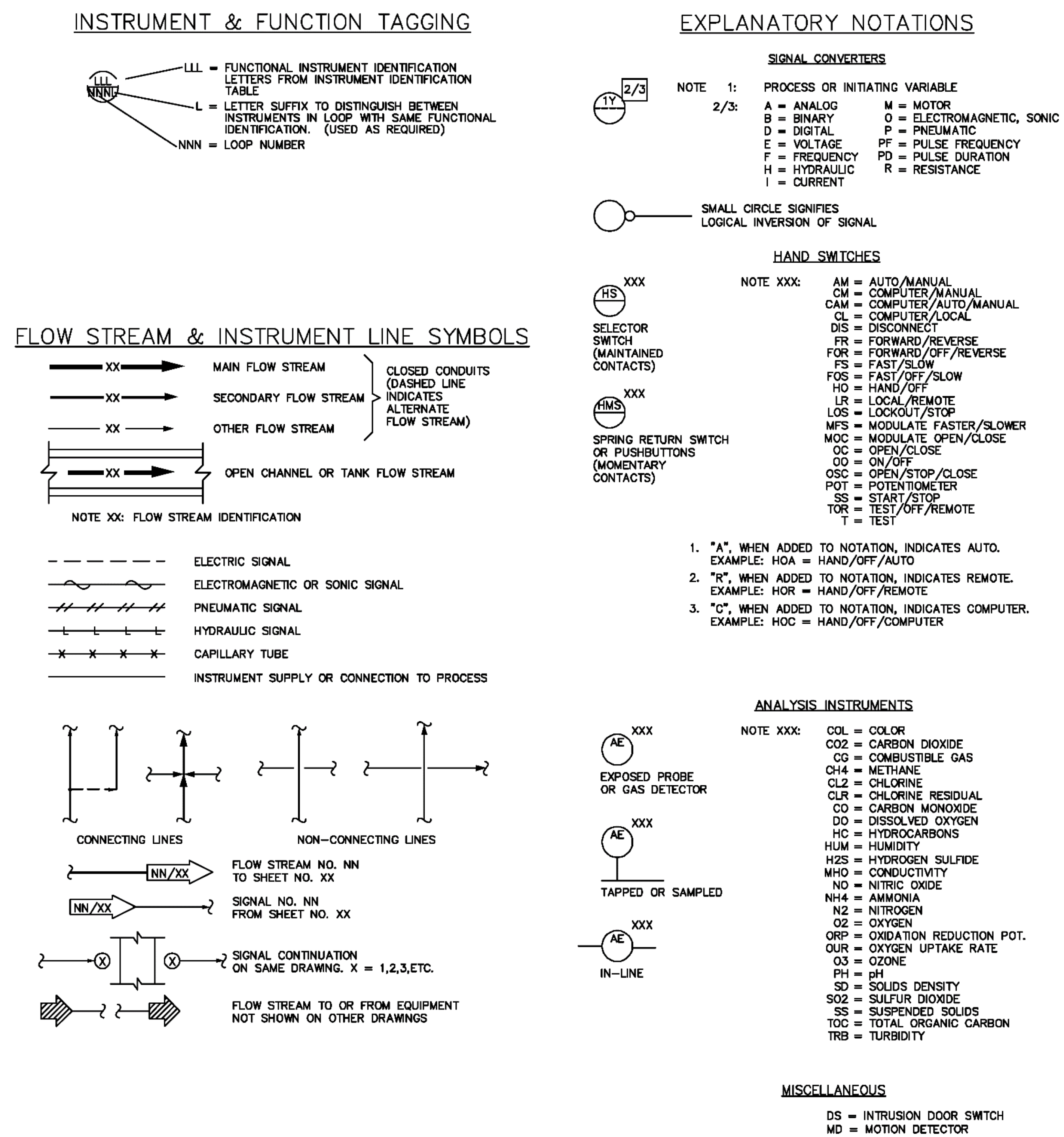


Figure A-2. P&ID Legend 1

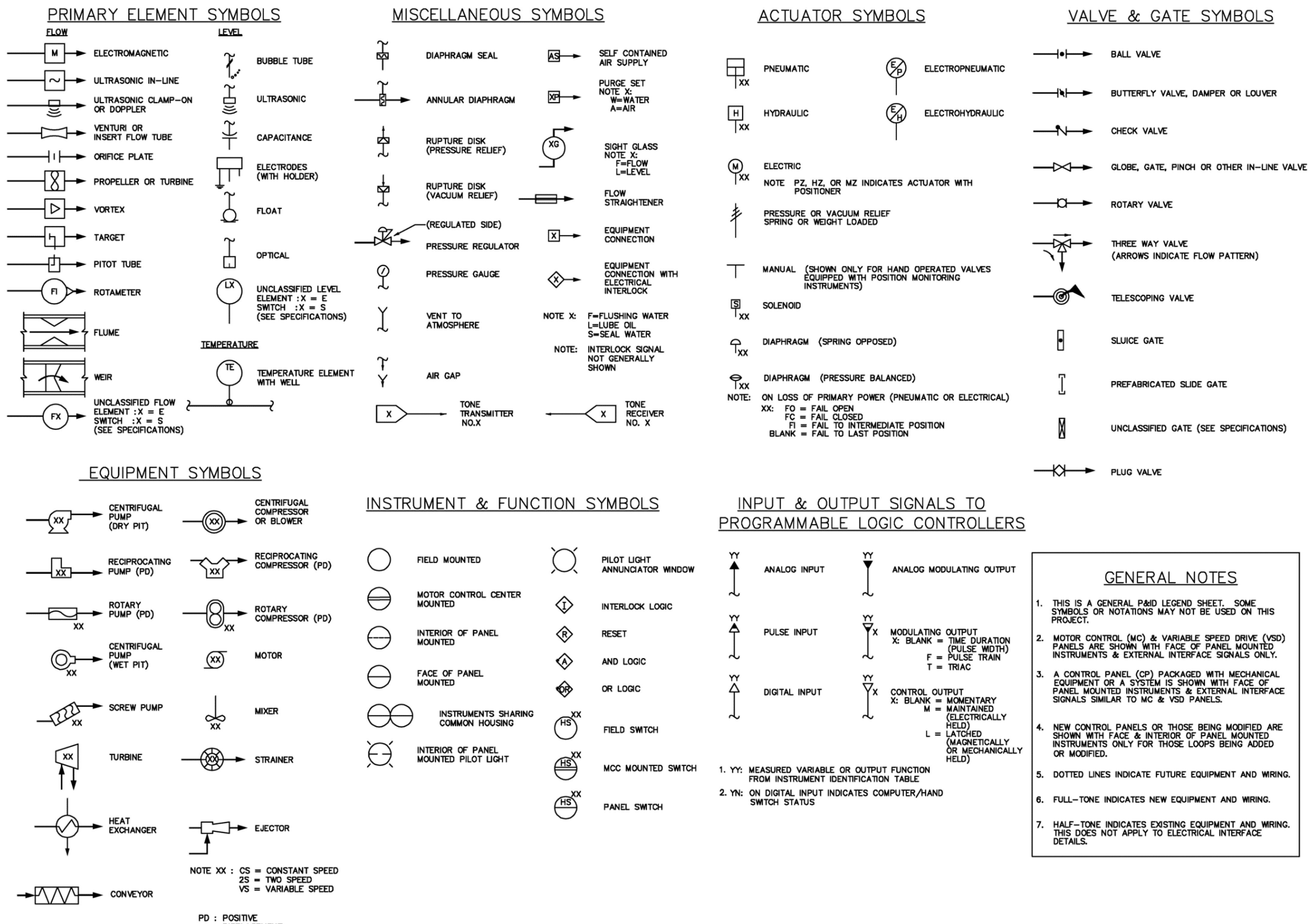
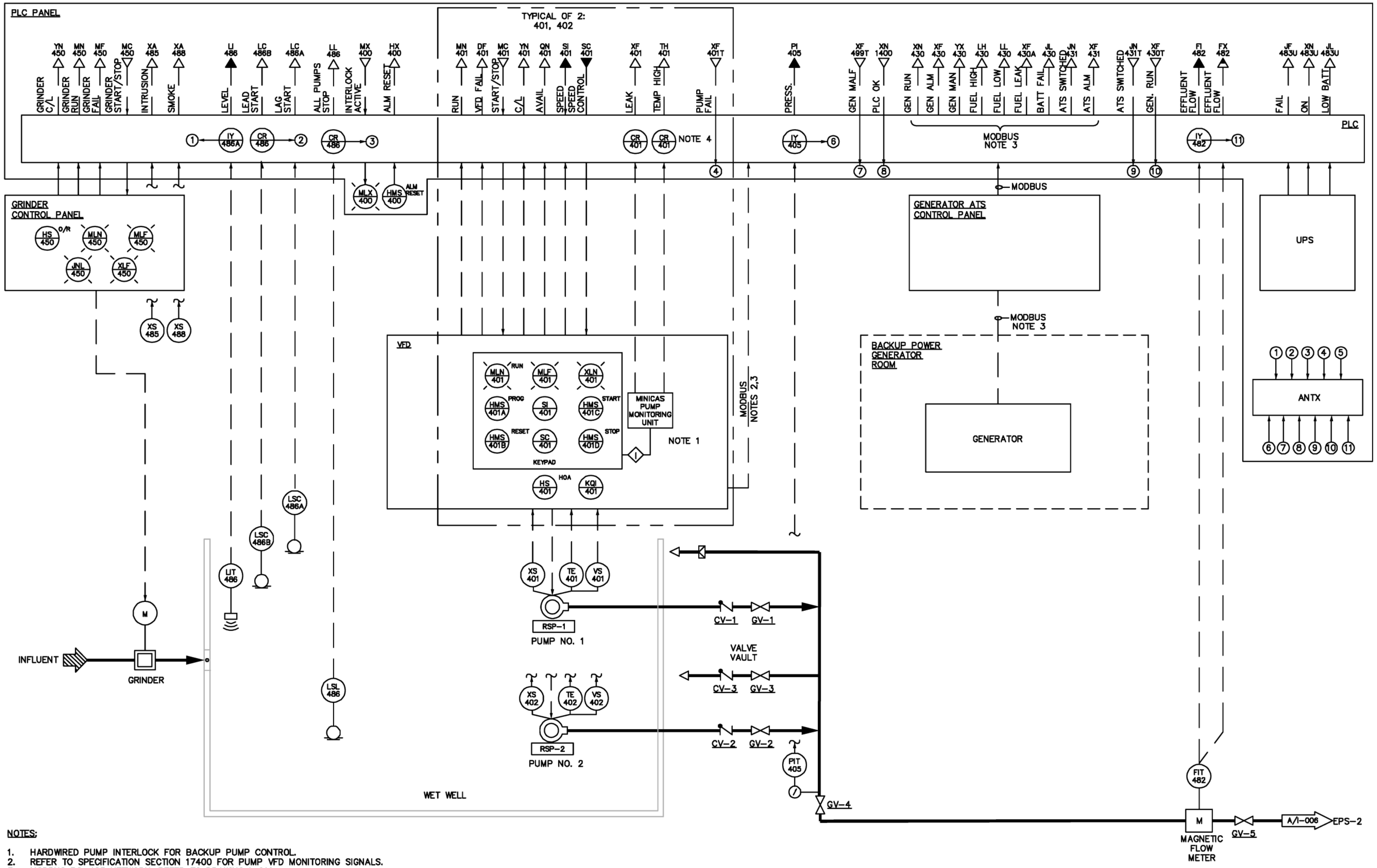


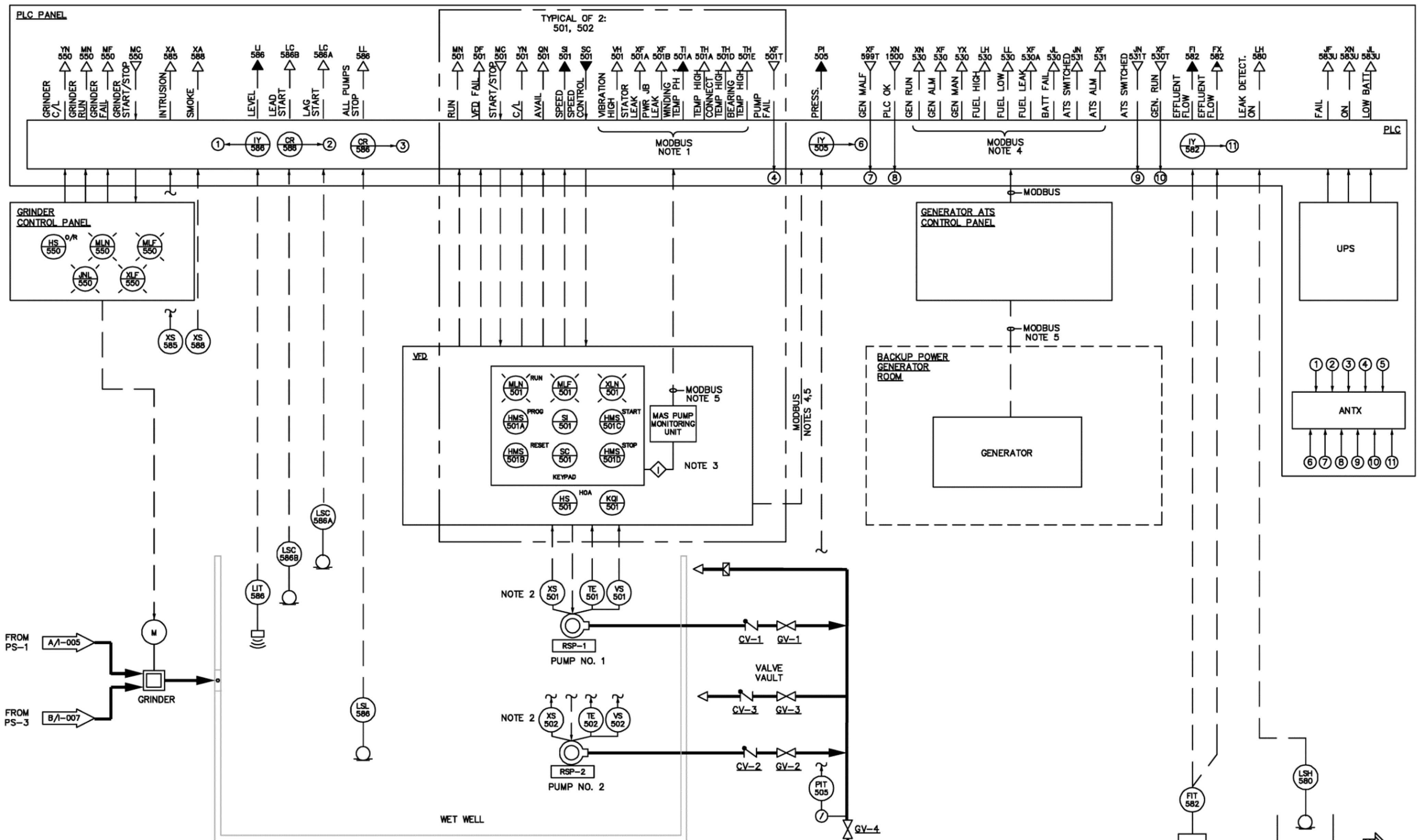
Figure A-3. P&ID Legend 2



NOTES:

1. HARDWIRED PUMP INTERLOCK FOR BACKUP PUMP CONTROL.
2. REFER TO SPECIFICATION SECTION 17400 FOR PUMP VFD MONITORING SIGNALS.
3. MODBUS RS-485 NETWORK. REFER TO DRAWING I-019.
4. PROVIDE AND INSTALL INTERPOSING RELAYS IN PLC CONTROL PANEL FOR PUMP MONITORING AS REQUIRED.

Figure A-4. Sample P&ID A



NOTES:

1. TYPICAL OF 5 RTDS AND 5 THERMAL SWITCHES PER PUMP:
   TI501A–PHASE 1 WINDING TEMP
   TI501B–PHASE 2 WINDING TEMP
   TI501C–PHASE 3 WINDING TEMP
   TI501D–MOTOR STATOR TEMP
   TI501E–BEARING TEMP

   TH501A–PHASE 1 WINDING TEMP HIGH
   TH501B–PHASE 2 WINDING TEMP HIGH
   TH501C–PHASE 3 WINDING TEMP HIGH
   TH501D–PUMP CONNECT HIGH TEMP
   TH501E–BEARING TEMP HIGH
2. TYPICAL OF 2 LEAK SENSORS PER PUMP; XS501A, XS501B, TYP.
3. HARDWIRED PUMP INTERLOCK FOR BACKUP PUMP CONTROL.
4. REFER TO SPECIFICATION SECTION 17400 FOR PUMP VFD MONITORING SIGNALS.
5. MODBUS RS-485 NETWORK. REFER TO DRAWING I-019.

Figure A-5. Sample P&ID B

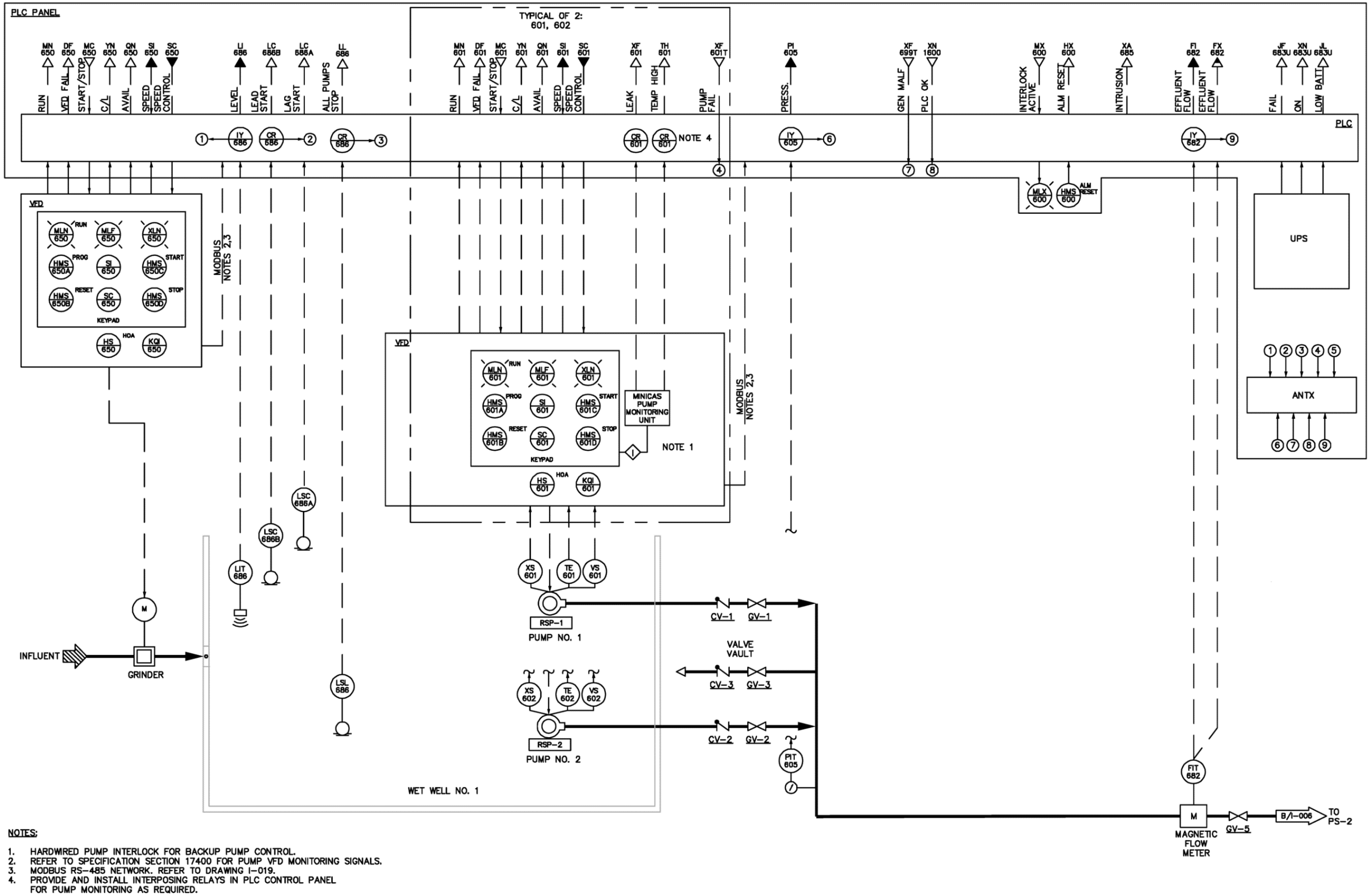


Figure A-6. Sample P&ID C

Appendix B
Sample I/O Point List

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Table B-1. Sample I/O Point List Sort 1 Page 1

Input/Output Point List - Version 1 - Sorted by PLC, Base, Slot, Point

System Grouping	Equipment Grouping	Wonderware Object.Attribute	ISA Tag	ISA Instrument	ISA Loop Number	Description	Field Interface Location	Signal Type	I/O Type	Range	Units	Loop Power	Loop Ground	Set Value	Reset Value	Invert	Alarm	I/O Interface	PLC	Rack	Slot	Point	PLC Address	Misc
Upper Anacostia SPS	Wet Well	SC_SPS_UA_WW01001.LI	LI01001	LI	01001	Wet Well 1 - Level	Bubbler Panel	AI	4 - 20 mA	0 - 28	Feet	Field	PLC				A	PLC	1	1	4	1	30001	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.PI	PI02010	PI	02010	Pump 1 Discharge Pressure	Pump	AI	4 - 20 mA	0 - 50	PSI	PLC	PLC				A	PLC	1	1	4	2	30002	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.SI	SI02010	SI	02010	Pump 1 VFD Speed	VFD	AI	4 - 20 mA	0 - 100	%	Field	PLC					PLC	1	1	4	3	30003	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.PI	PI02020	PI	02020	Pump 2 Discharge Pressure	Pump	AI	4 - 20 mA	0 - 50	PSI	PLC	PLC				A	PLC	1	1	4	4	30004	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.SI	SI02020	SI	02020	Pump 2 VFD Speed	VFD	AI	4 - 20 mA	0 - 100	%	Field	PLC					PLC	1	1	4	5	30005	
Upper Anacostia SPS	Flowmeter	SC_SPS_UA_FIT02050.FI	FI 02050	FI	02050	Pump Discharge Flow		AI	4 - 20 mA	0 - 44	GPM	Field	PLC					PLC	1	1	4	6	30006	
Upper Anacostia SPS						Spare		AI	4 - 20 mA									PLC	1	1	4	7	30007	
Upper Anacostia SPS						Spare		AI	4 - 20 mA									PLC	1	1	4	8	30008	
Upper Anacostia SPS	Wet Well	SC_SPS_UA_WW01002.LI	LI01002	LI	01002	Wet Well 2 - Level	Bubbler Panel	AI	4 - 20 mA	0 - 28	Feet	Field	PLC				A	PLC	1	1	5	1	30009	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.PI	PI02030	PI	02030	Pump 3 Discharge Pressure	Pump	AI	4 - 20 mA	0 - 50	PSI	PLC	PLC				A	PLC	1	1	5	2	30010	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.SI	SI02030	SI	02030	Pump 3 VFD Speed	VFD	AI	4 - 20 mA	0 - 100	%	Field	PLC					PLC	1	1	5	3	30011	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.PI	PI02040	PI	02040	Pump 4 Discharge Pressure	Pump	AI	4 - 20 mA	0 - 50	PSI	PLC	PLC				A	PLC	1	1	5	4	30012	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.SI	SI02040	SI	02040	Pump 4 VFD Speed	VFD	AI	4 - 20 mA	0 - 100	%	Field	PLC					PLC	1	1	5	5	30013	
Upper Anacostia SPS	Valve Vault	SC_SPS_UA_VV01010.TI	TI01010	TI	01010	Valve Vault Temperature	Valve Vault	AI	4 - 20 mA	0 - 200	F deg	PLC	PLC				A	PLC	1	1	5	6	30014	
Upper Anacostia SPS						Spare		AI	4 - 20 mA									PLC	1	1	5	7	30015	
Upper Anacostia SPS						Spare		AI	4 - 20 mA									PLC	1	1	5	8	30016	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.SC	SC02010	SC	02010	Pump 1 VFD Speed Control	MCC	AO	4 - 20 mA	0 - 100	%	PLC	PLC					PLC	1	1	7	1	40001	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.SC	SC02020	SC	02020	Pump 2 VFD Speed Control	MCC	AO	4 - 20 mA	0 - 100	%	PLC	PLC					PLC	1	1	7	2	40002	
Upper Anacostia SPS						Spare		AO	4 - 20 mA									PLC	1	1	7	3	40003	
Upper Anacostia SPS						Spare		AO	4 - 20 mA									PLC	1	1	7	4	40004	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.SC	SC02030	SC	02030	Pump 3 VFD Speed Control	MCC	AO	4 - 20 mA	0 - 100	%	PLC	PLC					PLC	1	1	8	1	40005	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.SC	SC02040	SC	02040	Pump 4 VFD Speed Control	MCC	AO	4 - 20 mA	0 - 100	%	PLC	PLC					PLC	1	1	8	2	40006	
Upper Anacostia SPS						Spare		AO	4 - 20 mA									PLC	1	1	8	3	40007	
Upper Anacostia SPS						Spare		AO	4 - 20 mA									PLC	1	1	8	4	40008	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.MN	MN02010	MN	02010	Pump 1 Run	MCC	DI	24 VDC					Run	Stop	No		PLC	1	1	9	1	10001	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.HG	HG02010	HG	02010	Pump 1 In Computer	MCC	DI	24 VDC					Computer	Local	No		PLC	1	1	9	2	10002	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.MF	MF02010	MF	02010	Pump 1 VFD Fail	MCC	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	9	3	10003	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.OX	OX02010	OX	02010	Pump 1 Seal Failure	Pump	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	9	4	10004	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.TH	TH02010	TH	02010	Pump 1 Over Temperature	Pump	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	9	5	10005	
Upper Anacostia SPS	Exhaust Fan 1	SC_SPS_UA_FAN08030.ZL	ZL08030	ZL	08030	Exhaust Fan 1 Circuit Breaker Closed	MCC	DI	24 VDC					Closed	Open	No	A	PLC	1	1	9	6	10006	
Upper Anacostia SPS	Exhaust Fan 1	SC_SPS_UA_FAN08030.MN	MN08030	MN	08030	Exhaust Fan 1 Run	MCC	DI	24 VDC					Run	Stop	No		PLC	1	1	9	7	10007	
Upper Anacostia SPS	Exhaust Fan 1	SC_SPS_UA_FAN08030.HG	HG08030	HG	08030	Exhaust Fan 1 In Computer	MCC	DI	24 VDC					Computer	Local	No		PLC	1	1	9	8	10008	
Upper Anacostia SPS	Exhaust Fan 1	SC_SPS_UA_FAN08030.MQ	MQ08030	MQ	08030	Exhaust Fan 1 Motor Overload	MCC	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	9	9	10009	
Upper Anacostia SPS	Exhaust Fan 1	SC_SPS_UA_FAN08030.ZN	ZN08030	ZN	08030	Exhaust Fan 1 Disconnect Switch	MCC	DI	24 VDC					Closed	Open	No	A	PLC	1	1	9	10	10010	
Upper Anacostia SPS	Exhaust Fan 1	SC_SPS_UA_FAN08030.FL	FL08030	FL	08030	Exhaust Fan 1 Air Flow	MCC	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	9	11	10011	
Upper Anacostia SPS	Wet Well	SC_SPS_UA_WW01000.LL	LL01000	LL	01000	Wet Well Low Water Level	Wetwell	DI	24 VDC					Normal	Low	No	A	PLC	1	1	9	12	10012	
Upper Anacostia SPS	Wet Well	SC_SPS_UA_WW01000.LH	LH01000	LH	01000	Wet Well Primary High Water Level	Wetwell	DI	24 VDC					Normal	High	No	A	PLC	1	1	9	13	10013	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	9	14	10014	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	9	15	10015	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	9	16	10016	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.MN	MN02020	MN	02020	Pump 2 Run	MCC	DI	24 VDC					Run	Stop	No		PLC	1	1	10	1	10017	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.HG	HG02020	HG	02020	Pump 2 In Computer	MCC	DI	24 VDC					Computer	Local	No		PLC	1	1	10	2	10018	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.MF	MF02020	MF	02020	Pump 2 VFD Fail	MCC	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	10	3	10019	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.OX	OX02020	OX	02020	Pump 2 Seal Failure	Pump	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	10	4	10020	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.TH	TH02020	TH	02020	Pump 2 Over Temperature	Pump	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	10	5	10021	
Upper Anacostia SPS	Supply Fan 1	SC_SPS_UA_FAN08010.ZL	ZL08010	ZL	08010	Supply Fan 1 Circuit Breaker Closed	MCC	DI	24 VDC					Closed	Open	No	A	PLC	1	1	10	6	10022	
Upper Anacostia SPS	Supply Fan 1	SC_SPS_UA_FAN08010.MN	MN08010	MN	08010	Supply Fan 1 Run	MCC	DI	24 VDC					Run	Stop	No		PLC	1	1	10	7	10023	
Upper Anacostia SPS	Supply Fan 1	SC_SPS_UA_FAN08010.HG	HG08010	HG	08010	Supply Fan 1 In Computer	MCC	DI	24 VDC					Computer	Local	No		PLC	1	1	10	8	10024	
Upper Anacostia SPS	Supply Fan 1	SC_SPS_UA_FAN08010.MQ	MQ08010	MQ	08010	Supply Fan 1 Motor Overload	MCC	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	10	9	10025	
Upper Anacostia SPS	Supply Fan 1	SC_SPS_UA_FAN08010.ZN	ZN08010	ZN	08010	Supply Fan 1 Disconnect Switch	MCC	DI	24 VDC					Closed	Open	No	A	PLC	1	1	10	10	10026	
Upper Anacostia SPS	Supply Fan 1	SC_SPS_UA_FAN08010.FL	FL08010	FL	08010	Supply Fan 1 Air Flow	MCC	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	10	11	10027	
Upper Anacostia SPS	Wet Well	SC_SPS_UA_WW01000.LA	LA01000	LA	01000	Wet Well Backup High Water Level		DI	24 VDC					Normal	High	No	A	PLC	1	1	10	12	10028	
Upper Anacostia SPS	Valve Vault	SC_SPS_UA_VV01010.LH	LH01010	LH	01010	Valve Vault High Water Level		DI	24 VDC					Normal	High	No	A	PLC	1	1	10	13	10029	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	10	14	10030	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	10	15	10031	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	10	16	10032	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.MN	MN02030	MN	02030	Pump 3 Run	MCC	DI	24 VDC					Run	Stop	No		PLC	1	1	11	1	10033	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.HG	HG02030	HG	02030	Pump 3 In Computer	MCC	DI	24 VDC					Computer	Local	No		PLC	1	1	11	2	10034	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.MF	MF02030	MF	02030	Pump 3 VFD Fail	MCC	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	11	3	10035	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.OX	OX02030	OX	02030	Pump 3 Seal Failure	Pump	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	11	4	10036	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.TH	TH02030	TH	02030	Pump 3 Over Temperature	Pump	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	11	5	10037	
Upper Anacostia SPS	Sump Pump 1	SC_SPS_UA_P03040.ZL	ZL03040	ZL	03040	Sump Pump 1 Circuit Breaker Closed	Sump Pump CP	DI	24 VDC					Closed	Open	No	A	PLC	1	1	11	6	10038	
Upper Anacostia SPS	Sump Pump 1	SC_SPS_UA_P03040.HG	HG03040	HG	03040	Sump Pump 1 In Auto	Sump Pump CP	DI	24 VDC					Auto	Not Auto	No		PLC	1	1	11	7	10039	
Upper Anacostia SPS	Sump Pump 1	SC_SPS_UA_P03040.MN	MN03040	MN	03040	Sump Pump 1 Run	Sump Pump CP	DI	24 VDC					Run	Stop	No		PLC	1	1	11	8	10040	
Upper Anacostia SPS	Sump Pump 1	SC_SPS_UA_P03040.MQ	MQ03040	MQ	03040	Sump Pump 1 Motor Overload	Sump Pump CP	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	11	9	10041	
Upper Anacostia SPS	AHU	SC_SPS_UA_FAN08040.MN	MN08040	MN	08040	Electric Room AHU CP 1 Run	MCC	DI	24 VDC					Run	Stop	No		PLC	1	1	11	10	10042	
Upper Anacostia SPS	AHU	SC_SPS_UA_FAN08040.HG	HG08040	HG	08040	Electric Room AHU CP 1 In Auto	MCC	DI	24 VDC					Auto	Not Auto	No		PLC	1	1	11	11	10043	
Upper Anacostia SPS	AHU	SC_SPS_UA_FAN08040.MQ	MQ08040	MQ	08040	Electric Room AHU CP 1 Overload	MCC	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	11	12	10044	
Upper Anacostia SPS	AHU	SC_SPS_UA_FAN08040.ZN	ZN08040	ZN	08040	Electric Room AHU CP 1 Disconnect Switch	MCC	DI	24 VDC					Closed	Open	No	A	PLC	1	1	11	13	10045	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	11	14	10046	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	11	15	10047	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	11	16	10048	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.MN	MN02040	MN	02040	Pump 4 Run	MCC	DI	24 VDC					Run	Stop	No		PLC	1	1	12	1	10049	

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Table B-2. Sample I/O Point List Sort 1 Page 2

System Grouping	Equipment Grouping	Wonderware Object.Attribute	ISA Tag	ISA Instrument	ISA Loop Number	Description	Field Interface Location	Signal Type	I/O Type	Range	Units	Loop Power	Loop Ground	Set Value	Reset Value	Invert	Alarm	I/O Interface	PLC	Rack	Slot	Point	PLC Address	Misc
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.HG	HG02040	HG	02040	Pump 4 In Computer	MCC	DI	24 VDC					Computer	Local	No		PLC	1	1	12	2	10050	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.MF	MF02040	MF	02040	Pump 4 VFD Fail	MCC	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	12	3	10051	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.OX	OX02040	OX	02040	Pump 4 Seal Failure	Pump	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	12	4	10052	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.TH	TH02040	TH	02040	Pump 4 Over Temperature	Pump	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	12	5	10053	
Upper Anacostia SPS	Sump Pump 2	SC_SPS_UA_P03050.ZL	ZL03050	ZL	03050	Sump Pump 2 Circuit Breaker Closed	Sump Pump CP	DI	24 VDC					Closed	Open	No	A	PLC	1	1	12	6	10054	
Upper Anacostia SPS	Sump Pump 2	SC_SPS_UA_P03050.HG	HG03050	HG	03050	Sump Pump 2 In Auto	Sump Pump CP	DI	24 VDC					Auto	Not Auto	No		PLC	1	1	12	7	10055	
Upper Anacostia SPS	Sump Pump 2	SC_SPS_UA_P03050.MN	MN03050	MN	03050	Sump Pump 2 Run	Sump Pump CP	DI	24 VDC					Run	Stop	No		PLC	1	1	12	8	10056	
Upper Anacostia SPS	Sump Pump 2	SC_SPS_UA_P03050.MQ	MQ03050	MQ	03050	Sump Pump 2 Motor Overload	Sump Pump CP	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	12	9	10057	
Upper Anacostia SPS	Valve Vault	SC_SPS_UA_VV01011.AQI	AQI01011	AQI	01011	Valve Vault Area Low Oxygen	Gas Detector	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	12	10	10058	
Upper Anacostia SPS	Valve Vault	SC_SPS_UA_VV01011.AHI	AHI01011	AHI	01011	Valve Vault Area High Hydrogen Sulfide	Gas Detector	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	12	11	10059	
Upper Anacostia SPS	Valve Vault	SC_SPS_UA_VV01011.AGI	AGI01011	AGI	01011	Valve Vault Area High LEL	Gas Detector	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	12	12	10060	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	12	13	10061	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	12	14	10062	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	12	15	10063	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	12	16	10064	
Upper Anacostia SPS	UPS	SC_SPS_UA_UPS09010.JA	JA09010	JA	09010	UPS Fault	UPS	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	1	10065	
Upper Anacostia SPS	UPS	SC_SPS_UA_UPS09010.JAL	JAL09010	JAL	09010	UPS On Battery	UPS	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	2	10066	
Upper Anacostia SPS	UPS	SC_SPS_UA_UPS09010.JL	JL09010	JL	09010	UPS Battery Low	UPS	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	3	10067	
Upper Anacostia SPS	Power	SC_SPS_UA_PWR09002.JA	JA09002	JA	09002	Loss of Power	MCC	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	4	10068	
Upper Anacostia SPS	Power	SC_SPS_UA_PWR09000.JA	JA09000	JA	09000	Power Monitor	MCC	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	5	10069	
Upper Anacostia SPS	Power	SC_SPS_UA_PWR09001.JA	JA09001	JA	09001	Normal Power On	MCC	DI	24 VDC					On	Fail	No	A	PLC	1	1	13	6	10070	
Upper Anacostia SPS	Wet Well	SC_SPS_UA_WW01000.ZXO	ZXO01000	ZXO	01000	Wet Well Intrusion	Wet Well Hatch	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	7	10071	
Upper Anacostia SPS	Valve Vault	SC_SPS_UA_VV01010.ZXO	ZXO01010	ZXO	01010	Valve Vault Intrusion	Valve Vault Hatch	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	8	10072	
Upper Anacostia SPS	Security	SC_SPS_UA_SEC07001.ZXO	ZXO07001	ZXO	07001	Building Intrusion Front Door	Front Door	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	9	10073	
Upper Anacostia SPS	Security	SC_SPS_UA_SEC07000.XI	XI07000	XI	07000	Security System Status		DI	24 VDC					Normal	Fail	No	A	PLC	1	1	13	10	10074	
Upper Anacostia SPS	Security	SC_SPS_UA_SEC07002.ZXO	ZXO07002	ZXO	07002	Building Intrusion Back Door	Back Door	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	11	10075	
Upper Anacostia SPS	Security	SC_SPS_UA_SEC07003.ZXO	ZXO07003	ZXO	07003	PLC Panel Intrusion	PLC Panel	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	12	10076	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	13	13	10077	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	13	14	10078	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	13	15	10079	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	13	16	10080	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	14	1	10081	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	14	2	10082	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	14	3	10083	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	14	4	10084	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	14	5	10085	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	14	6	10086	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	14	7	10087	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	14	8	10088	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	14	9	10089	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	14	10	10090	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	14	11	10091	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	14	12	10092	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	14	13	10093	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	14	14	10094	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	14	15	10095	
Upper Anacostia SPS						Spare		DI	24 VDC									PLC	1	1	14	16	10096	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.MMD	MMD02010	MMD	02010	Pump 1 Start		DO	MO - N.O.					Start		No		PLC	2	2	15	1	00001	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.MMB	MMB02010	MMB	02010	Pump 1 Stop		DO	MO - N.C.					Stop		No		PLC	2	2	15	2	00002	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.MMD	MMD02020	MMD	02020	Pump 2 Start		DO	MO - N.O.					Start		No		PLC	2	2	15	3	00003	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.MMB	MMB02020	MMB	02020	Pump 2 Stop		DO	MO - N.C.					Stop		No		PLC	2	2	15	4	00004	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.MMD	MMD02030	MMD	02030	Pump 3 Start		DO	MO - N.O.					Start		No		PLC	2	2	15	5	00005	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.MMB	MMB02030	MMB	02030	Pump 3 Stop		DO	MO - N.C.					Stop		No		PLC	2	2	15	6	00006	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.MMD	MMD02040	MMD	02040	Pump 4 Start		DO	MO - N.O.					Start		No		PLC	2	2	15	7	00007	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.MMB	MMB02040	MMB	02040	Pump 4 Stop		DO	MO - N.C.					Stop		No		PLC	2	2	15	8	00008	
Upper Anacostia SPS	Exhaust Fan 1	SC_SPS_UA_FAN08030.MMD	MMD08030	MMD	08030	Exhaust Fan 1 Start		DO	MO - N.O.					Start		No		PLC	2	2	15	9	00009	
Upper Anacostia SPS	Exhaust Fan 1	SC_SPS_UA_FAN08030.MMB	MMB08030	MMB	08030	Exhaust Fan 1 Stop		DO	MO - N.C.					Stop		No		PLC	2	2	15	10	00010	
Upper Anacostia SPS	Supply Fan 1	SC_SPS_UA_FAN08010.MMD	MMD08010	MMD	08010	Supply Fan 1 Start		DO	MO - N.O.					Start		No		PLC	2	2	15	11	00011	
Upper Anacostia SPS	Supply Fan 1	SC_SPS_UA_FAN08010.MMB	MMB08010	MMB	08010	Supply Fan 1 Stop		DO	MO - N.C.					Stop		No		PLC	2	2	15	12	00012	
Upper Anacostia SPS						Spare		DO										PLC	2	2	15	13	00013	
Upper Anacostia SPS						Spare		DO										PLC	2	2	15	14	00014	
Upper Anacostia SPS						Spare		DO										PLC	2	2	15	15	00015	
Upper Anacostia SPS						Spare		DO										PLC	2	2	15	16	00016	

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Table B-3. Sample I/O Point List Sort 2 Page 1

Input/Output Point List - Version 2 - ISA Loop Number, Signal Type, ISA Instrument

System Grouping	Equipment Grouping	Wonderware Object.Attribute	ISA Tag	ISA Instrument	ISA Loop Number	Description	Field Interface Location	Signal Type	I/O Type	Range	Units	Loop Power	Loop Ground	Set Value	Reset Value	Invert	Alarm	I/O Interface	PLC	Rack	Slot	Point	PLC Address	Misc
Upper Anacostia SPS	Wet Well	SC_SPS_UA_WW01000.LA	LA01000	LA	01000	Wet Well Backup High Water Level		DI	24 VDC					Normal	High	No	A	PLC	1	1	10	12	10028	
Upper Anacostia SPS	Wet Well	SC_SPS_UA_WW01000.LH	LH01000	LH	01000	Wet Well Primary High Water Level	Wetwell	DI	24 VDC					Normal	High	No	A	PLC	1	1	9	13	10013	
Upper Anacostia SPS	Wet Well	SC_SPS_UA_WW01000.LL	LL01000	LL	01000	Wet Well Low Water Level	Wetwell	DI	24 VDC					Normal	Low	No	A	PLC	1	1	9	12	10012	
Upper Anacostia SPS	Wet Well	SC_SPS_UA_WW01000.ZXO	ZXO01000	ZXO	01000	Wet Well Intrusion	Wet Well Hatch	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	7	10071	
Upper Anacostia SPS	Wet Well	SC_SPS_UA_WW01001.LI	LI01001	LI	01001	Wet Well 1 - Level	Bubbler Panel	AI	4 - 20 mA	0 - 28	Feet	Field	PLC				A	PLC	1	1	4	1	30001	
Upper Anacostia SPS	Wet Well	SC_SPS_UA_WW01002.LI	LI01002	LI	01002	Wet Well 2 - Level	Bubbler Panel	AI	4 - 20 mA	0 - 28	Feet	Field	PLC				A	PLC	1	1	5	1	30009	
Upper Anacostia SPS	Valve Vault	SC_SPS_UA_VV01010.TI	TI01010	TI	01010	Valve Vault Temperature	Valve Vault	AI	4 - 20 mA	0 - 200	F deg	PLC	PLC				A	PLC	1	1	5	6	30014	
Upper Anacostia SPS	Valve Vault	SC_SPS_UA_VV01010.LH	LH01010	LH	01010	Valve Vault High Water Level		DI	24 VDC					Normal	High	No	A	PLC	1	1	10	13	10029	
Upper Anacostia SPS	Valve Vault	SC_SPS_UA_VV01010.ZXO	ZXO01010	ZXO	01010	Valve Vault Intrusion	Valve Vault Hatch	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	8	10072	
Upper Anacostia SPS	Valve Vault	SC_SPS_UA_VV01011.AGI	AGI01011	AGI	01011	Valve Vault Area High LEL	Gas Detector	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	12	12	10060	
Upper Anacostia SPS	Valve Vault	SC_SPS_UA_VV01011.AHI	AHI01011	AHI	01011	Valve Vault Area High Hydrogen Sulfide	Gas Detector	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	12	11	10059	
Upper Anacostia SPS	Valve Vault	SC_SPS_UA_VV01011.AQI	AQI01011	AQI	01011	Valve Vault Area Low Oxygen	Gas Detector	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	12	10	10058	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.PI	PI02010	PI	02010	Pump 1 Discharge Pressure	Pump	AI	4 - 20 mA	0 - 50	PSI	PLC	PLC				A	PLC	1	1	4	2	30002	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.SI	SI02010	SI	02010	Pump 1 VFD Speed	VFD	AI	4 - 20 mA	0 - 100	%	Field	PLC					PLC	1	1	4	3	30003	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.SC	SC02010	SC	02010	Pump 1 VFD Speed Control	MCC	AO	4 - 20 mA	0 - 100	%	PLC	PLC					PLC	1	1	7	1	40001	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.HG	HG02010	HG	02010	Pump 1 In Computer	MCC	DI	24 VDC					Computer	Local	No		PLC	1	1	9	2	10002	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.MF	MF02010	MF	02010	Pump 1 VFD Fail	MCC	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	9	3	10003	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.MN	MN02010	MN	02010	Pump 1 Run	MCC	DI	24 VDC					Run	Stop	No		PLC	1	1	9	1	10001	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.OX	OX02010	OX	02010	Pump 1 Seal Failure	Pump	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	9	4	10004	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.TH	TH02010	TH	02010	Pump 1 Over Temperature	Pump	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	9	5	10005	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.MMB	MMB02010	MMB	02010	Pump 1 Stop		DO	MO - N.C.					Stop		No		PLC	2	2	15	2	00002	
Upper Anacostia SPS	Pump 1	SC_SPS_UA_P02010.MMD	MMD02010	MMD	02010	Pump 1 Start		DO	MO - N.O.					Start		No		PLC	2	2	15	1	00001	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.PI	PI02020	PI	02020	Pump 2 Discharge Pressure	Pump	AI	4 - 20 mA	0 - 50	PSI	PLC	PLC				A	PLC	1	1	4	4	30004	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.SI	SI02020	SI	02020	Pump 2 VFD Speed	VFD	AI	4 - 20 mA	0 - 100	%	Field	PLC					PLC	1	1	4	5	30005	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.SC	SC02020	SC	02020	Pump 2 VFD Speed Control	MCC	AO	4 - 20 mA	0 - 100	%	PLC	PLC					PLC	1	1	7	2	40002	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.HG	HG02020	HG	02020	Pump 2 In Computer	MCC	DI	24 VDC					Computer	Local	No		PLC	1	1	10	2	10018	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.MF	MF02020	MF	02020	Pump 2 VFD Fail	MCC	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	10	3	10019	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.MN	MN02020	MN	02020	Pump 2 Run	MCC	DI	24 VDC					Run	Stop	No		PLC	1	1	10	1	10017	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.OX	OX02020	OX	02020	Pump 2 Seal Failure	Pump	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	10	4	10020	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.TH	TH02020	TH	02020	Pump 2 Over Temperature	Pump	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	10	5	10021	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.MMB	MMB02020	MMB	02020	Pump 2 Stop		DO	MO - N.C.					Stop		No		PLC	2	2	15	4	00004	
Upper Anacostia SPS	Pump 2	SC_SPS_UA_P02020.MMD	MMD02020	MMD	02020	Pump 2 Start		DO	MO - N.O.					Start		No		PLC	2	2	15	3	00003	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.PI	PI02030	PI	02030	Pump 3 Discharge Pressure	Pump	AI	4 - 20 mA	0 - 50	PSI	PLC	PLC				A	PLC	1	1	5	2	30010	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.SI	SI02030	SI	02030	Pump 3 VFD Speed	VFD	AI	4 - 20 mA	0 - 100	%	Field	PLC					PLC	1	1	5	3	30011	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.SC	SC02030	SC	02030	Pump 3 VFD Speed Control	MCC	AO	4 - 20 mA	0 - 100	%	PLC	PLC					PLC	1	1	8	1	40005	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.HG	HG02030	HG	02030	Pump 3 In Computer	MCC	DI	24 VDC					Computer	Local	No		PLC	1	1	11	2	10034	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.MF	MF02030	MF	02030	Pump 3 VFD Fail	MCC	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	11	3	10035	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.MN	MN02030	MN	02030	Pump 3 Run	MCC	DI	24 VDC					Run	Stop	No		PLC	1	1	11	1	10033	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.OX	OX02030	OX	02030	Pump 3 Seal Failure	Pump	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	11	4	10036	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.TH	TH02030	TH	02030	Pump 3 Over Temperature	Pump	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	11	5	10037	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.MMB	MMB02030	MMB	02030	Pump 3 Stop		DO	MO - N.C.					Stop		No		PLC	2	2	15	6	00006	
Upper Anacostia SPS	Pump 3	SC_SPS_UA_P02030.MMD	MMD02030	MMD	02030	Pump 3 Start		DO	MO - N.O.					Start		No		PLC	2	2	15	5	00005	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.PI	PI02040	PI	02040	Pump 4 Discharge Pressure	Pump	AI	4 - 20 mA	0 - 50	PSI	PLC	PLC				A	PLC	1	1	5	4	30012	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.SI	SI02040	SI	02040	Pump 4 VFD Speed	VFD	AI	4 - 20 mA	0 - 100	%	Field	PLC					PLC	1	1	5	5	30013	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.SC	SC02040	SC	02040	Pump 4 VFD Speed Control	MCC	AO	4 - 20 mA	0 - 100	%	PLC	PLC					PLC	1	1	8	2	40006	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.HG	HG02040	HG	02040	Pump 4 In Computer	MCC	DI	24 VDC					Computer	Local	No		PLC	1	1	12	2	10050	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.MF	MF02040	MF	02040	Pump 4 VFD Fail	MCC	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	12	3	10051	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.MN	MN02040	MN	02040	Pump 4 Run	MCC	DI	24 VDC					Run	Stop	No		PLC	1	1	12	1	10049	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.OX	OX02040	OX	02040	Pump 4 Seal Failure	Pump	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	12	4	10052	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.TH	TH02040	TH	02040	Pump 4 Over Temperature	Pump	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	12	5	10053	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.MMB	MMB02040	MMB	02040	Pump 4 Stop		DO	MO - N.C.					Stop		No		PLC	2	2	15	8	00008	
Upper Anacostia SPS	Pump 4	SC_SPS_UA_P02040.MMD	MMD02040	MMD	02040	Pump 4 Start		DO	MO - N.O.					Start		No		PLC	2	2	15	7	00007	
Upper Anacostia SPS	Flowmeter	SC_SPS_UA_FIT02050.FI	FI 02050	FI	02050	Pump Discharge Flow		AI	4 - 20 mA	0 - 44	GPM	Field	PLC					PLC	1	1	4	6	30006	
Upper Anacostia SPS	Sump Pump 1	SC_SPS_UA_P03040.HG	HG03040	HG	03040	Sump Pump 1 In Auto	Sump Pump CP	DI	24 VDC					Auto	Not Auto	No		PLC	1	1	11	7	10039	
Upper Anacostia SPS	Sump Pump 1	SC_SPS_UA_P03040.MN	MN03040	MN	03040	Sump Pump 1 Run	Sump Pump CP	DI	24 VDC					Run	Stop	No		PLC	1	1	11	8	10040	
Upper Anacostia SPS	Sump Pump 1	SC_SPS_UA_P03040.MQ	MQ03040	MQ	03040	Sump Pump 1 Motor Overload	Sump Pump CP	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	11	9	10041	
Upper Anacostia SPS	Sump Pump 1	SC_SPS_UA_P03040.ZL	ZL03040	ZL	03040	Sump Pump 1 Circuit Breaker Closed	Sump Pump CP	DI	24 VDC					Closed	Open	No	A	PLC	1	1	11	6	10038	
Upper Anacostia SPS	Sump Pump 2	SC_SPS_UA_P03050.HG	HG03050	HG	03050	Sump Pump 2 In Auto	Sump Pump CP	DI	24 VDC					Auto	Not Auto	No		PLC	1	1	12	7	10055	
Upper Anacostia SPS	Sump Pump 2	SC_SPS_UA_P03050.MN	MN03050	MN	03050	Sump Pump 2 Run	Sump Pump CP	DI	24 VDC					Run	Stop	No		PLC	1	1	12	8	10056	
Upper Anacostia SPS	Sump Pump 2	SC_SPS_UA_P03050.MQ	MQ03050	MQ	03050	Sump Pump 2 Motor Overload	Sump Pump CP	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	12	9	10057	
Upper Anacostia SPS	Sump Pump 2	SC_SPS_UA_P03050.ZL	ZL03050	ZL	03050	Sump Pump 2 Circuit Breaker Closed	Sump Pump CP	DI	24 VDC					Closed	Open	No	A	PLC	1	1	12	6	10054	
Upper Anacostia SPS	Security	SC_SPS_UA_SEC07000.XI	XI07000	XI	07000	Security System Status		DI	24 VDC					Normal	Fail	No	A	PLC	1	1	13	10	10074	
Upper Anacostia SPS	Security	SC_SPS_UA_SEC07001.ZXO	ZXO07001	ZXO	07001	Building Intrusion Front Door	Front Door	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	9	10073	
Upper Anacostia SPS	Security	SC_SPS_UA_SEC07002.ZXO	ZXO07002	ZXO	07002	Building Intrusion Back Door	Back Door	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	11	10075	
Upper Anacostia SPS	Security	SC_SPS_UA_SEC07003.ZXO	ZXO07003	ZXO	07003	PLC Panel Intrusion	PLC Panel	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	12	10076	
Upper Anacostia SPS	Supply Fan 1	SC_SPS_UA_FAN08010.FL	FL08010	FL	08010	Supply Fan 1 Air Flow	MCC	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	10	11	10027	
Upper Anacostia SPS	Supply Fan 1	SC_SPS_UA_FAN08010.HG	HG08010	HG	08010	Supply Fan 1 In Computer	MCC	DI	24 VDC					Computer	Local	No		PLC	1	1	10	8	10024	
Upper Anacostia SPS	Supply Fan 1	SC_SPS_UA_FAN08010.MN	MN08010	MN	08010	Supply Fan 1 Run	MCC	DI	24 VDC					Run	Stop	No		PLC	1	1	10	7	10023	
Upper Anacostia SPS	Supply Fan 1	SC_SPS_UA_FAN08010.MQ	MQ08010	MQ	08010	Supply Fan 1 Motor Overload	MCC	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	10	9	10025	
Upper Anacostia SPS	Supply Fan 1	SC_SPS_UA_FAN08010.ZL	ZL08010	ZL	08010	Supply Fan 1 Circuit Breaker Closed	MCC	DI	24 VDC					Closed	Open	No	A	PLC	1	1	10	6	10022	
Upper Anacostia SPS	Supply Fan 1	SC_SPS_UA_FAN08010.ZN	ZN08010	ZN	08010	Supply Fan 1 Disconnect Switch	MCC	DI	24 VDC					Closed	Open	No	A	PLC	1	1	10	10	10026	
Upper Anacostia SPS	Supply Fan 1	SC_SPS_UA_FAN08010.MMB	MMB08010	MMB	08010	Supply Fan 1 Stop		DO	MO - N.C.					Stop		No		PLC	2	2	15	12	00012	
Upper Anacostia SPS	Supply Fan 1	SC_SPS_UA_FAN08010.MMD	MMD08010	MMD	08010	Supply Fan 1 Start		DO	MO - N.O.					Start		No		PLC	2	2	15	11	00011	

NOTE: A significant amount of information on this I/O List was altered for illustrative purpose. Do not use this I/O List.

Table B-4. Sample I/O Point List Sort 2 Page 2

Input/Output Point List - Version 2 - ISA Loop Number, Signal Type, ISA Instrument

Upper Anacostia SPS	Exhaust Fan 1	SC_SPS_UA_FAN08030.FL	FL08030	FL	08030	Exhaust Fan 1 Air Flow	MCC	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	9	11	10011	
Upper Anacostia SPS	Exhaust Fan 1	SC_SPS_UA_FAN08030.HG	HG08030	HG	08030	Exhaust Fan 1 In Computer	MCC	DI	24 VDC					Computer	Local	No		PLC	1	1	9	8	10008	
Upper Anacostia SPS	Exhaust Fan 1	SC_SPS_UA_FAN08030.MN	MN08030	MN	08030	Exhaust Fan 1 Run	MCC	DI	24 VDC					Run	Stop	No		PLC	1	1	9	7	10007	
Upper Anacostia SPS	Exhaust Fan 1	SC_SPS_UA_FAN08030.MQ	MQ08030	MQ	08030	Exhaust Fan 1 Motor Overload	MCC	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	9	9	10009	
Upper Anacostia SPS	Exhaust Fan 1	SC_SPS_UA_FAN08030.ZL	ZL08030	ZL	08030	Exhaust Fan 1 Circuit Breaker Closed	MCC	DI	24 VDC					Closed	Open	No	A	PLC	1	1	9	6	10006	
Upper Anacostia SPS	Exhaust Fan 1	SC_SPS_UA_FAN08030.ZN	ZN08030	ZN	08030	Exhaust Fan 1 Disconnect Switch	MCC	DI	24 VDC					Closed	Open	No	A	PLC	1	1	9	10	10010	
Upper Anacostia SPS	Exhaust Fan 1	SC_SPS_UA_FAN08030.MMB	MMB08030	MMB	08030	Exhaust Fan 1 Stop		DO	MO - N.C.					Stop		No		PLC	2	2	15	10	00010	
Upper Anacostia SPS	Exhaust Fan 1	SC_SPS_UA_FAN08030.MMD	MMD08030	MMD	08030	Exhaust Fan 1 Start		DO	MO - N.O.					Start		No		PLC	2	2	15	9	00009	
Upper Anacostia SPS	AHU	SC_SPS_UA_FAN08040.HG	HG08040	HG	08040	Electric Room AHU CP 1 In Auto	MCC	DI	24 VDC					Auto	Not Auto	No		PLC	1	1	11	11	10043	
Upper Anacostia SPS	AHU	SC_SPS_UA_FAN08040.MN	MN08040	MN	08040	Electric Room AHU CP 1 Run	MCC	DI	24 VDC					Run	Stop	No		PLC	1	1	11	10	10042	
Upper Anacostia SPS	AHU	SC_SPS_UA_FAN08040.MQ	MQ08040	MQ	08040	Electric Room AHU CP 1 Overload	MCC	DI	24 VDC					Normal	Fail	No	A	PLC	1	1	11	12	10044	
Upper Anacostia SPS	AHU	SC_SPS_UA_FAN08040.ZN	ZN08040	ZN	08040	Electric Room AHU CP 1 Disconnect Switch	MCC	DI	24 VDC					Closed	Open	No	A	PLC	1	1	11	13	10045	
Upper Anacostia SPS	Power	SC_SPS_UA_PWR09000.JA	JA09000	JA	09000	Power Monitor	MCC	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	5	10069	
Upper Anacostia SPS	Power	SC_SPS_UA_PWR09001.JA	JA09001	JA	09001	Normal Power On	MCC	DI	24 VDC					On	Fail	No	A	PLC	1	1	13	6	10070	
Upper Anacostia SPS	Power	SC_SPS_UA_PWR09002.JA	JA09002	JA	09002	Loss of Power	MCC	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	4	10068	
Upper Anacostia SPS	UPS	SC_SPS_UA_UPS09010.JA	JA09010	JA	09010	UPS Fault	UPS	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	1	10065	
Upper Anacostia SPS	UPS	SC_SPS_UA_UPS09010.JAL	JAL09010	JAL	09010	UPS On Battery	UPS	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	2	10066	
Upper Anacostia SPS	UPS	SC_SPS_UA_UPS09010.JL	JL09010	JL	09010	UPS Battery Low	UPS	DI	24 VDC					Normal	Alarm	No	A	PLC	1	1	13	3	10067	

NOTE: A significant amount of information on this I/O List was altered for illustrative purpose. Do not use this I/O List.

Appendix C
Sample Process Flow Diagram

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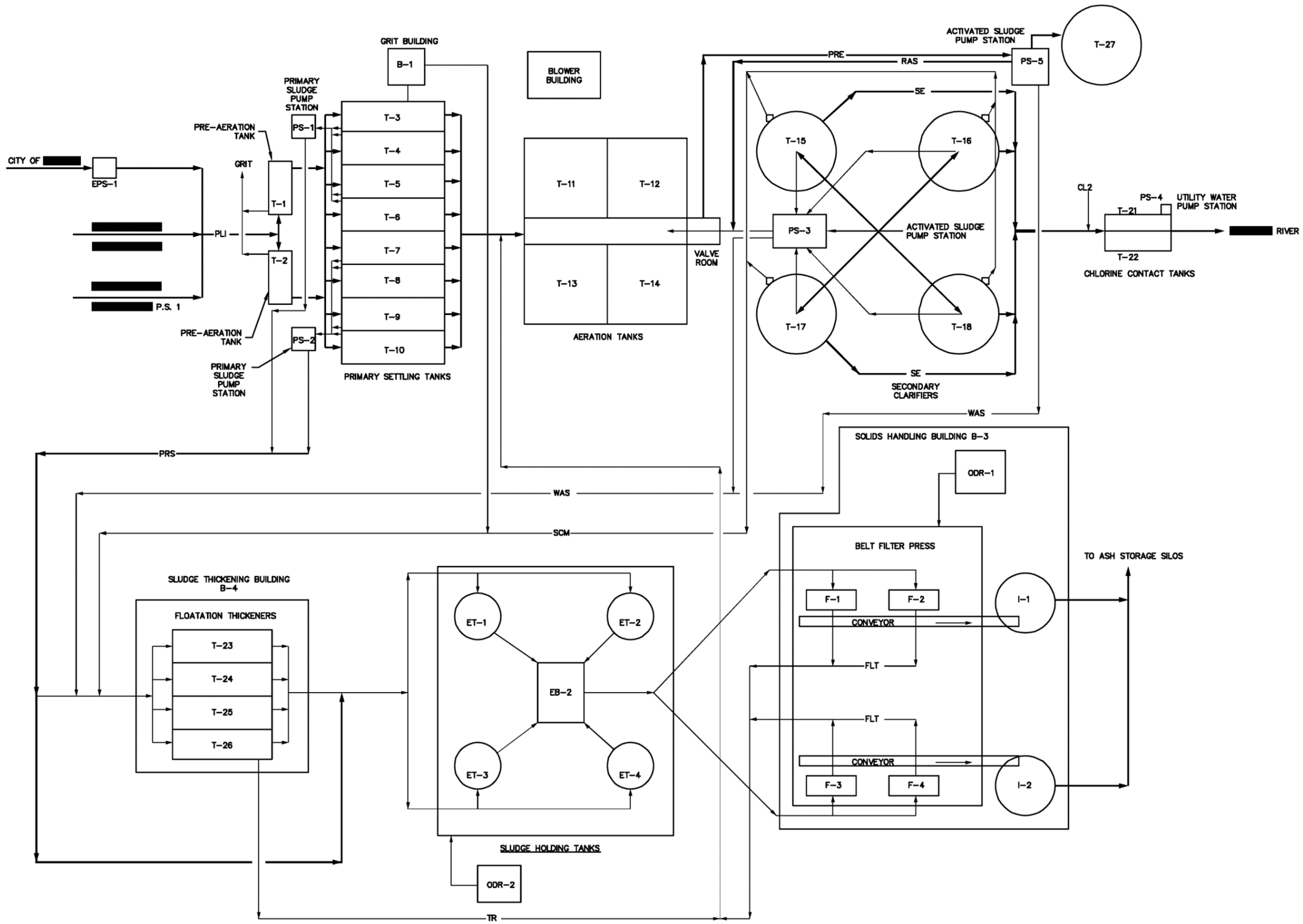

Figure C-1.Sample Process Flow Diagram

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Appendix D
Sample Network and Communication Drawing

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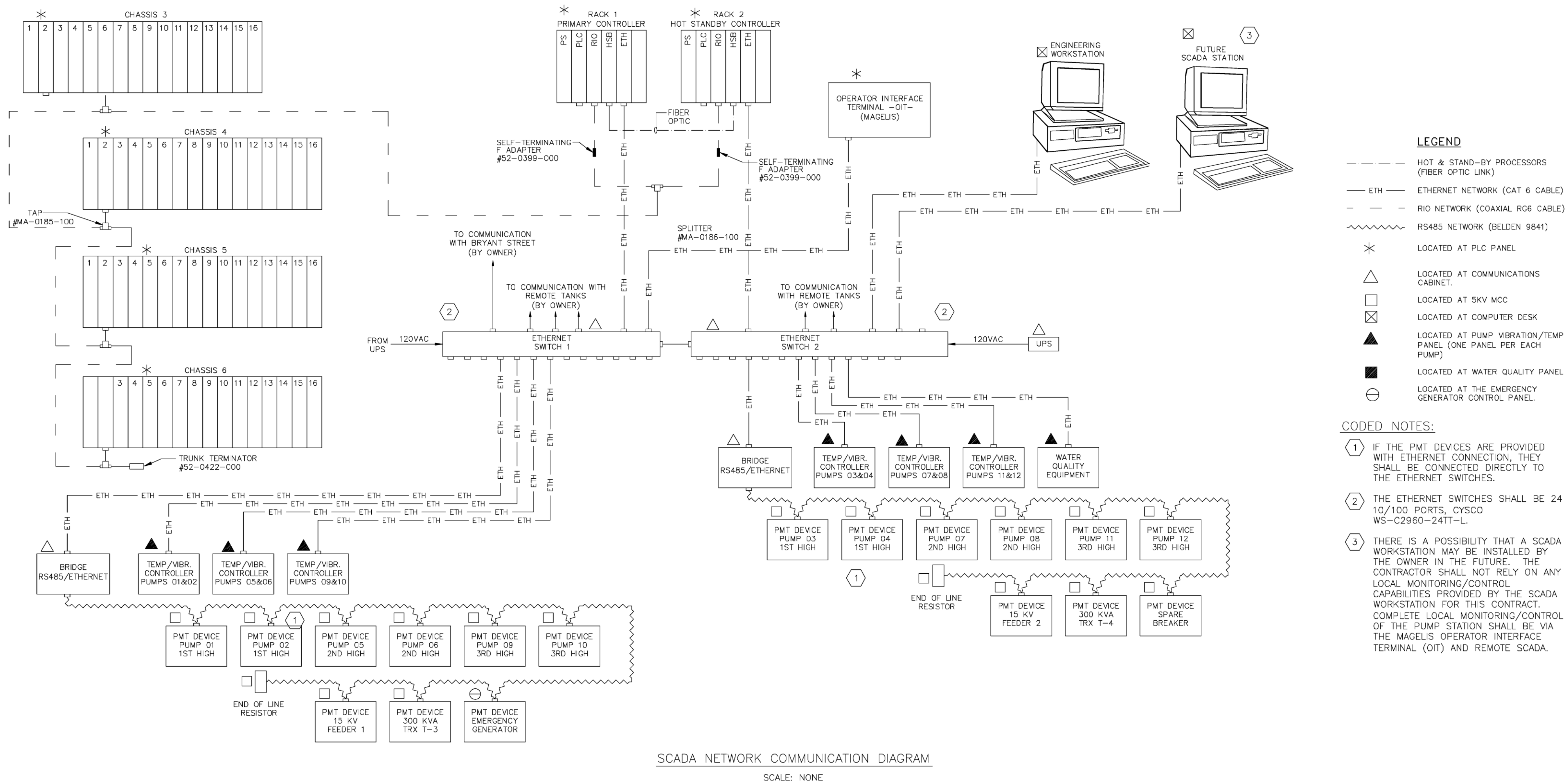

Figure D-1. Sample Network and Communication Drawing

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Appendix E
Sample Software Architecture & Data Flow Drawing

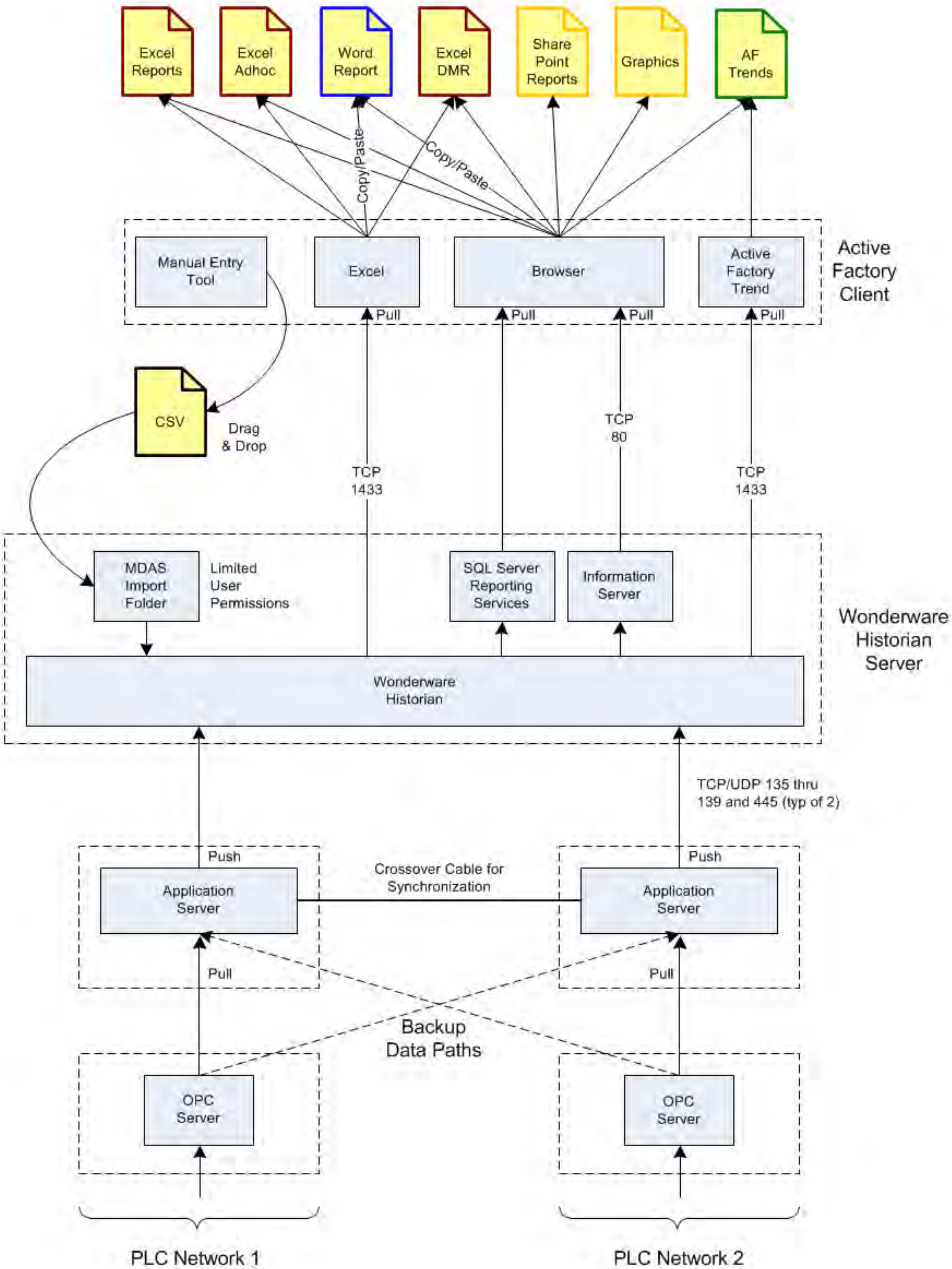

Figure E-1. Sample Software Architecture & Data Flow Drawing

Appendix F
Sample Control Panel Drawings

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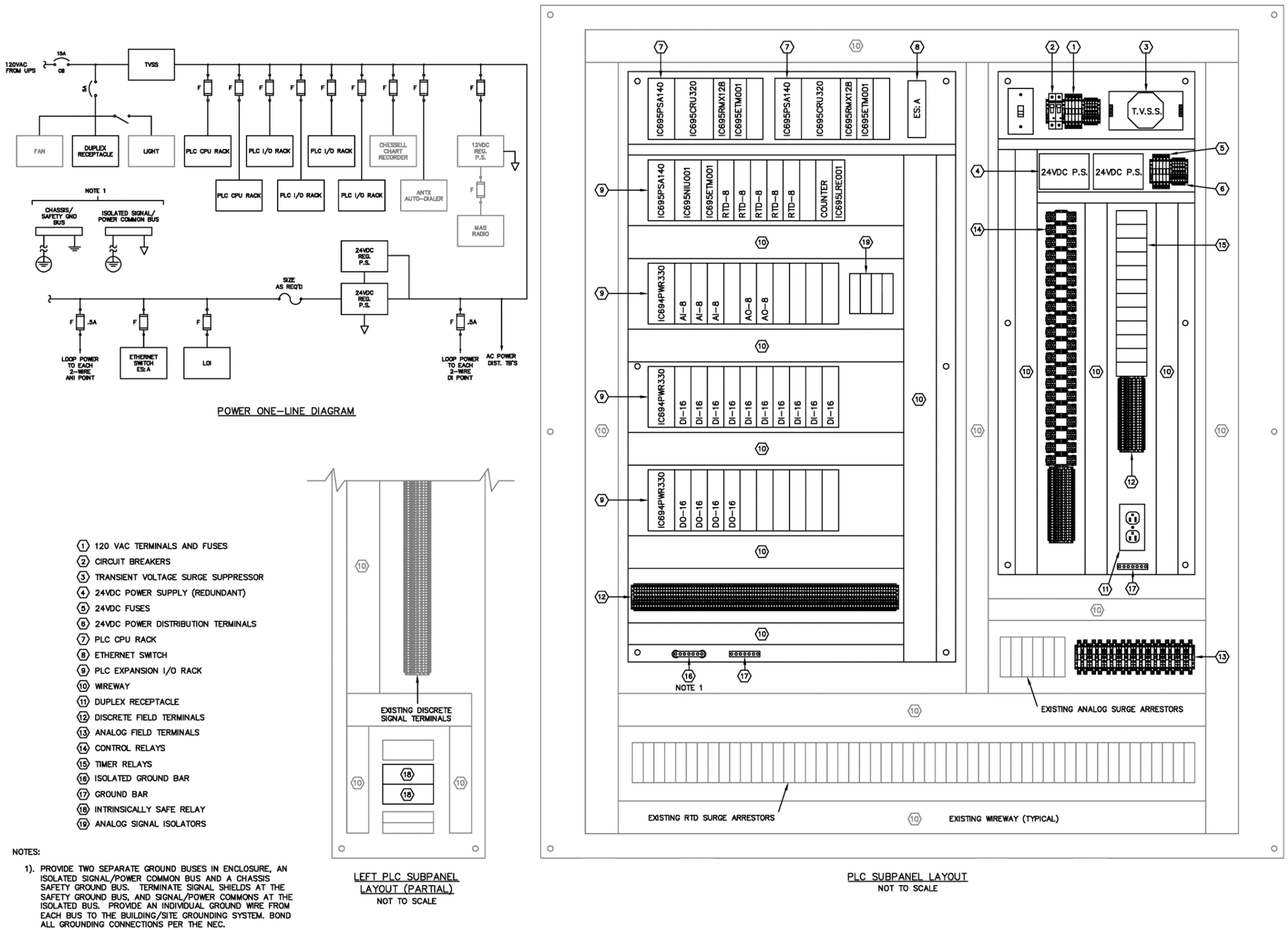

Figure F-1. Sample Control Panel Drawing A

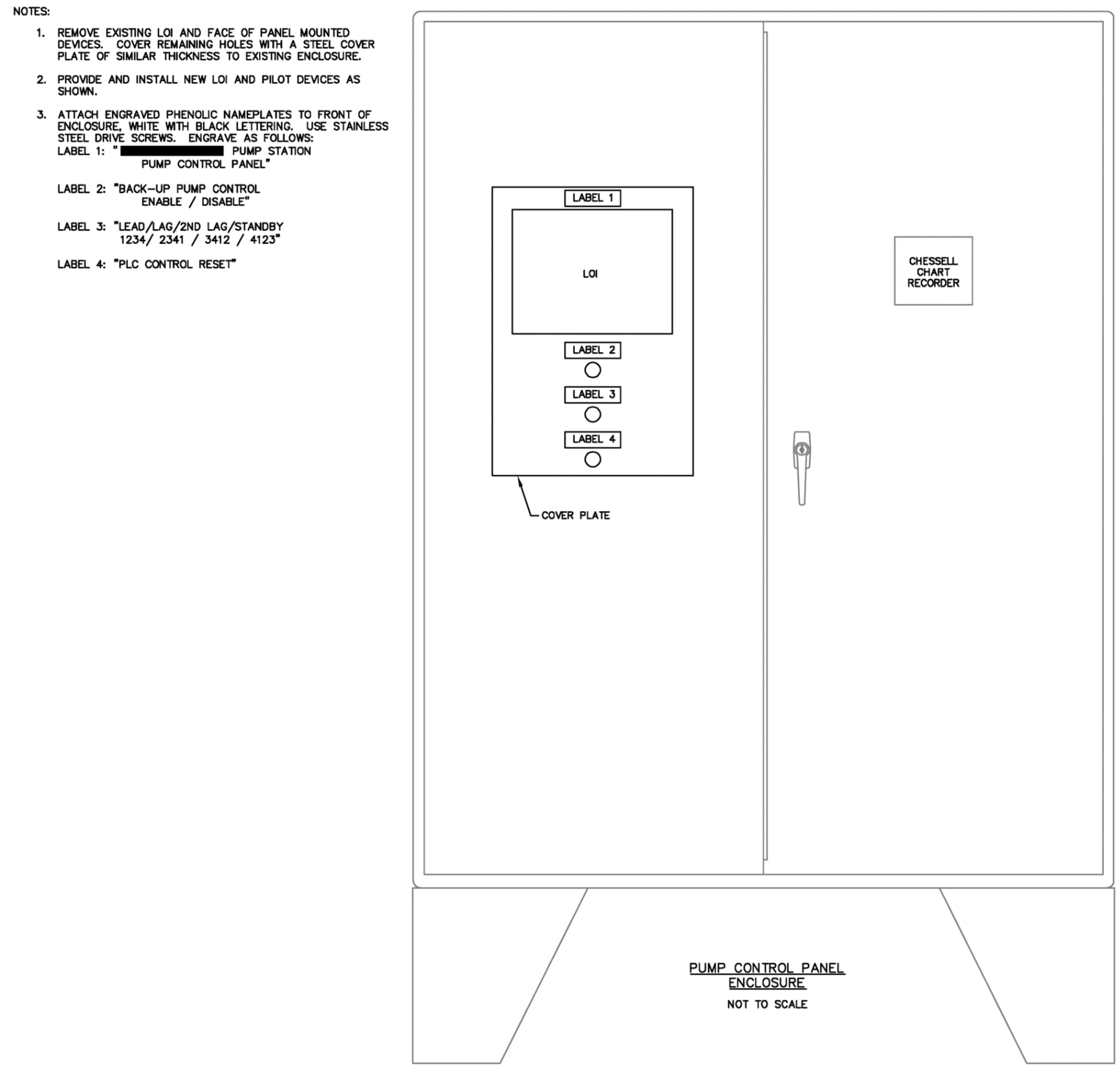

Figure F-2. Sample Control Panel Drawing B

Appendix G
Sample Single Line Diagrams

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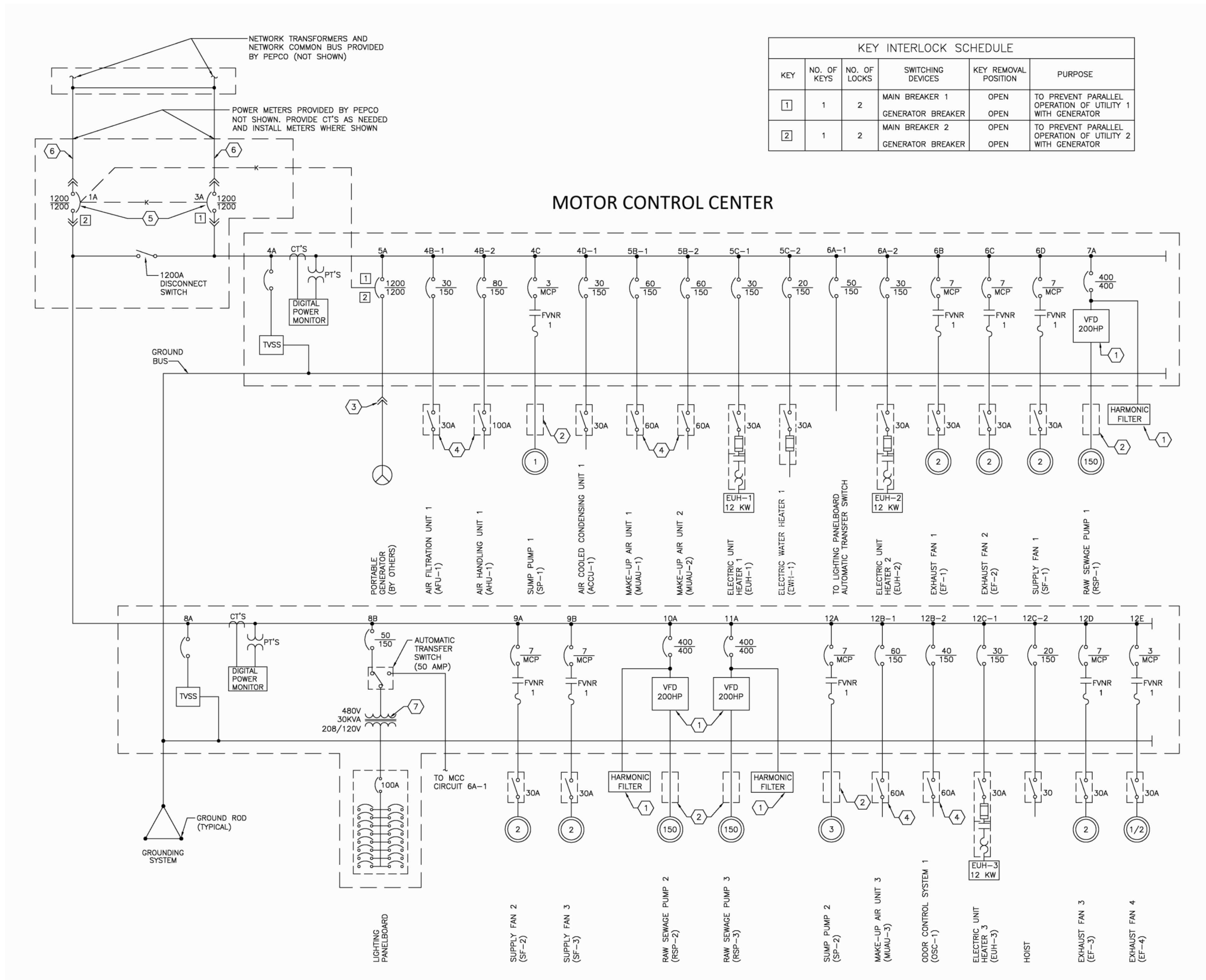


KEY INTERLOCK SCHEDULE

KEY	NO. OF KEYS	NO. OF LOCKS	SWITCHING DEVICES	KEY REMOVAL POSITION	PURPOSE
1	1	2	MAIN BREAKER 1 GENERATOR BREAKER	OPEN OPEN	TO PREVENT PARALLEL OPERATION OF UTILITY 1 WITH GENERATOR
2	1	2	MAIN BREAKER 2 GENERATOR BREAKER	OPEN OPEN	TO PREVENT PARALLEL OPERATION OF UTILITY 2 WITH GENERATOR

Figure G-1. Sample Single Line Diagram A

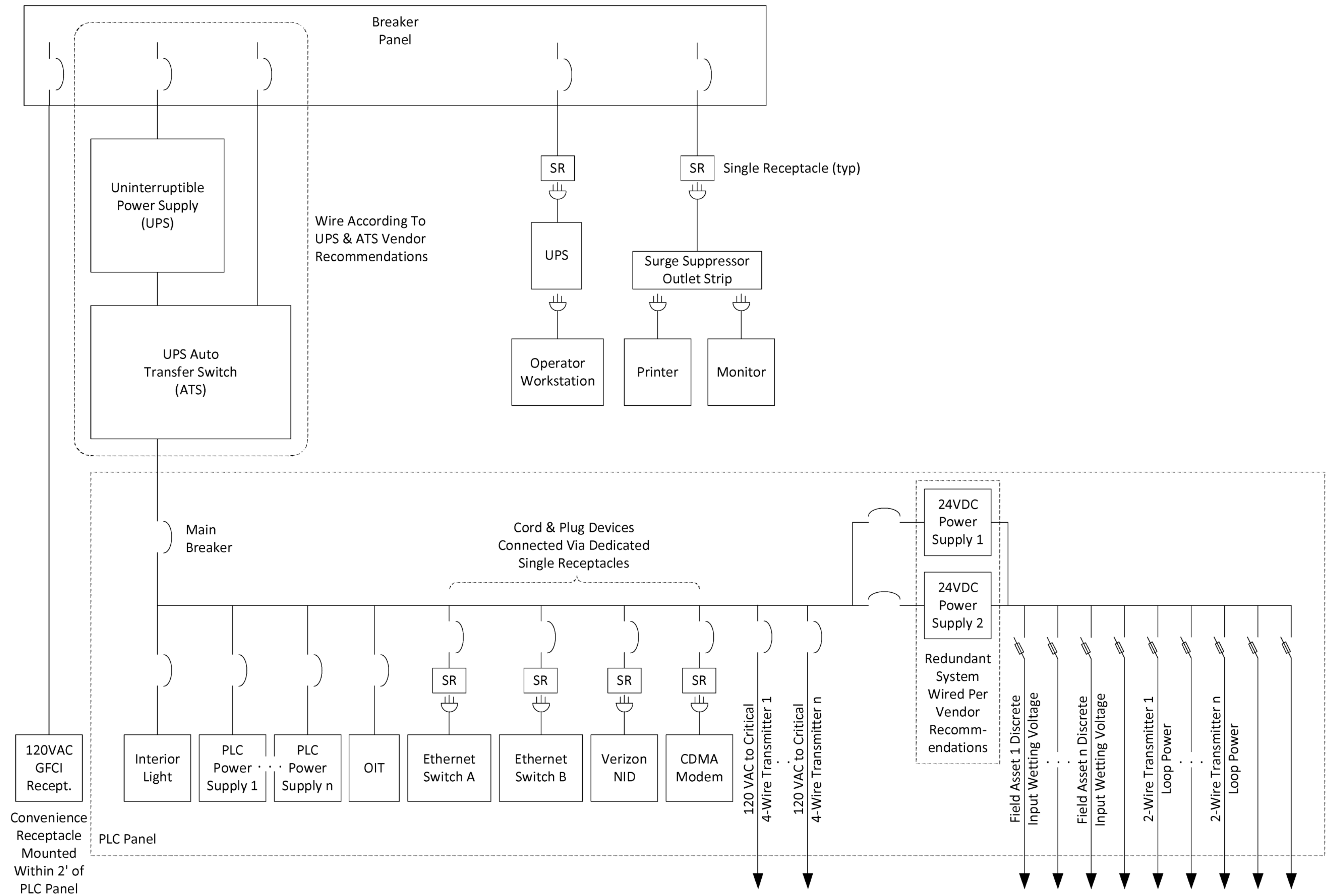


Figure G-2. Sample Single Line Diagram B

Appendix H
Sample Field Electrical Interface Diagrams

List of Figures

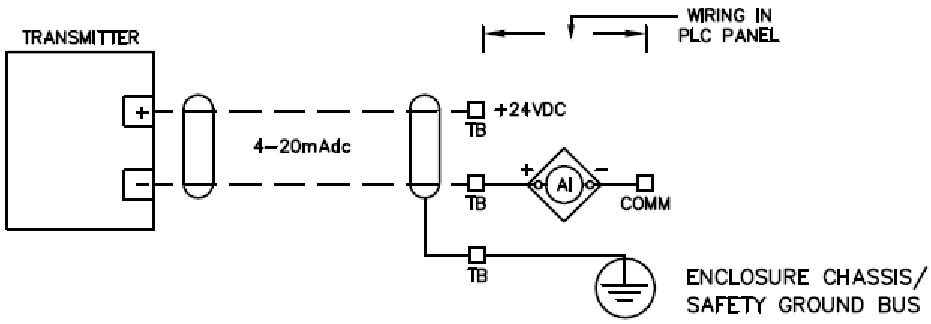


Figure H-1. Two-Wire Analog Transmitter

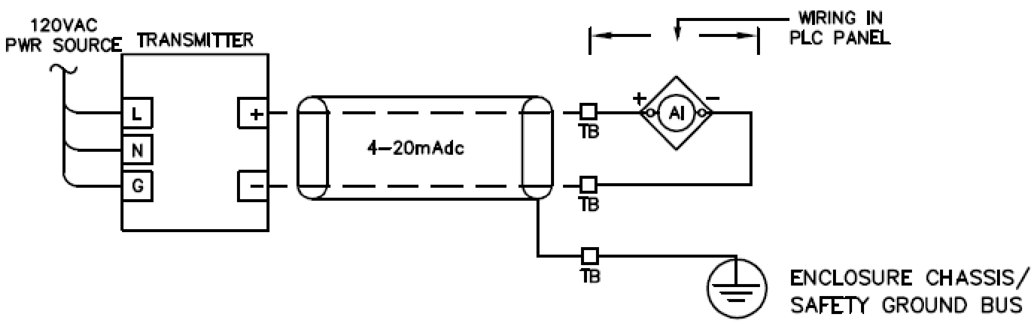
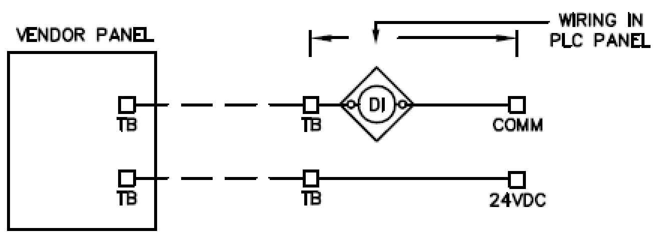


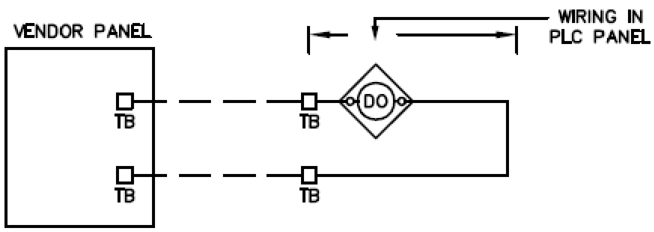
Figure H-2. Four-Wire Analog Transmitter



Notes:

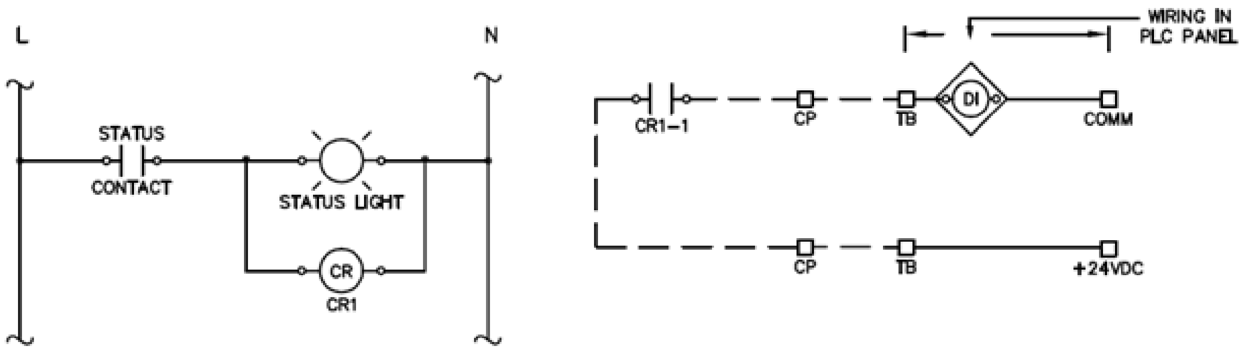
1. Use dry relay contact in vendor panel.

Figure H-3. Discrete Input



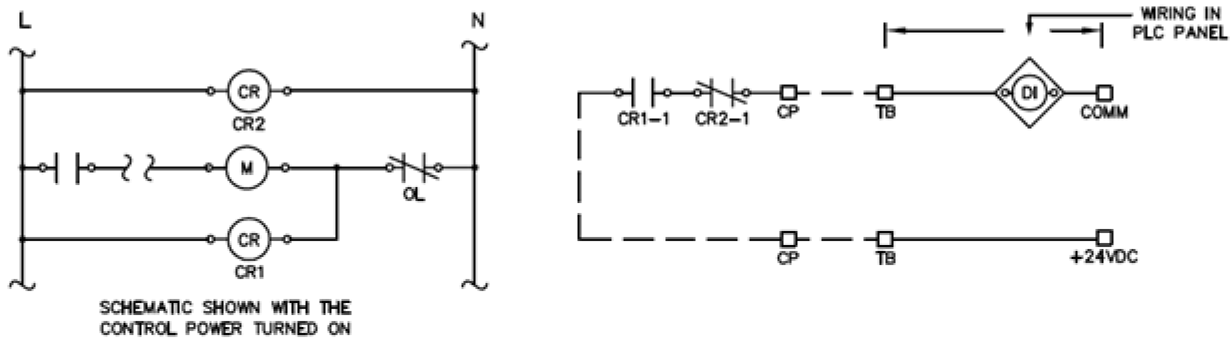
Notes:
1. DO is a dry relay contact in PLC panel wetted from voltage source in vendor panel.

Figure H-4. Discrete Output



Notes:
1. This applies to status points, not alarm points.
2. For new construction, specify and use a normally open contact on the relay that controls the light.
3. For retrofit projects, use a spare normally open contact on relay that controls the light, if available. Otherwise, use this circuit

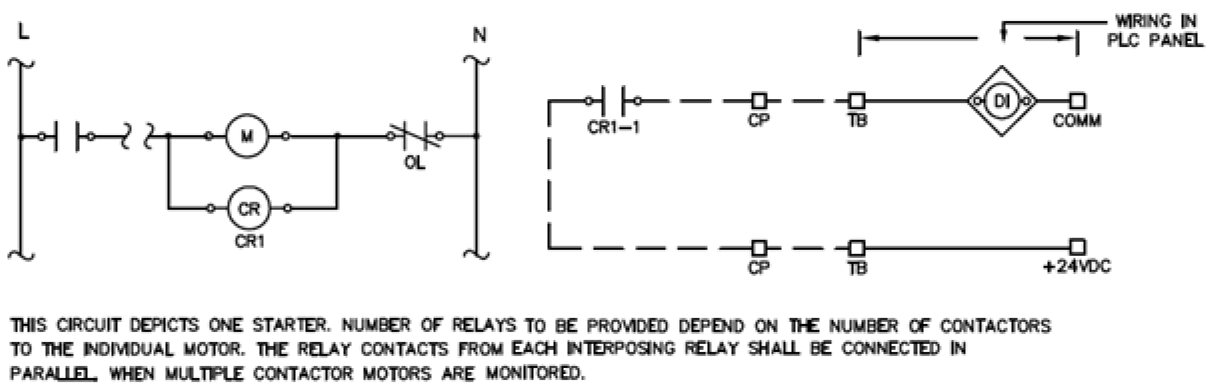
Figure H-5. Status Monitoring Using Existing Status Light



Notes:

1. For new construction, specify and use a normally closed contact on the motor overload relay.
2. For retrofit projects, use a spare normally closed contact on the motor overload relay, if available. Otherwise, use this circuit.

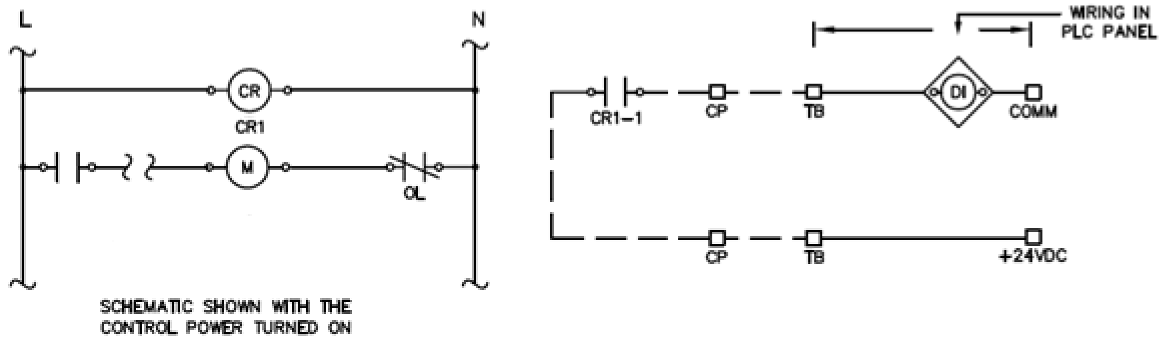
Figure H-6. Motor Fail Monitoring Without Fail Light



Notes:

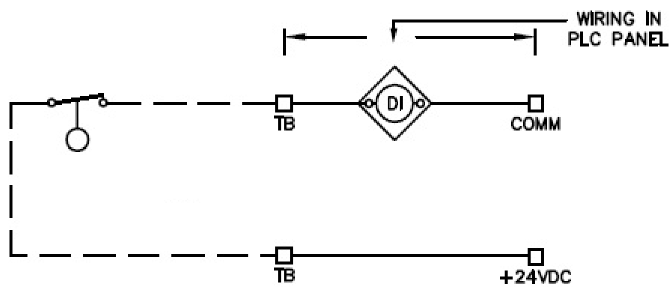
1. For new construction, specify and use a normally open contact on the motor starter.
2. For retrofit projects, use a spare normally open contact on the motor starter, if available. Otherwise, use this circuit.

Figure H-7. Motor Run Monitoring Without Run Light



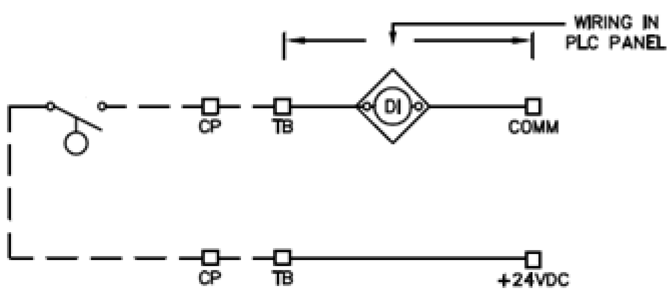
Notes:
1. CR1-1 is held closed when equipment is available.
2. For new construction, specify and use a normally open contact on the disconnect switch.

Figure H-8. Motor Run Monitoring Without Run Light



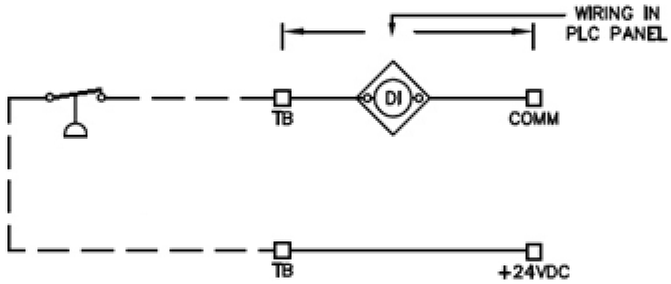
Notes:
1. Float switch is closed when level is not high, opens on high level.

Figure H-9. Wetwell High Level Alarm and Station Flood Alarm



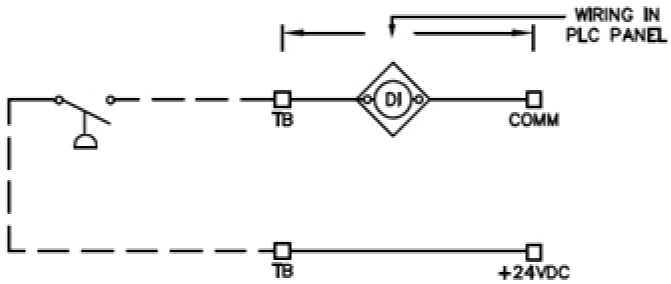
Notes:
1. Float switch is closed when level is not low, opens when level is low.

Figure H-10. Wetwell Low Level Alarm



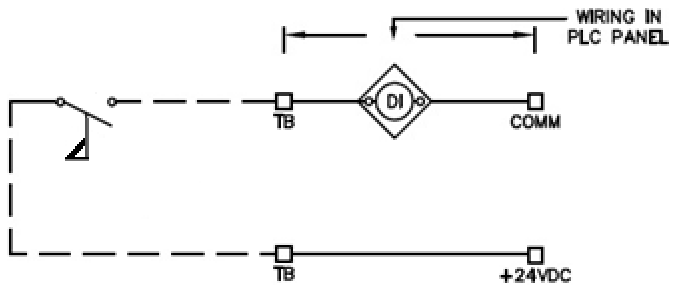
Notes:
1. Pressure switch is closed when pressure is not high, opens when pressure is high.

Figure H-11. High Pressure Alarm



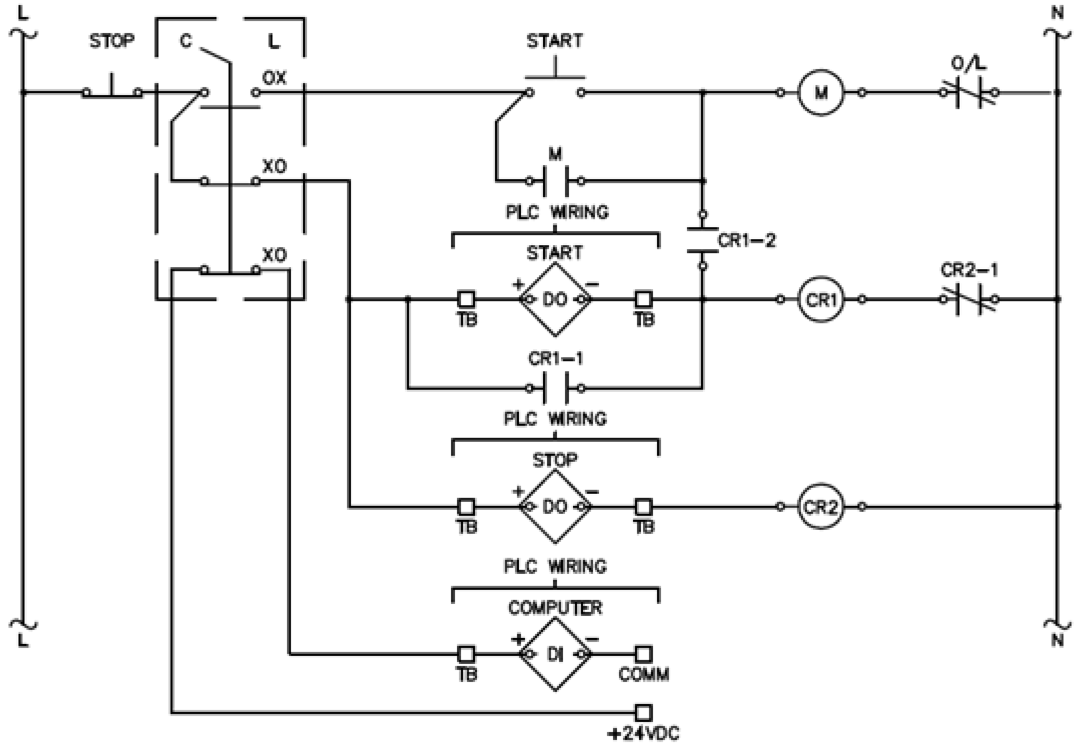
Notes:
1. Pressure switch is closed when pressure is not low, opens when pressure is low.

Figure H-12. Low Pressure Alarm



Notes:
1. Flow switch is closed when flow is normal, opens when flow is low.

Figure H-13. Low Flow Alarm



Notes:

1. Local control is isolated from PLC and control relays.

Figure H-14. Computer/Local Momentary Start/Stop Circuit

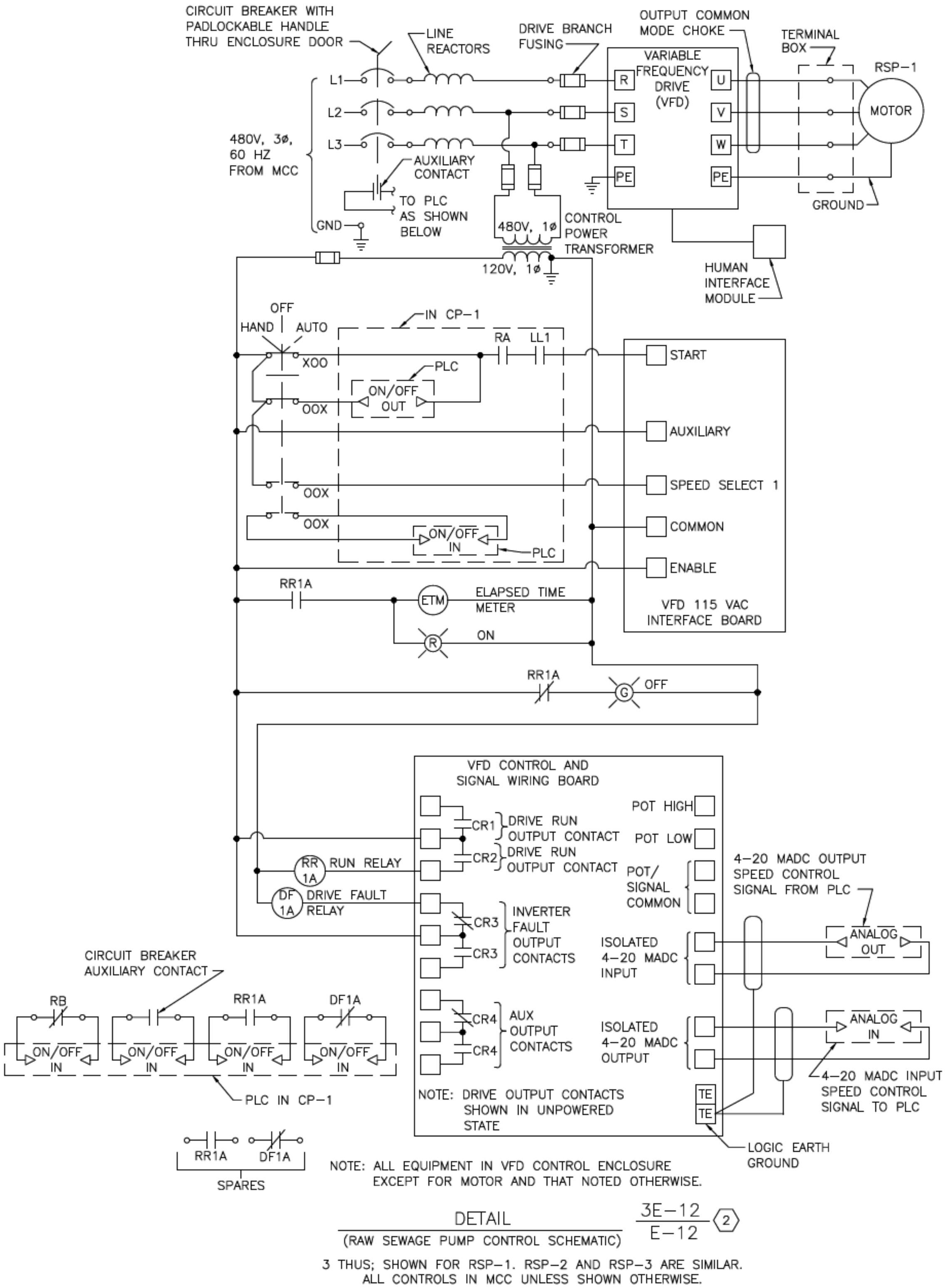


Figure H-15. VFD Interface

Appendix I
Sample Control and Equipment Room Layout Drawing

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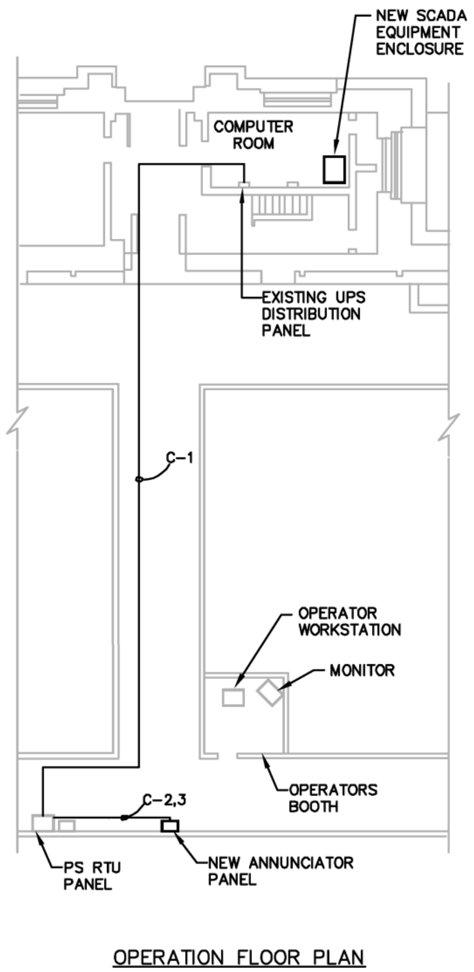
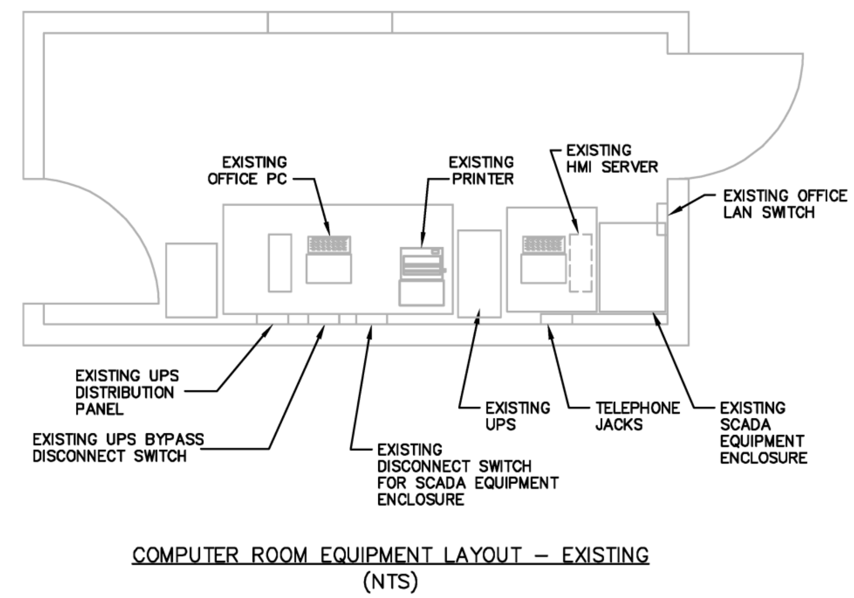
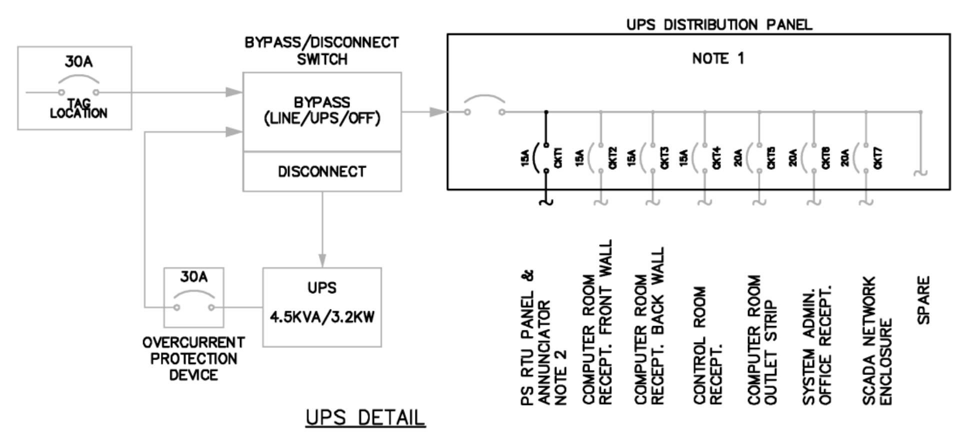




CONDUIT AND CABLE SCHEDULE

CONDUIT NO.	CONDUIT SIZE	WIRE / CABLE	FROM	TO	COMMENTS
C-1	3/4" RGS	3-#12 AWG	UPS DISTRIBUTION PANEL	EAPS RTU PANEL	UPS POWER TO RTU
C-2	3/4" RGS	3-#12 AWG	PS RTU PANEL	ANNUNCIATOR PANEL	UPS POWER TO ANNUNCIATOR
C-3	3/4" RGS	2-1 PR. #14 TW. PR.	PS RTU PANEL	ANNUNCIATOR PANEL	DISCRETE I/O



NOTES:

1. RE-USE EXISTING UPS DISTRIBUTION PANEL. CONTRACTOR TO INVESTIGATE LOAD REQUIREMENTS AND REPLACE EXISTING BREAKERS AS REQUIRED. REUSE EXISTING BYPASS/DISCONNECT SWITCH AND EXISTING OVERCURRENT PROTECTION DEVICE.
2. PROVIDE AND INSTALL A NEW CIRCUIT BREAKER IN EXISTING UPS DISTRIBUTION PANEL FOR 120 VAC POWER TO EAPS RTU AND ANNUNCIATOR PANEL. PROVIDE NEW WIRE AND CONDUIT AS SHOWN.

Figure I-1. Sample Control and Equipment Room Layout Drawing

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Appendix J
Sample Wire/Conduit Drawing & Schedule

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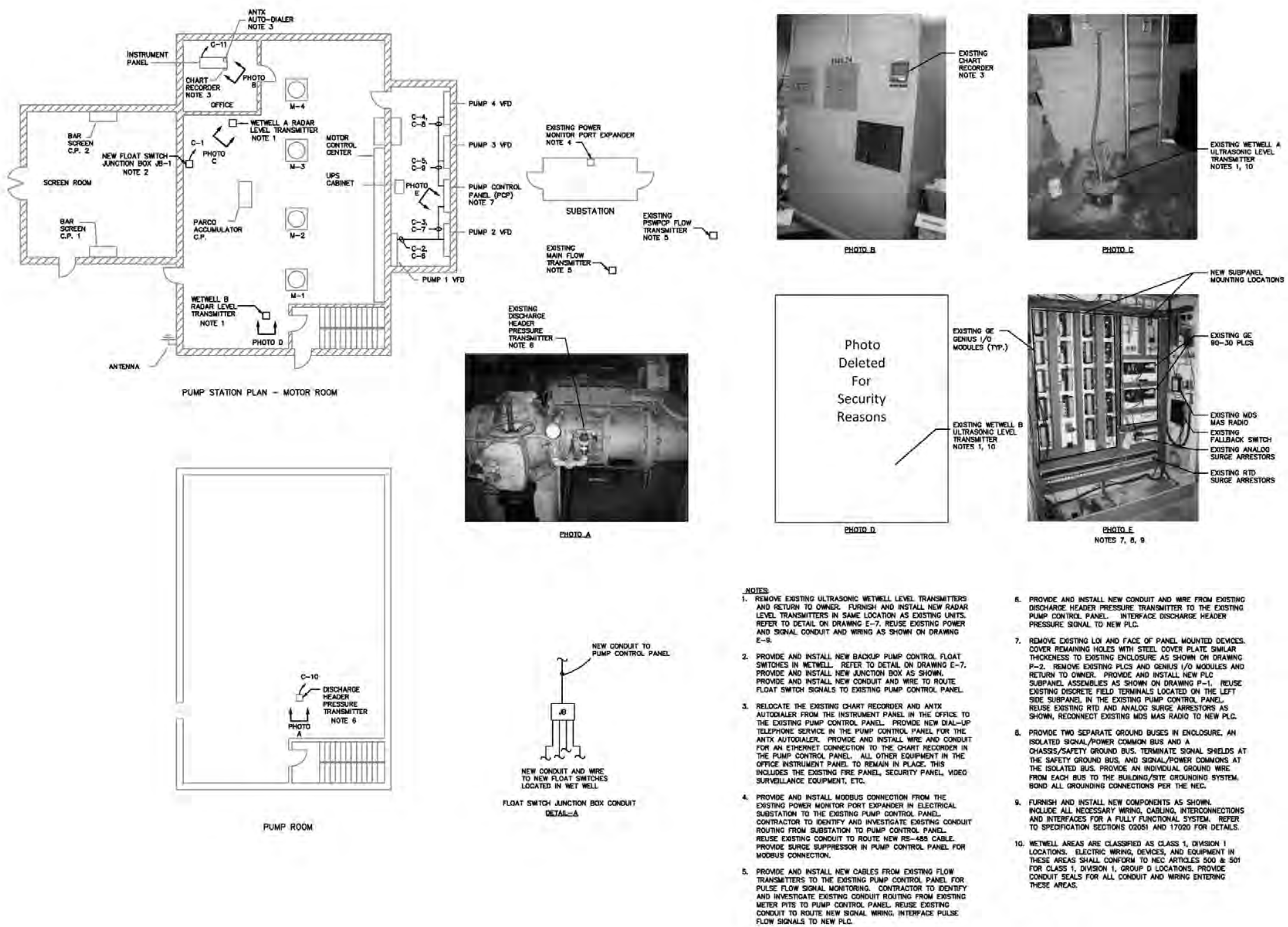

Figure J-1. Sample Wire/Conduit Drawing

CONDUIT AND CABLE SCHEDULE

CONDUIT NO.	CONDUIT SIZE	WIRE / CABLE	FROM	TO	COMMENTS
REUSE EXISTING CONDUIT AND WIRE			WETWELL B RADAR LEVEL TRANSMITTER	WETWELL A RADAR LEVEL TRANSMITTER	WETWELL B LEVEL
REUSE EXISTING CONDUIT AND WIRE			WETWELL A RADAR LEVEL TRANSMITTER	PCP	WETWELL A & B LEVEL
REUSE EXISTING CONDUIT		1-RS-485 CABLE	PUMP 1 VFD	PCP	PUMP 1 MODBUS COMM.
REUSE EXISTING CONDUIT		1-RS-485 CABLE	PUMP 2 VFD	PCP	PUMP 2 MODBUS COMM.
REUSE EXISTING CONDUIT		1-RS-485 CABLE	PUMP 4 VFD	PCP	PUMP 4 MODBUS COMM.
REUSE EXISTING CONDUIT		1-RS-485 CABLE	PUMP 3 VFD	PCP	PUMP 3 MODBUS COMM.
REUSE EXISTING CONDUIT		1-RS-485 CABLE	SUBSTATION POWER MONITOR	PCP	POWER MONITOR COMM.
C-1A	3/4" RGS	1-1 PR. #14 TW. PR.	FLOAT SWITCH	JB-1	FLOAT SWITCH STATUS
C-1B	3/4" RGS	1-1 PR. #14 TW. PR.	FLOAT SWITCH	JB-1	FLOAT SWITCH STATUS
C-1C	3/4" RGS	1-1 PR. #14 TW. PR.	FLOAT SWITCH	JB-1	FLOAT SWITCH STATUS
C-1D	3/4" RGS	1-1 PR. #14 TW. PR.	FLOAT SWITCH	JB-1	FLOAT SWITCH STATUS
C-1	1 1/2" RGS	4-1 PR. #14 TW. PR.	JB-1	PCP	FLOAT SWITCH STATUS
C-2	1 1/2" RGS	8-1 PR. #14 TW. PR.	PUMP 1 VFD	PUMP 2 VFD	PUMP 1 DISCRETE I/O
C-3	2 1/2" RGS	16-1 PR. #14 TW. PR.	PUMP 2 VFD	PCP	CONTENTS OF C-2; PUMP 2 DISCRETE I/O
C-4	1 1/2" RGS	8-1 PR. #14 TW. PR.	PUMP 4 VFD	PUMP 3 VFD	PUMP 4 DISCRETE I/O
C-5	2 1/2" RGS	16-1 PR. #14 TW. PR.	PUMP 3 VFD	PCP	CONTENTS OF C-4; PUMP 3 DISCRETE I/O
C-6	1 1/2" RGS	2-1 PR. #16 TW. SH. PR.	PUMP 1 VFD	PUMP 2 VFD	PUMP 1 ANALOG I/O
C-7	1 1/2" RGS	4-1 PR. #16 TW. SH. PR.	PUMP 2 VFD	PCP	CONTENTS OF C-6; PUMP 2 ANALOG I/O
C-8	1 1/2" RGS	2-1 PR. #16 TW. SH. PR.	PUMP 4 VFD	PUMP 3 VFD	PUMP 4 ANALOG I/O
C-9	1 1/2" RGS	4-1 PR. #16 TW. SH. PR.	PUMP 3 VFD	PCP	CONTENTS OF C-4; PUMP 3 ANALOG I/O
C-10	3/4" RGS	1-1 PR. #16 TW. SH. PR.	EXISTING DISCH. HEADER PRESSURE TRANSMITTER	PCP	DISCHARGE HEADER PRESSURE
C-11	3/4" RGS	1-CAT5/6 CABLE	OFFICE INSTRUMENT PANEL	PCP	ETHERNET COMM.
REUSE EXISTING CONDUIT		1-1 PR. #16 TW. SH. PR.	EXISTING MAIN FLOW TRANSMITTER	PCP	FLOW PULSE SIGNAL
REUSE EXISTING CONDUIT		1-1 PR. #16 TW. SH. PR.	EXISTING PSWPCP FLOW TRANSMITTER	PCP	FLOW PULSE SIGNAL

Figure J-2. Sample Wire/Conduit Schedule

Appendix K
Sample Ductbank Drawing & Schedule

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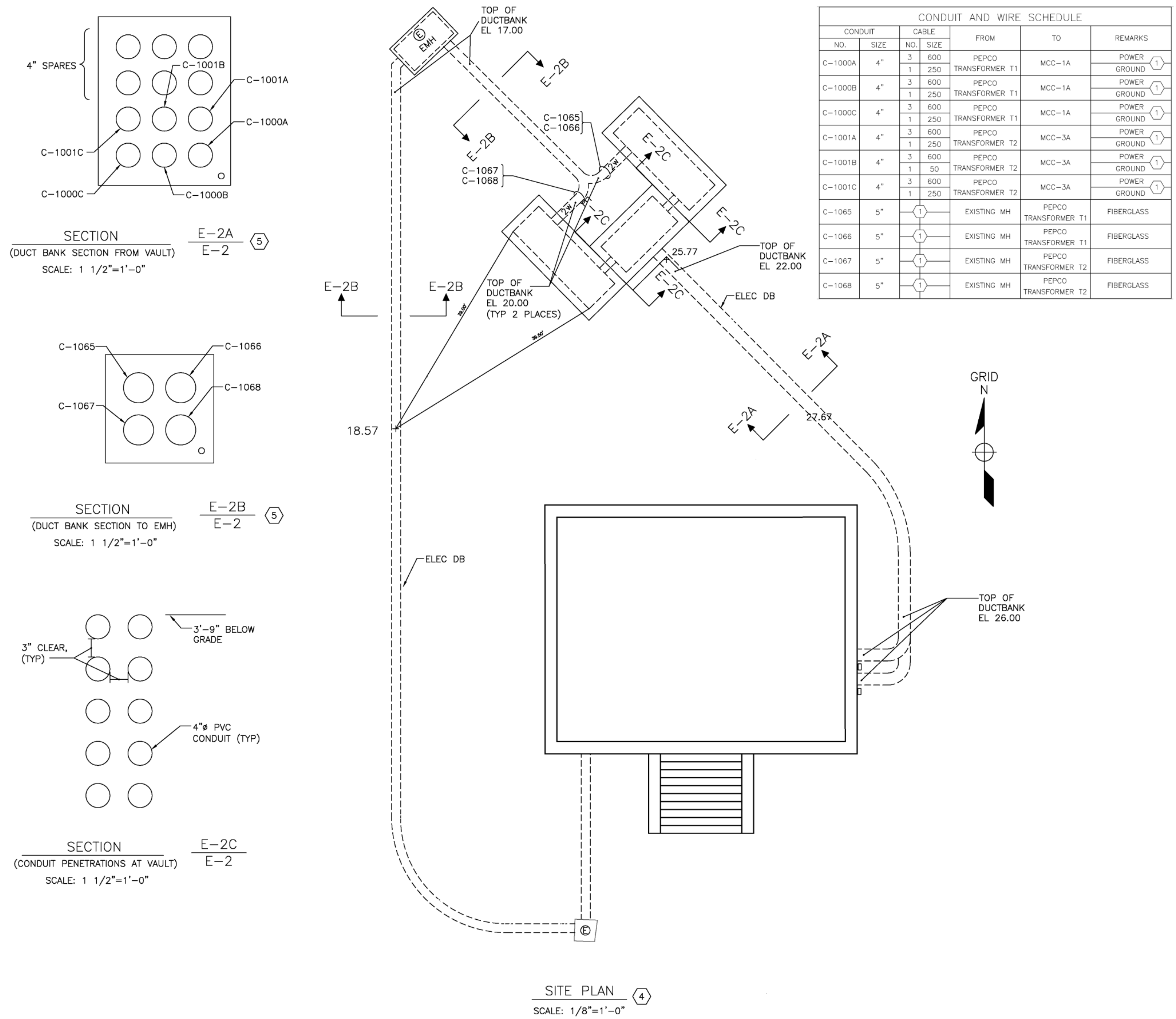

CONDUIT AND WIRE SCHEDULE						
CONDUIT		CABLE		FROM	TO	REMARKS
NO.	SIZE	NO.	SIZE			
C-1000A	4"	3	600	PEPCO TRANSFORMER T1	MCC-1A	POWER (1)
		1	250			GROUND
C-1000B	4"	3	600	PEPCO TRANSFORMER T1	MCC-1A	POWER (1)
		1	250			GROUND
C-1000C	4"	3	600	PEPCO TRANSFORMER T1	MCC-1A	POWER (1)
		1	250			GROUND
C-1001A	4"	3	600	PEPCO TRANSFORMER T2	MCC-3A	POWER (1)
		1	250			GROUND
C-1001B	4"	3	600	PEPCO TRANSFORMER T2	MCC-3A	POWER (1)
		1	50			GROUND
C-1001C	4"	3	600	PEPCO TRANSFORMER T2	MCC-3A	POWER (1)
		1	250			GROUND
C-1065	5"	(1)		EXISTING MH	PEPCO TRANSFORMER T1	FIBERGLASS
C-1066	5"	(1)		EXISTING MH	PEPCO TRANSFORMER T1	FIBERGLASS
C-1067	5"	(1)		EXISTING MH	PEPCO TRANSFORMER T2	FIBERGLASS
C-1068	5"	(1)		EXISTING MH	PEPCO TRANSFORMER T2	FIBERGLASS

Figure K-1. Sample Ductbank Drawing & Schedule

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Appendix L
Sample Area Classification Drawing

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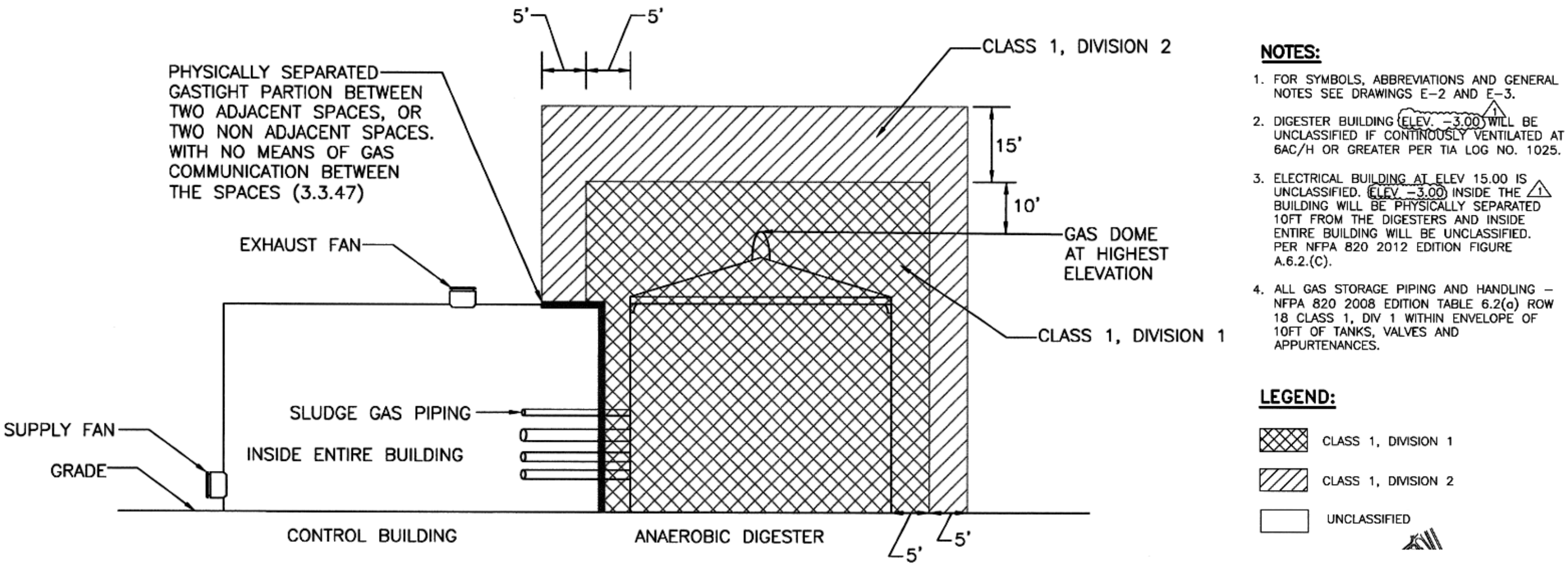

AREA CLASSIFICATIONS AND FIRE ALARM SUMMARY

No.	AREA DESCRIPTION	CLASSIFICATION	NFPA 820 2012 EDITION	REQUIREMENT	NOTES
1	DIGESTER BUILDING – ELEV -3.00	UNCLASSIFIED	TABLE 6.2(a) ROW 17C	CGD, H, FE	1, 2, 3
2	ELECTRICAL ROOM – ELEV 15.00	UNCLASSIFIED		H, FE	4

ABBREVIATIONS

CGD – COMBUSTIBLE GAS DETECTION
H – HYDRANT PROTECTION
FE – PORTABLE FIRE EXTINGUISHER
FAS – FIRE ALARM SYSTEM

NOTES:

1. CONTINUOUSLY VENTILATED AT 6 AIR CHANGES PER HOUR.
2. PHYSICALLY SEPARATED MINIMUM 10' FROM DIGESTERS
3. DAMP/CORROSIVE
4. DRY

Figure L-1. Sample Area Classification Drawing

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Appendix M
Sample Instrument Mounting Detail Drawings

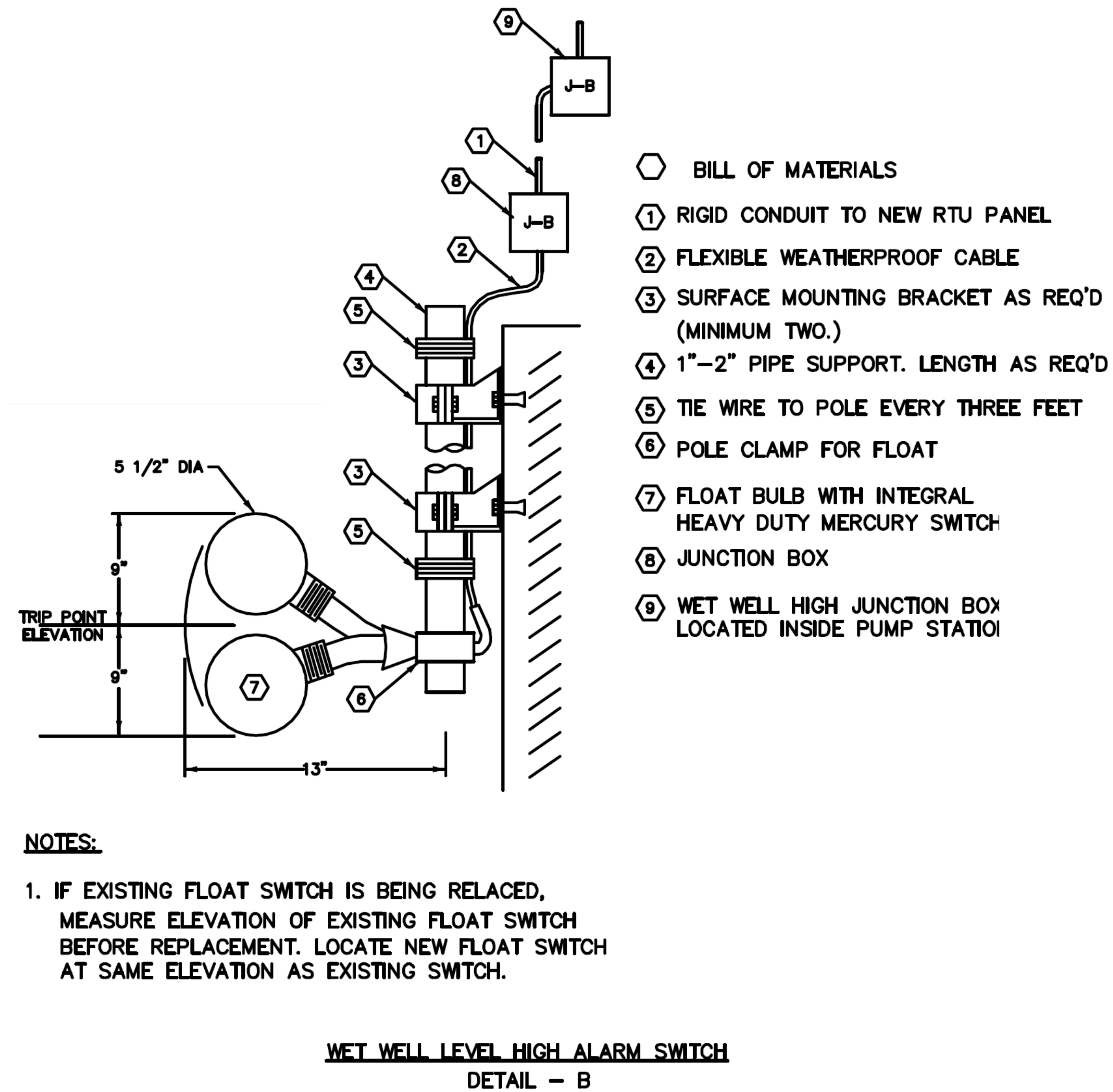

Figure M-1. Sample Instrument Mounting Detail Drawing A

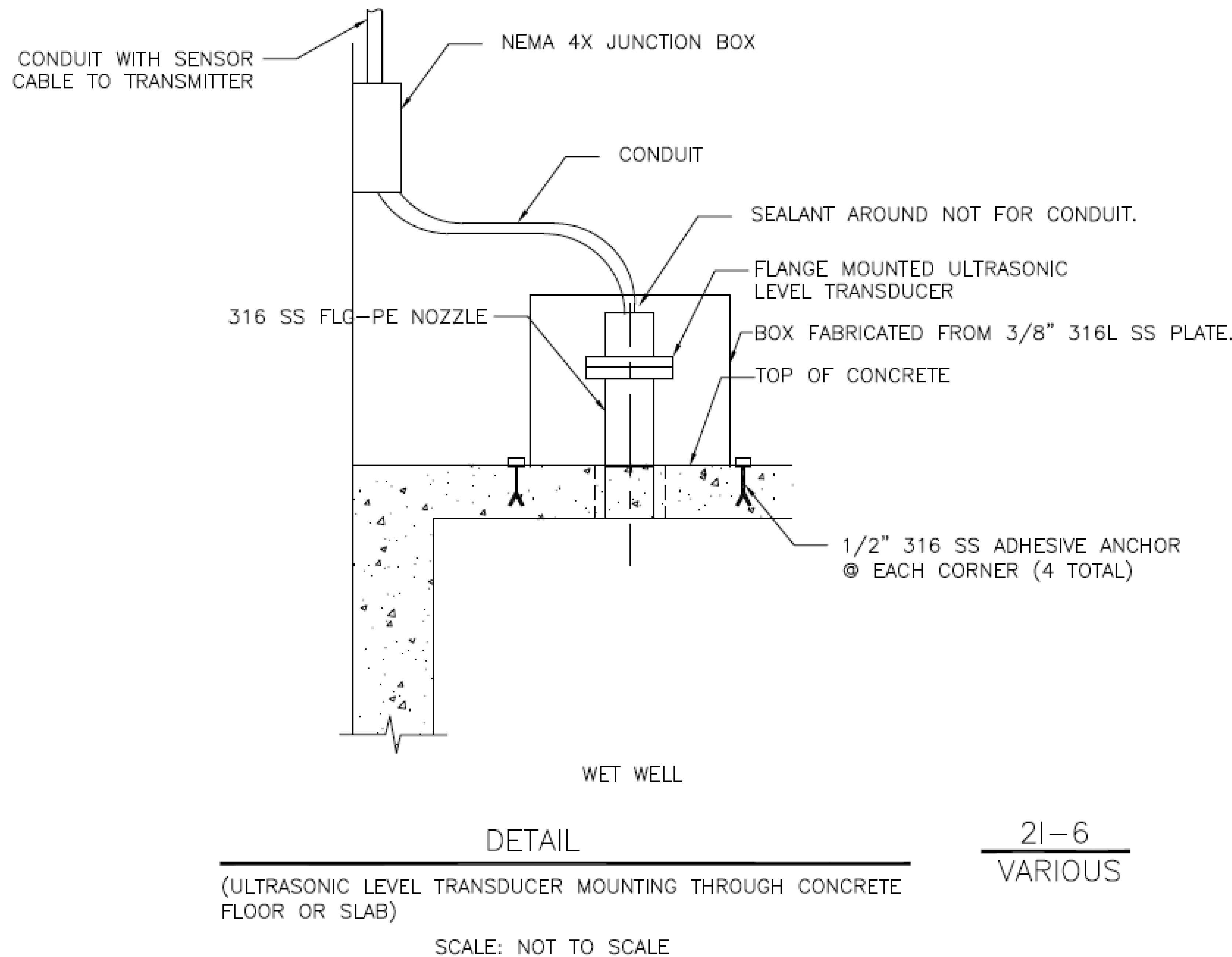

Figure M-2. Sample Instrument Mounting Detail Drawing B

Appendix N
Sample Loop Drawings

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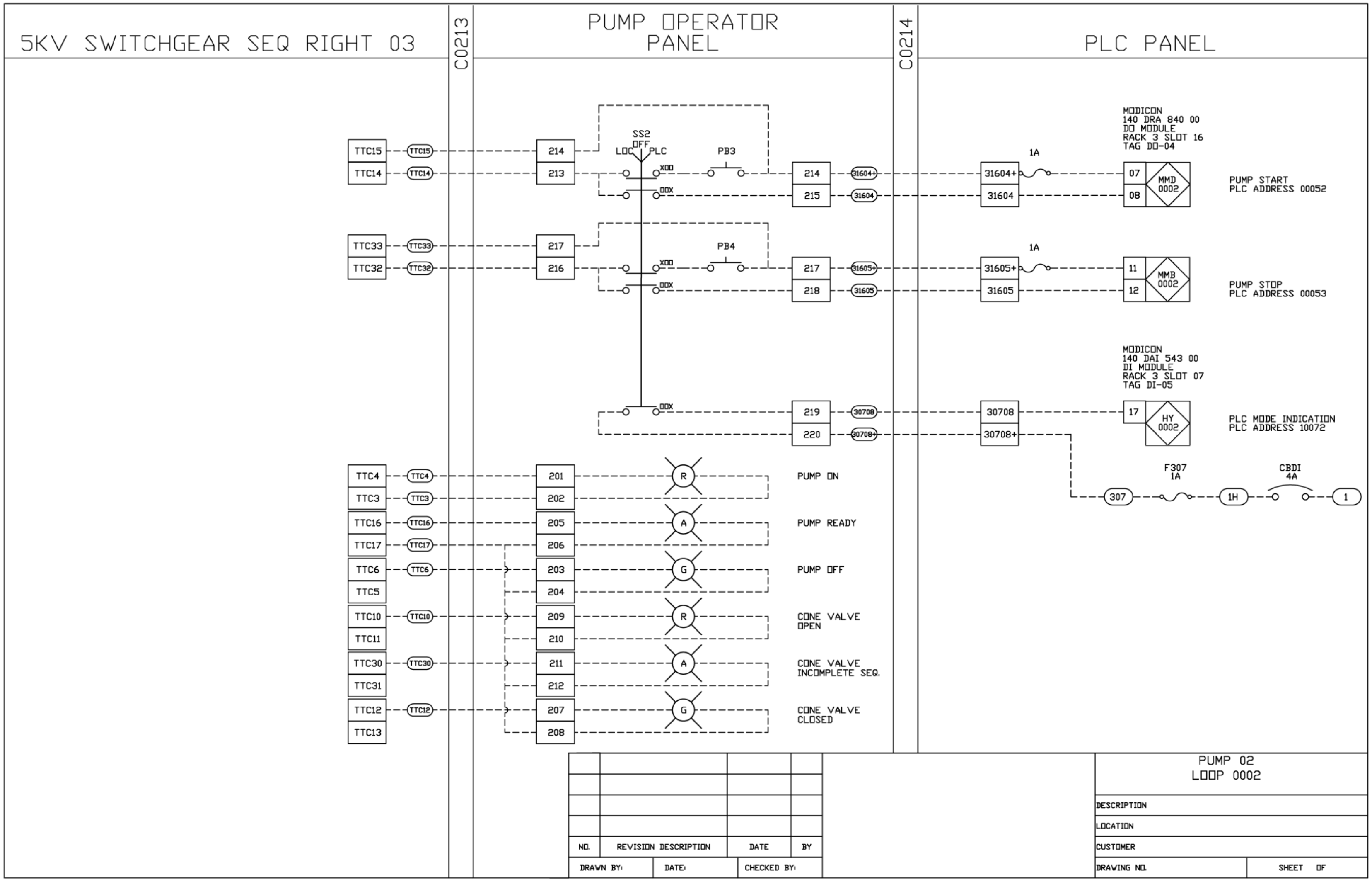

Figure N-1. Sample Loop Drawing A

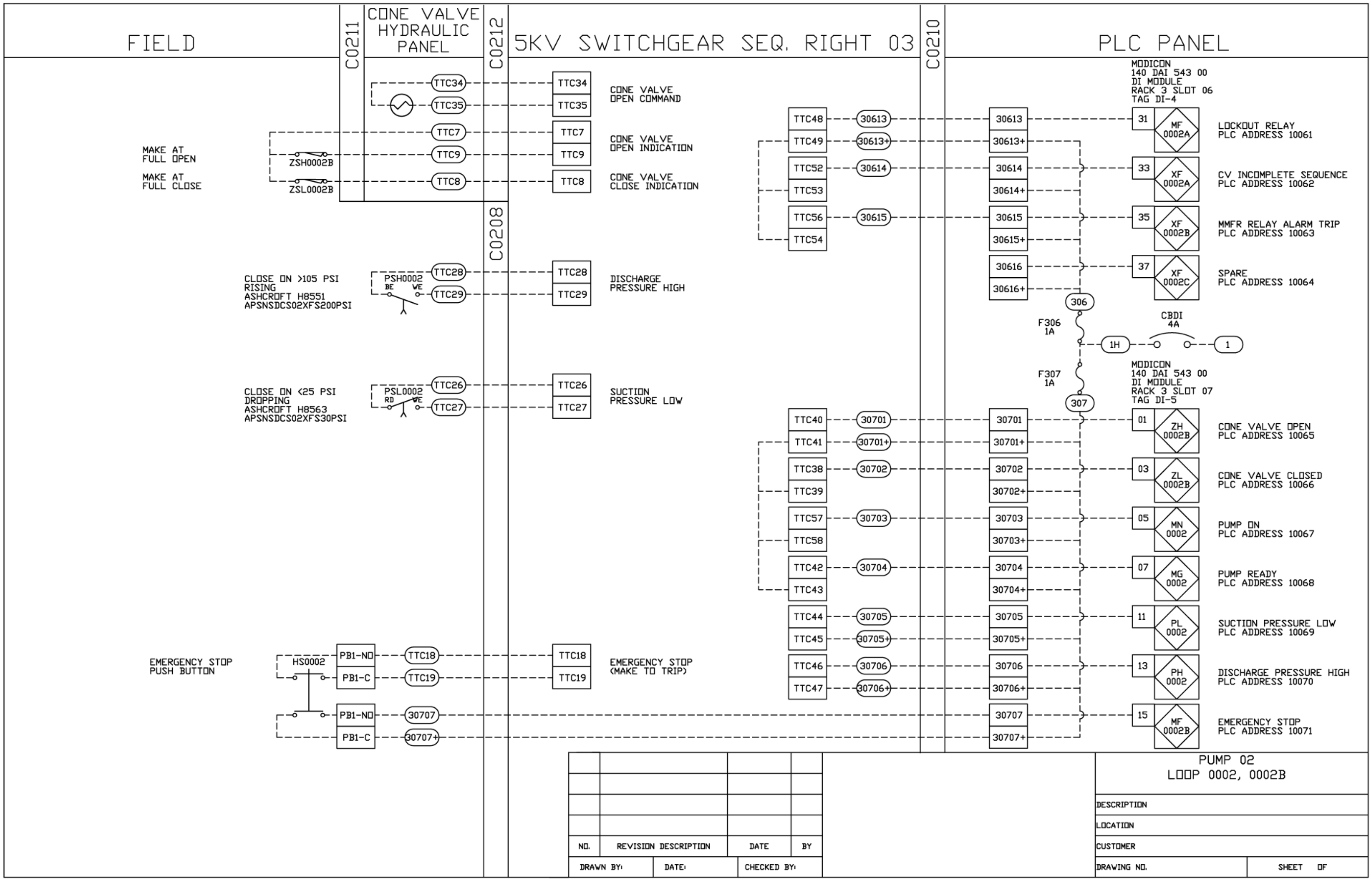

Figure N-2. Sample Loop Drawing B

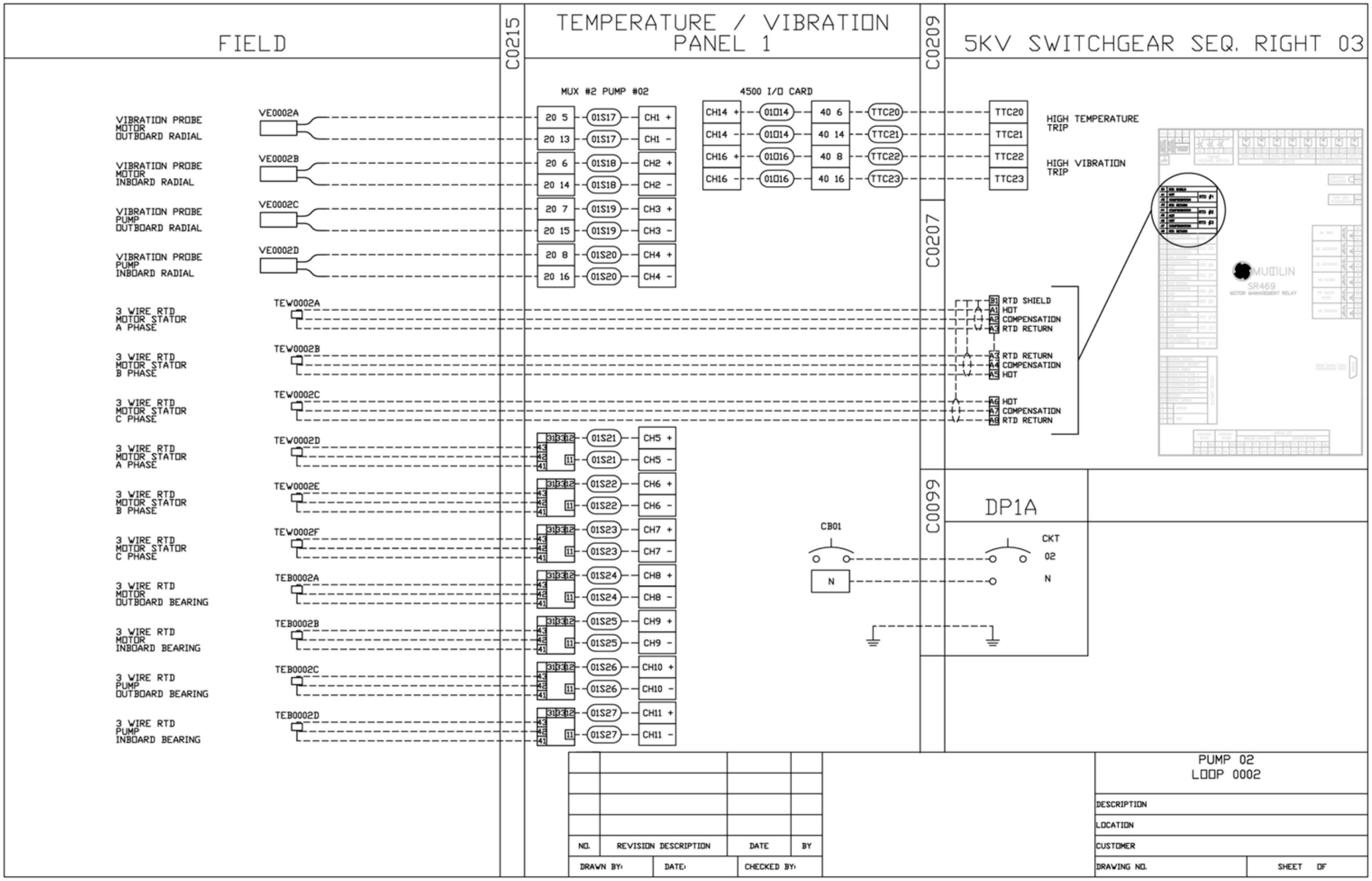

Figure N-3. Sample Loop Drawing C

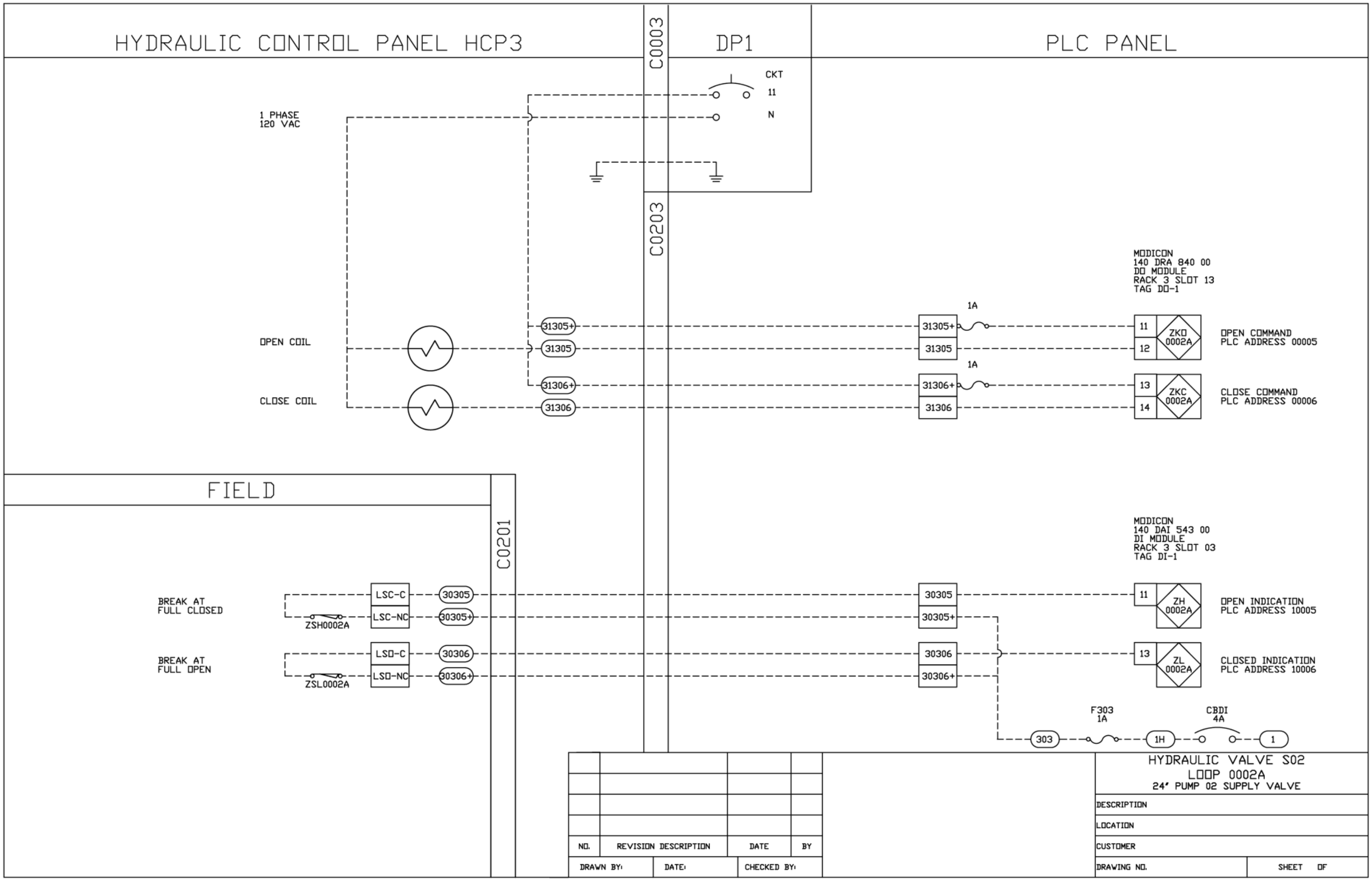

Figure N-4. Sample Loop Drawing D

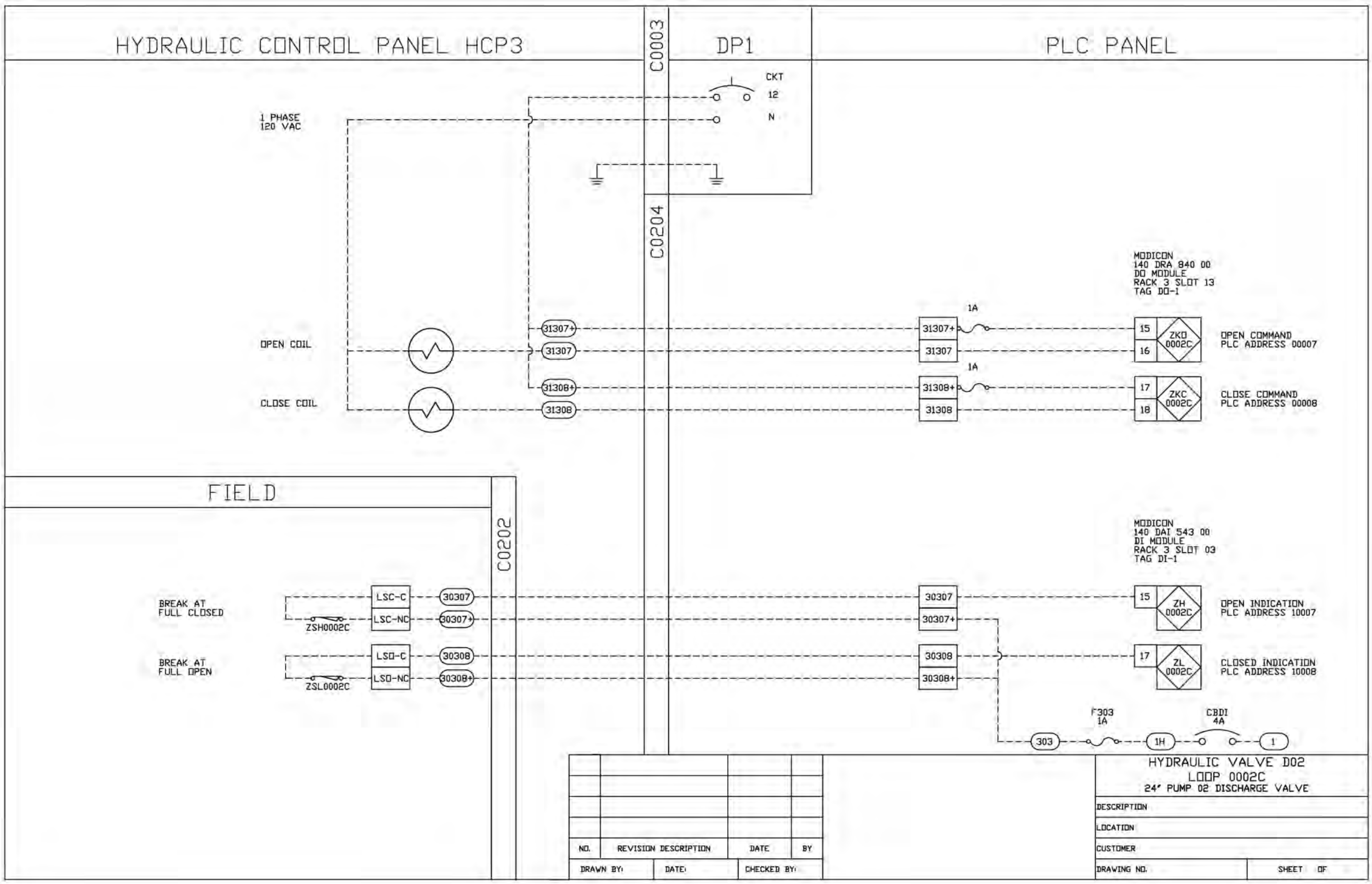

Figure N-5. Sample Loop Drawing E

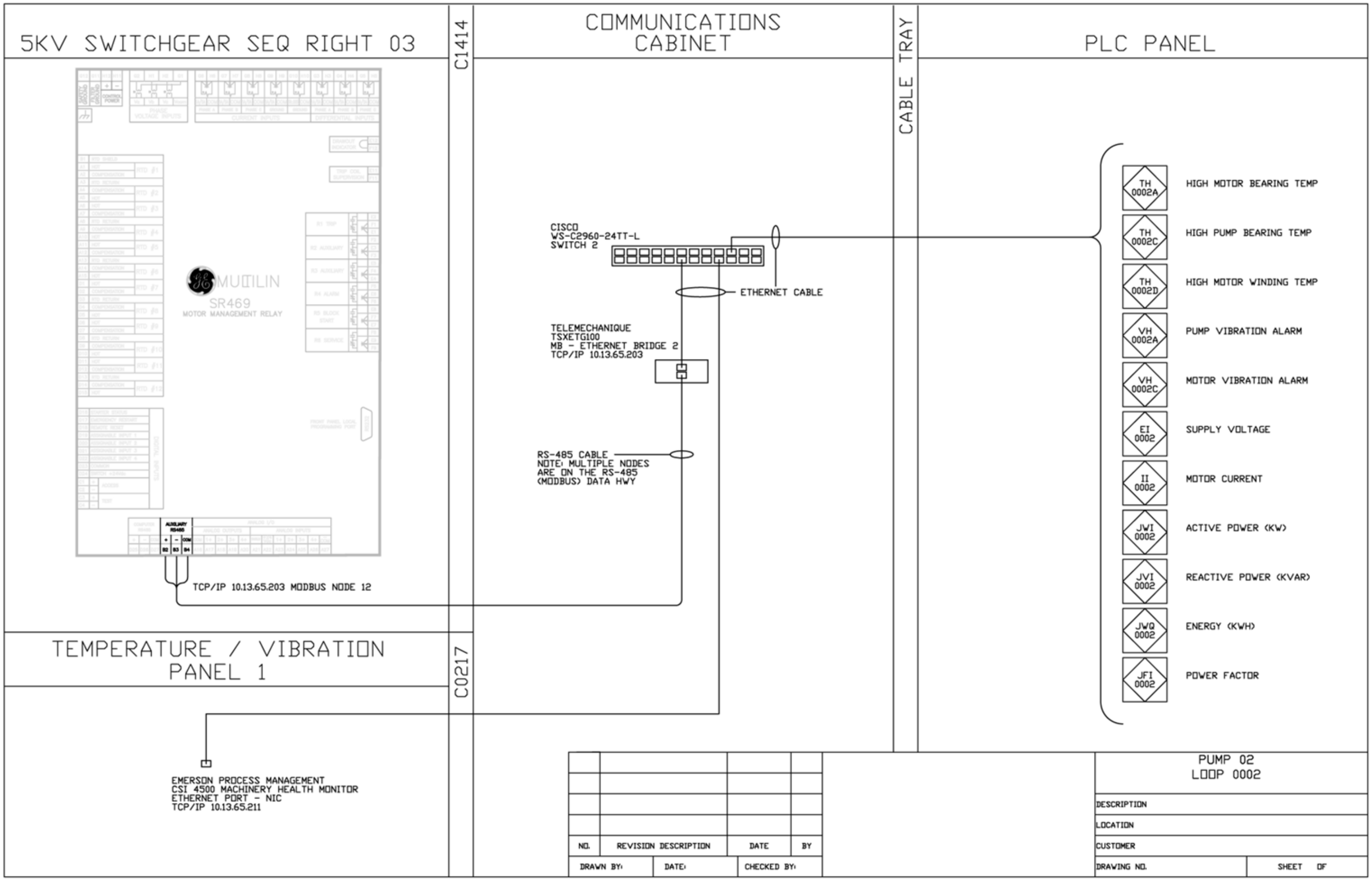

Figure N-6. Sample Loop Drawing F

Appendix O
Sample Testing Documents

dc water is life

DC Water

Notice of System Readiness for Witnessed combined Loop Test
WCLT
Revised 2012

Site:____

Contract Name:____

Must be Filled in Prior to WCLT Approval	System Coordination meeting was held on: _______________Date System Pre-Test finalized on: _________________________Date Requested WCLT Test Starting Date/Time: ____________________ DC Water Existing Equipment Needed for WCLT.

____

____

____

The contractor, construction manager PDE,DSS and DWS, have discussed the requirements during a coordination meeting, and checked the attached Input/Output (I/O) Point List for this specific test. This confirms that the field equipment I/O successfully pre-tested, and each party is ready for the requested test starting date and time. DSS or DWS will participate in the Testing.

Contractor: ______________________ Date: ____________

DC Water CM ______________________ Date: ____________

Dept. of Water Services: ______________________ Date: ____________

Dept. of Sewer Services: ______________________ Date: ____________

Attachments: I/O List, I&C Equipment Certifications

Cc
DWS
DSS
Facilities
DETS
IT

Figure O-1. Sample Witnessed Combined Loop Test Request

dc water is life

MEMO

5000 Overlook Avenue SW
Washington, DC 20032-5212

phone: 202.787.2760
fax: 202.787.2761
www.ema-inc.com

DATE:

TO: DWS/DSS/DETS

FROM: CM/PDE

SUBJECT: Loop Test Results Summary, Facility name and contract

WCLT Readiness Certification, System Integrator/Contractor:

WCLT Schedule Date:

Results Summary:

I/O planned to be tested	78
I/O actually loop tested	65
I/O that passed loop test	58
Failure Percentage	10.77%
Not Ready Percentage	16.67%

Systems Tested:

System Descriptions	Results	Comments
PUMP 1	18 Passed	
PUMP 1	4 Not Available	Discharge Valve Local/Remote switch, Synch Lockout, Brk. trip coil and Brk. Trip - USC
PUMP 2	18 Passed	
PUMP 2	4 Not Available	Discharge Valve Local/Remote switch, Synch Lockout, Brk. trip coil and Brk. Trip - USC
PUMP 3	16 Passed	
PUMP 3	4 Not Available	Discharge Valve Local/Remote switch, Synch Lockout, Brk. trip coil and Brk. Trip - USC
PUMP 3	1 Failed	Discharge Valve "ZL" Limit switch - EPM
PRIMING B	9 Passed	
PRIMING C	2 Failled	Vacuum Pumps 1 & 2 Fail status - USC
PRIMINGD	1 Not Available	Vacuum Tank Pressure – USC
SWITCHGEAR 1	11 Passed	
SWITCHGEAR 2	1 Not Available	Batt. Charge AC volt - USC

END OF MEMO

Figure O-2. Sample Witnessed Combined Loop Test Results

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DC Water's PROJECT NO ________
Calibration Sheet

COMPONENT	MANUFACTURER	PROJECT
Name:	Name:	Number:
Loop No's:	Model:	Name/Address
	Serial:	

FUNCTIONS					
	RANGE	VALUE	UNITS	Describe:	CONTROL: Y / N
Indicate: Y / N	Chart:				
Record: Y / N	Scale:				SWITCH: Y / N
Transmit:	Input:				Fixed / Adjustable
Y / N	Output:	4-20	M/amp		Reset? Automatic / Manual

ANALOG CALIBRATIONS					DISCRETE CALIBRATIONS					Note.
REQUIRED			AS CALIBRATED		REQUIRED			AS CALIBRATED		
Input	Indicated	Output	At Panel Indicated	At Workstation Indicated	Number	(note rising or falling))		(note rising or falling))		
10%		5.6ma			1					
50%		12.0ma			2					
90%		18.4ma			3					
100%		20.0ma			4					
					5					
					6					
ITC: PCS:			Conduit #		7					

PLC / Gateway or HW	Note:	Component Calibrated and ready for Loop Test
ADDRESS:		
PLC ID:		By:
BRANCH:		Date:
MODULE:		Instrument Location:
CHANEL:		Tag No:
POWER:		Lighting Panel No's Circuit Breaker no's

Figure O-3. Sample Calibration Report (Blank)

INSTRUMENTS CALIBRATION REPORT

COMPONENT	MANUFACTURER	PROJECT
NAME: SSLP Flow meter	Name: Siemens	Number: 100120
Loop No's: FE/FIT-63064	Model: MAG5100W	Name/Address D.C Water 5000 Over look ave, S.W.
Dwg. reference: I-20	Serial: 7ME658 338401U173	Washington, D.C-20032

FUNCTIONS

	CAL. RANGE	VALUE	E.UNITS	Describe:	CONTROL? Y / N
Indicate? **Y** / N	Chart:				
Record? Y / **N**	Scale:	0-4500	GPM		SWITCH? Y / N
Transmit/	Input:				Fixed / Adjustable
Y / N	Output:	4-20	ma		Reset? Automatic / Manual

ANALOG CALIBRATIONS					DISCRETE CALIBRATIONS					Note.
REQUIRED			AS CALIBRATED		REQUIRED			AS CALIBRATED		
Input	Indicated	Output	Indicated at Local GPM	Indicated at PCS/Remote GPM/ma	Number	(note rising or falling))		(note rising or falling))		
0%	0	4.0 ma	0.0	0.0	1					
25%	1125	8.0 ma			2					
50%	2250	12.0 ma	2250	2250	3					
90%	4050	18.40 ma			4					
100%	4500	20.0 ma	4500	4500	5					
					6					
PLC/ITC- TB #			Conduit # C71447 Conduit size- 3/4"		7					

PLC / Gateway or HW	Note:	
PLC- IP add		
PCS-DCU/RIO	SPBRIO5CAB1; 4.2.1.7	By: A. AREVALO [signature] Date: 04-03-2014
BRANCH:	A	Instrument Range: 0-4500GPM Operating Range:0-4500GPM
MODULE:	7	Instrument Location: SPB EL 5
CHANEL:	7	Tag No: FE/FIT-63064 Maximo Asst. No: 243005
~~Loop/~~**Field Power**	Surge Protector No's: N/A	Lighting Panel: C.B# Fuse # N/A

Figure O-4. Sample Calibration Report

Appendix P
Sample Object Definitions (Upper Anacostia & Eastside Pump Stations)

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Table P-1. Sample Object Definitions (Upper Anacostia & Eastside Pump Stations) - Page 1

Object	Attribute	UAPS	EPS	New	Point Type	Calc Type	Alarm	Historize	Graphic Trend	Report	Safety	Regulatory
Automatic_Transfer_Switch	Emergency_Position	Y			DI		Alarm	Yes				
	Normal_Position	Y			DI			Yes				
	Time_In_Emerg			Y	PLC Calc	Accumulator		Yes				
	Transition_Count			Y	PLC Calc	Counter		Yes				
Bubbler_System	Fail	Y			DI		Alarm	Yes				
	Low_Air_Flow_Switch			Y	DI		Alarm	Yes				
	Low_Oil_Level			Y	DI		Alarm	Yes				
	Low_Pressure			Y	DI		Alarm	Yes				
	Overload	Y			DI		Alarm	Yes				
	Purging	Y			DI		Event	Yes				
Check_Valve	Opened		Y?		DI		Event	Yes				
	Closed			Y?	DI		Event	Yes				
	In_Transition			Y	PLC Calc	Logic		Yes				
	Fail_To_Open			Y	PLC Calc	Timer	Alarm	Yes				
	Fail_To_Close			Y	PLC Calc	Timer	Alarm	Yes				
	Time_To_Transition_Last			Y	PLC Calc	Timer		Yes				
	Transition_Count			Y	PLC Calc	Counter		Yes				
Discharge_Valve	Opened		Y		DI		Event	Yes				
	Closed		Y		DI		Event	Yes				
	In_Remote		Y		DI		Alarm	Yes				
	High_Torque			Y	DI			Yes				
	Open_Command		Y		DO							
	Close_Command		Y		DO							
	In_Transition			Y	PLC Calc	Logic		Yes				
	Fail_To_Open			Y	PLC Calc	Timer		Yes				
	Fail_To_Close			Y	PLC Calc	Timer		Yes				
	Time_To_Transition			Y	PLC Calc	Timer		Yes				
	Transition_Count			Y	PLC Calc	Counter		Yes				
Fan	Air_Flow	Y			DI		Event	Yes				
	Breaker_Closed	Y			DI		Alarm	Yes				
	Disconnect_Switch	Y			DI		Alarm	Yes				
	In_Remote	Y			DI		Alarm	Yes				
	Motor_Overload	Y			DI		Alarm	Yes				
	Running	Y			DI		Event	Yes				
	Start_Fast			Y	DO							
	Start_Slow			Y	DO							
	Runtime			Y	PLC Calc	Accumulator		Yes				
Flowmeter	Flow_Rate	Y	Y		DI			Yes	Yes			
	Flow_Total_Today			Y	PLC Calc	Accumulator		Yes				
	Flow_Total_Yesterday			Y	PLC Calc	Accumulator		Yes				
	Flow_Minimum_Today			Y	PLC Calc	Minimum		Yes	Yes			
	Flow_Minimum_Yesterday			Y	PLC Calc	Minimum		Yes				
	Flow_Maximum_Today			Y	PLC Calc	Maximum		Yes	Yes			
	Flow_Maximum_Yesterday			Y	PLC Calc	Maximum		Yes				
	Flow_Average_Today			Y	PLC Calc	Average		Yes	Yes			
	Flow_Average_Yesterday			Y	PLC Calc	Average		Yes				
Gas_Monitor	CO_Level			Y	AI			Yes	Yes			
	H2S_Level			Y	AI			Yes	Yes			
	LEL_Level			Y	AI			Yes	Yes			
	O2_Level			Y	AI			Yes	Yes			
	CO_Alarm			Y	DI		Alarm	Yes				
	Common_Alarm		Y		DI		Alarm	Yes				
	H2S_Alarm	Y			DI		Alarm	Yes				
	LEL_Alarm	Y			DI		Alarm	Yes				

DRAFT Preliminary Wonderware Object/Attributes For Upper Anacostia and Eastside Sewage Pump Stations

Table P-2. Sample Object Definitions (Upper Anacostia & Eastside Pump Stations) - Page 2

	O2_Alarm	Y			DI		Alarm	Yes				
	Time_In_Alarm			Y	PLC Calc	Timer		Yes				
	Alarm_Count			Y	PLC Calc	Counter		Yes				
HVAC	Ambient_Temperature		Y		AI			Yes				
MCC_Breaker	Closed		Y		DI		Event	Yes				
	Feeder_Voltage		Y		DI		Alarm	Yes				
	Opened		Y		DI		Alarm	Yes				
	Overload		Y		DI		Alarm	Yes				
	Reverse		Y		DI		Event	Yes				
	Under/Over_Voltage		Y		DI		Alarm	Yes				
MCC	Power_Loss	Y			DI		Alarm	Yes				
	Power_Normal	Y			DI		Event	Yes				
	PMT_Alarm	Y			DI		Alarm	Yes				
	Power_Loss_Total_Time			Y	PLC Calc	Accumulator		Yes				
Panel_Power_Supply	Ac_Power_Normal			Y	DI		Alarm	Yes				
	Fail	Y			DI		Alarm	Yes				
	Backup_Power_Supply_In_Use			Y	DI		Alarm	Yes				
	Primary_Power_Supply_In_Use			Y	DI		Event	Yes				
Pump	Discharge_Pressure	Y			AI			Yes				
	E-Stop		Y		DI		Alarm	Yes				
	High_Bearing_Temperature	Y			DI		Alarm	Yes				
	Motor_Malfunction		Y		DI		Alarm	Yes				
	Running	Y	Y		DI		Event	Yes	Yes			
	Seal_Fail	Y			DI		Alarm	Yes				
	Start_Command	Y			DO							
	Stop_Command	Y			DO							
	Discharge_Pressure_High				PLC Calc	Logic	Alarm	Yes				
	Fail_To_Start				PLC Calc	Timer	Alarm	Yes				
	Fail_To_Stop				PLC Calc	Timer	Alarm	Yes				
	Runtime				PLC Calc	Accumulator		Yes				
Pump VFD	Speed_Feedback	Y	Y		AI			Yes	Yes			
	Speed_Command	Y	Y		AO							
	Fail	Y	Y		DI		Alarm	Yes				
	In_Remote	Y	Y		DI		Event	Yes				
	Incomplete_Sequence		Y		DI		Alarm	Yes				
	Not_In_Remote	Y			DI		Alarm	Yes				
	Start/Stop_Command		Y		DO							
Screen	Channel_Level		Y		AI			Yes	Yes			
	Channel_Differential		Y		DI		Alarm	Yes				
	Channel_Level_High		Y		DI		Alarm	Yes				
	Estop_Activated			Y	DI		Alarm	Yes				
	High_Current			Y	DI		Alarm	Yes				
	High_Speed			Y	DI		Event	Yes				
	High_Torque		Y		DI		Alarm	Yes				
	In_Remote		Y		DI		Alarm	Yes				
	Limit_Switch_Confirmation			Y	DI		Alarm	Yes				
	Running		Y		DI		Event	Yes				
	Slow_Speed			Y	DI		Event	Yes				
	Start/Stop_Command		Y		DO							
	Runtime			Y	PLC Calc	Accumulator		Yes				
Security	Back_Door_Intrusion	Y			DI		Alarm	Yes				
	Control_Panel_Intrusion	Y			DI		Alarm	Yes				
	Front_Door_Intrusion	Y			DI		Alarm	Yes				
	Security_System_Status	Y			DI		Alarm	Yes				
	Valve_Vault_Intrusion	Y			DI		Alarm	Yes				

DRAFT Preliminary Wonderware Object/Attributes For Upper Anacostia and Eastside Sewage Pump Stations

Table P-3. Sample Object Definitions (Upper Anacostia & Eastside Pump Stations) - Page 3

	Wet_Well_Intrusion	Y			DI		Alarm	Yes				
Sluice_Gate	Opened		Y		DI		Event	Yes				
	Closed		Y		DI		Event	Yes				
	In_Auto		Y		DI		Alarm	Yes				
	In_Remote		Y		DI		Alarm	Yes				
	Torque_High		Y		DI		Alarm	Yes				
	Open_Command		Y		DO							
	Close_Command		Y		DO							
	In_Transition			Y	PLC Calc	Logic	Event	Yes				
	Fail_To_Open			Y	PLC Calc	Timer	Alarm	Yes				
	Fail_To_Close			Y	PLC Calc	Timer	Alarm	Yes				
	Time_To_Transition_Last			Y	PLC Calc	Timer		Yes				
	Transition_Count			Y	PLC Calc	Counter		Yes				
Smoke_Detector	Alarm		Y		DI		Alarm	Yes				
Suction_Valve	Opened		Y		DI		Event	Yes				
	Closed		Y		DI		Event	Yes				
	In_Remote		Y		DI		Alarm	Yes				
	Hi_Torque			Y	DI		Alarm	Yes				
	Close_Command		Y		DO							
	Open_Command		Y		DO							
	In_Transition			Y	PLC Calc	Logic	Event	Yes				
	Fail_To_Open			Y	PLC Calc	Timer	Alarm	Yes				
	Fail_To_Close			Y	PLC Calc	Timer	Alarm	Yes				
	Time_To_Transition_Last			Y	PLC Calc	Timer		Yes				
	Transition_Count			Y	PLC Calc	Counter		Yes				
Sump_Pump	Circuit_Breaker_Closed	Y			DI		Alarm	Yes				
	In_Auto	Y			DI		Alarm	Yes				
	In_Local	Y			DI		Alarm	Yes				
	High_Level			Y	DI		Alarm	Yes				
	Motor_Overload	Y			DI		Alarm	Yes				
	Running	Y			DI		Event	Yes				
	Runtime			Y	PLC Calc	Accumulator		Yes				
UPS	Fault	Y			DI		Alarm	Yes				
	Low_Battery	Y			DI		Alarm	Yes				
	Maint_Bypass			Y	DI		Alarm	Yes				
	Normal_Power			Y	DI		Alarm	Yes				
	On	Y			DI		Event	Yes				
	On_Battery_Power	Y			DI		Alarm	Yes				
	Static_Bypass			Y	DI		Alarm	Yes				
	UPS_Trouble			Y	DI		Alarm	Yes				
	Time_On_Battery_Power			Y	PLC Calc	Accumulator		Yes				
Vault	Level_High	Y			DI		Alarm	Yes				
Vent_System	Operating		Y		DI		Alarm	Yes				
Washer / Compactor / Conveyor	In_Remote	Y			DI		Alarm	Yes				
	Overload			Y	DI		Alarm	Yes				
	Running	Y			DI		Event	Yes				
	Torque	Y			DI		Alarm	Yes				
	Washer/Compactor_Alarm	Y			DI		Alarm	Yes				
	Runtime			Y	PLC Calc	Accumulator		Yes				
Wetwell	Level	Y	Y		AI			Yes	Yes			
	Backup_Controls_Active		Y		DI		Alarm	Yes				
	Backup_Controls_High_Level	Y			DI		Alarm	Yes				
	Level_High	Y	Y		DI		Alarm	Yes				
	Level_Low		Y		DI		Alarm	Yes				
	Wetwell_Selection		Y		DI		Event	Yes				

DRAFT Preliminary Wonderware Object/Attributes For Upper Anacostia and Eastside Sewage Pump Stations

Table P-4. Sample Object Definitions (Upper Anacostia & Eastside Pump Stations) - Page 4

Pump Contoller	Lead_Start	?	?	?	PLC Register			Yes				
	Lead_Stop	?	?	?	PLC Register			Yes				
	Lag_Start	?	?	?	PLC Register			Yes				
	Lag_Stop	?	?	?	PLC Register			Yes				
	Lag_Lag_Start	?	?	?	PLC Register			Yes				
	Lag_Lag_Stop	?	?	?	PLC Register			Yes				
	All_Pumps_Off	?	?	?	PLC Register			Yes				
	Manual/Auto	?	?	?	PLC Register			Yes				
	Alternation_Seq	?	?	?	PLC Register			Yes				
	Lead_Pump	?	?	?	PLC Register			Yes				
	Lag_Pump	?	?	?	PLC Register			Yes				
	Lag_Lag_Pump	?	?	?	PLC Register			Yes				
	Standby_Pump	?	?	?	PLC Register			Yes				

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Preliminary Wonderware Object/Attributes For Upper Anacostia and Eastside Sewage Pump Stations

Appendix Q
Sample Control Description

Note that this sample makes use of an older CSI specification numbering system. All new control descriptions must utilize the current CSI numbering system used by DC Water.

SAMPLE PROCESS CONTROL SYSTEM (PCS) CONTROL DESCRIPTION

SECTION 17400

PROCESS MONITORING AND CONTROL STRATEGIES

PART 1 - GENERAL

1.01 SUMMARY

A. This section describes the process monitoring and control strategies to be implemented by the System Integrator for the SCADA System at the Regional Treatment Plant (RTP) and the <Name Removed> Pump Station (NRPS).

B. Related sections include:

1. Section 17200 – General SCADA System Requirements

2. Section 17299 – Input/Output Point List

1.02 SUBMITTALS

A. Submit monitoring and control strategy descriptions to the Engineer for review. Include the following information in the submittals for this section:

1. A narrative of the monitoring and control strategies to be provided.

2. NRPS PLC and Master Polling PLC memory maps describing the allocation of memory space with the PLC for field I/O, space for standard equipment interface module logic and high level logic, PID module setup logic, and communications buffers.

3. A descriptive narrative of the function of each module and commented PLC program listings for each program module. Show detailed programming for each module to serve as an example of how the module will be programmed wherever it is required. Describe memory usage and communications associated with the module. Describe the Local Operator Interface (LOI) programming associated with the module.

4. A detailed control diagram(s) showing database names for all field inputs and outputs and the type and linkage of software modules, order of execution and execution frequency for all programming.

5. A written description of the operation of each sequence used. Provide a written description of the input/output point or output message.

6. A listing of database points identifying alarm/event description for each point, alarm points, alarm limits, event points, and alarm priorities.

B. Control strategy descriptions must be reviewed by the Engineer and Owner prior to PLC programming.

C. Review by the Engineer shall not constitute acceptance of the detailed programming. Correct any logic errors noted during checkout and testing. Make field changes necessary to provide the specified control at any time until acceptance.

1. Meetings will be scheduled as necessary at the RTP to jointly review control strategy submittals. This will also serve to coordinate and resolve any issues or discrepancies in regard to the operator interface software programming and implementation and detailed PLC programming. **Plan to attend one (1) meeting of one-day duration to jointly review all strategies.**

1.03 LOI FUNCTIONAL REQUIREMENTS

A. Detail the LOI display content during strategy development and submit for Engineer's review. Follow display layout and color standards in accordance with <NAME REMOVED>'s PCS/SCADA Engineering Standards. Consider the following when laying out displays:

1. The display and keyboard functional characteristics.

2. The detailed monitoring and control strategy implementation.

3. The required interaction between the operator and the process.

4. Consistency among displays for color, symbols usage and general layout.

1.04 SCADA PLC PROGRAMMING

A. General

1. Provide communications programming as specified here and elsewhere.

2. For the NRPS PLC, program the control logic modules for each piece of equipment monitored and controlled by the PLC.

3. Provide ladder logic such that values are efficiently read by the Master Polling PLC using block reads. Provide data in contiguous registers.

4. Provide ladder logic such that values are efficiently sent by the Master Polling PLC using block writes. Provide data in contiguous registers.

5. Provide logic and memory to transfer to the Master Polling PLC any additional inputs the NRPS PLC that are in the I/O point list as described in Section 17299 but not listed in the logic described below or the monitoring and control narratives in Part 2 of this section.

B. Core Logic Module

1. Provide ladder logic configuration to perform the following in the NRPS PLC:
   a. Respond to the existing Master Polling PLC polling sequence.

   b. Provide an indication of successful communication with the Master Polling PLC each time a successful communication of input and calculated data with the Master Polling PLC occurs. If communication with the Master Station does not occur for 5 minutes (adjustable with PLC programmer), provide a communication failure flag. Reset the flag after one minute (adjustable) after successful communication with the Master Polling PLC.

   c. Provide a latched power failure alarm to be read by the Master Polling PLC. If the power failure condition is cleared, reset the power failure alarm 5 minutes (adjustable with PLC programmer) after the next successful communication as described in paragraph b above.

2. Provide logic to synchronize the clock and calendar of the NRPS PLC with the Master Polling PLC on a time-scheduled basis (for example, once per day at midnight).

3. Provide a PLC initialization flag that is set true on the first PLC scan. Provide logic for communication of the flag to the Master Polling PLC. Do not permit automatic transfer of any commands or set point changes to the NRPS PLC while the PLC initialization flag is set.

4. Provide a health flag that provides a common alarm to the Master Polling PLC for NRPS PLC faults, including PLC stopped. Provide logic to combine all NRPS PLC (including, but not limited to, CPU fault and card fault for each I/O and communications card) into the single NRPS PLC health flag.

5. Provide an indication to the Master Polling PLC that notifies the operator if the NRPS PLC program has stopped running.

PART 2 – PRODUCTS

2.01 SITE MONITORING AND CONTROL

A. Monitoring and control functions to be programmed under this Contract are outlined in the narratives described below.

2.02 <NAME REMOVED> PUMP STATION

A. Overview of the Process Components

Currently, the <Name Removed> County Municipal Authority (NRCMA) Wastewater Treatment Plant (WWTP) treats all wastewater from its collection and conveyance system onsite. The scope of the project includes constructing a pumping station and force main to convey wastewater collected by the NRCMA system to the <NAME REMOVED> RTP. The force main is currently being constructed by Others. The NRCMA WWTP will eventually be decommissioned after the new pumping station is online. Due to the significant screenable material and grit at the NRCMA WWTP, two (2) mechanical bar screens and a grit removal system are included in the project. The bar screens share a (1) common screenings washer/compactor, complete with wash water valves.

The grit system consists of a grit concentrator, two (2) grit pumps, a combined grit classifier/dewatering escalator and associated wash water valves. Once screened and degritted, the wastewater enters a wet well where four (4) submersible main pumps convey wastewater from the NRCMA collection system to the <NAME REMOVED> Regional Treatment Plant (RTP). Ancillary equipment linked to the control system includes a self-cleaning wash water strainer, two (2) solids conveyors, influent and effluent flow metering, and eleven (11) actuated sluice gates.

B. Summary of Process Operations

Raw wastewater enters the pumping station from one of two influent interceptors. Each interceptor is metered through Parshall flumes with ultrasonic level meters. Instantaneous flow measurements are relayed to the NRPS PLC.

A ratio of this flow will be utilized for billing purposes and will be regularly compared to the pumping station main effluent flow meter to verify that the sum of the two Parshall flume flow meters is equal to the main flow meter within 10%.

The metered raw influent passes through one of three channels. Two of the channels each have a mechanically cleaned inclined barscreen with actuated slide gates. The third channel is a manual barscreen for maintenance only operations. Raw wastewater mixes with recycle streams from the grit and screening dewatering operations and is screened by the barscreens.

Collected screenings are carried up the barscreen and discharged to a common screenings washer/compactor. An auger compacts the solids as they are washed with potable water. The potable water has four (4) solenoid valves to control washing of the screenings in the upper and lower sections of the screenings washer compactor and at each screen's associated effluent launder. The auger carries the solids up to Conveyor No. 1.

After the wastewater is screened, it enters another distribution channel to either flow to the grit chamber (normal) or directly to the pumping station wet well (maintenance only). The entrance to the grit concentrator has a funnel to align the incoming flow with one of several grit separating trays. The velocity of the wastewater moves the water in a circular pattern around the trays and separates the grit to the middle of the chamber.

Degritted wastewater flows up to the top of the chamber and is directed to one of two wet wells over one of two 8-foot weirs complete with actuated isolation gates. The dual wet well allows provisions for seasonal maintenance and inspection.

Two grit pumps are associated with the grit system in a duty-standby arrangement. The grit slurry is pumped up to the screening room to a grit classifier/dewatering unit. The grit is washed in the grit classifier on top of the unit. Washed grit flows to the integral dewatering unit below to be dewatered via an inclined auger. Five (5) solenoid valves are associated with the grit removal system. These valves open and close sequentially to allow washwater to be sprayed through the grit concentrator, the grit classifier and the grit dewatering unit utilizing a timed process. Dewatered grit is discharged by gravity to Conveyor No. 1.

Normally both isolation gates (SG-9 & 10) will be open allowing degritted wastewater into the wet wells. Each wet well houses two (2) submersible pumps. The pumping operation is lead-lag-lag 2 operation to maintain wet well level. The primary level indication instruments are radar sensors and the secondary a bubbler-based backup system. The VFD's control the speed of the pumps to maintain a PLC-based wet well level setpoint. As the lead pump's speed rises, the first lag pump engages. Once two pumps are in operation, both will operate at the same speed. If the speed of both pumps continues to rise, the lag 2 pump engages and all three pumps will operate at the same speed. The PLC will stop the lag 2 and lag pumps using a similar method. As the speed of all three pumps decrease, the lag 2 pump will stop. As the speed of the lead and lag pumps continues to decrease, the lag pump will stop. The lead pump will continue to operate to maintain wetwell level. If the wetwell level decreases below a minimum operating level, the lead pump will stop.

Washed and compacted screenings and grit are discharged to Conveyor No. 1. This first unit is the lifting conveyor that carries the solids outside the building and discharges to Conveyor No. 2. The second unit is the leveling conveyor that has multiple ports for discharging into a dumpster. The conveyor operations are tied to the operations of the either the screen washer/compactor or the grit dewatering unit and have a user defined time delay.

C. Process Equipment Linked to the NRPS PLC Panel

Hydraulic Gates, (Tags: SG -1 through 11) – Specification Section 11285

Wastewater Pumps, (Tags: RSP -1 through 4) – Specification Section 11310

Grit Pumps (Tags: GRP -1 & 2) – Specification Section 11311

Vortex Grit Collection Equipment (Tags: GC-1, GRC/DWE-1, GCV-1 through 5; VCP-200) – Specification Section 11326

Mechanically Cleaned Bar screen (Tags: MS – 1 & 2, SCC-1, WCV-1 through 4; VCP-100) – Specification Section 11331

Solids Conveyors (Tags: CON 1 & 2; VCP-300) – Specification Section 14500

Self-Cleaning Strainer (Tags: STR-1, SCV-1; VCP-400) – Specification Section 15200

D. Wetwell Level / Pump Control

A Hand-Off-Auto (HOA) selector switch located on each wastewater pump VFD will select the operational mode of each pump. When the switch is in Hand, a pump can be started, stopped and speed controlled locally at the VFD keypad. When the switch is in Auto, a pump can be started or stopped and its speed controlled by the PLC. The PLC will monitor the following parameters of each pump: Run status, Available/Out-Of-Service, VFD fail, speed indication and Auto (Computer) mode.

Program the NRPS PLC to provide the following monitoring and control functionality for the raw sewage pumps:

1. Perform checking of pump status including run status, availability, VFD fail, and pump mode selection (Computer/Local).

2. If in Computer mode, provide the ability to start a pump if the following conditions are satisfied:

a. Pump is available for control.

b. Pump is not failed.

c. Wetwell low-low level switch is not activated.

d. Pump high temperature interlock is not activated.

e. Pump high vibration interlock is not activated.

f. Pump power junction box leak switch is not activated.

The PLC shall provide indication to the LOI graphic screen that all of the above conditions are satisfied and the pump is ready to run.

3. If a pump start is initiated, and the PLC does not receive run status within a predetermined time delay, the PLC shall generate a fail to start alarm for display on the LOI. Similarly, if a pump stop is initiated, and the PLC does not receive pump stop status within a predetermined time delay, the PLC shall generate a fail to stop alarm for display on the LOI. This applies to Computer Manual and Computer Automatic control modes.

4. Provide the following operation modes:

a. Pump start and stop outputs based on a Computer Manual (start or stop) request from the LOI. Perform all status checking as described above prior to starting or stopping pumps. A Computer Manual (start or stop) request will generate the control outputs regardless of level as indicated by the level transmitter or level alarms generated by float switches. (Except for the low-low wetwell level float switch.) Computer Manual speed control shall be based on an operator-entered speed set point entered at the LOI.

b. The Computer Automatic mode of operation will start, stop and control the speed of the pumps to maintain an operator-entered level set point in the wetwell. Set point entry shall be performed at the LOI. Automatic pump speed control will be based on PID control.

The sewage level in the wetwell will be monitored by two radar level transmitters. Provide PLC logic that will allow the operator to select the transmitter for automatic pump control from the LOI. The PLC shall compare the two radar level transmitter values. If the difference between the transmitters is greater than ten percent, the PLC shall generate a deviation alarm for display on the LOI.

The wellwell level must be above the Start Level set point for the Lead pump to operate.

<u>Lead Pump</u>

Upon selecting Computer Automatic mode from the LOI, the PLC shall perform status checking as described above and immediately start the Lead Pump upon receiving the ready to run permissive. The PLC shall use PID control to modulate pump speed in order to maintain the wetwell level set point.

Lag Pump

Provide PLC logic that will allow operators to enter the following Lag Pump control set points at the LOI:

Start Level set point (for the Lag Pump)
Start Control Variable (CV) % Speed set point
Start Delay Time set point
Stop CV % Speed set point
Stop Delay Time set point

The PLC shall start the Lag Pump when the following conditions are met:

- Lead Pump is running
- Wetwell level is above the Start Level (for the Lag Pump)
- Lead Pump's speed exceeds the Lag Pump Start CV % Speed set point for a time duration longer than the Lag Pump Start Delay Time set point

Once started, the PLC shall control the Lag Pump's speed at the same speed as the Lead Pump.

The PLC shall stop the Lag Pump when the following conditions are met:

- Lead/Lag Pump speed decreases below the Lag Pump Stop CV% Speed set point for a time duration longer than the Lag Pump Stop Delay Time set point

Lag 2 Pump

Provide PLC logic that will allow operators to enter the following Lag 2 Pump control set points at the LOI:

Start Level set point (for the Lag 2 Pump)
Start Control Variable (CV) % Speed set point
Start Delay Time set point
Stop CV % Speed set point
Stop Delay Time set point

The PLC shall start the Lag 2 Pump when the following conditions are met:

- Lead and Lag Pumps are running
- Wetwell level exceeds the Start Level set point (for the Lag 2 Pump)

- Lead and Lag Pumps' speed exceeds the Lag 2 Pump Start CV % Speed set point for a time duration longer than the Lag 2 Pump Start Delay Time set point

Once started, the PLC shall control the Lag 2 Pump's speed at the same speed as the Lead and Lag Pumps.

The PLC shall stop the Lag 2 Pump when the following conditions are met:

- Lead, Lag, and Lag 2 Pump speed decreases below the Lag 2 Pump Stop CV% set point for a time duration longer than the Lag 2 Pump Stop Delay Time set point

Standby Pump

Provide logic that will allow operators to enable/disable Standby pump control at the LOI. When enabled, the Standby Pump will operate in the event of any Lead, Lag or Lag 2 Pump failure. Failures shall include pump/motor failures and VFD faults. All failures shall be displayed at the LOI graphic display.

Pump Alternation

Provide logic that will allow operators to select either Manual or Automatic Alternation of the pumps from the LOI graphic screen.

In Manual Alternation, the operator shall select one of the following Lead/Lag/2nd Lag/Standby Pump combinations:

Lead	**Lag**	**Lag 2**	**Standby**
P-1	P-2	P-3	P-4
P-1	P-2	P-4	P-3
P-1	P-3	P-4	P-2
P-1	P-3	P-2	P-4
P-1	P-4	P-2	P-3
P-1	P-4	P-3	P-2
P-2	P-1	P-3	P-4
P-2	P-1	P-4	P-3
P-2	P-3	P-1	P-4
P-2	P-3	P-4	P-1
P-2	P-4	P-3	P-1
P-2	P-4	P-1	P-3
P-3	P-1	P-2	P-4
P-3	P-1	P-4	P-2
P-3	P-2	P-1	P-4
P-3	P-2	P-4	P-1

Lead	Lag	Lag 2	Standby
P-3	P-4	P-1	P-2
P-3	P-4	P-2	P-1
P-4	P-1	P-2	P-3
P-4	P-1	P-3	P-2
P-4	P-2	P-1	P-3
P-4	P-2	P-3	P-1
P-4	P-3	P-1	P-2
P-4	P-3	P-2	P-1

In Automatic Alternation, the pumps will alternate when the Lead Pump accumulated runtime has exceeded an operator-entered Runtime Alternation set point. Set point entry will be made at the LOI and communicated to the PLC. Provide PLC logic to calculate pump motor runtime of each pump for display on the LOI graphic screens.

c. Provide logic in the PLC to enable the two pump operation modes, Computer Manual and Computer Automatic. The mode selection will be performed at the LOI, and the selection will be communicated to the PLC. Provide logic to monitor the high and low wetwell level float switches. The PLC shall generate wetwell level alarms for display on the LOI graphic screen.

5. Each pump will be equipped with a pump monitoring unit to monitor pump vibration, temperature and leak detection. The pump monitoring unit will communicate with the PLC via a MODBUS communication link. The pump monitoring system will also relay sensor data to a memory system on each respective pump. Provide the following monitoring and interlocking PLC logic for the raw sewage pumps:

a. Upon detection of a high motor vibration condition, the PLC will generate a latched high vibration alarm for display on the LOI and the PLC will immediately stop the pump. The pump will not be permitted to start while the high vibration alarm is active. The high vibration latched alarm shall be manually reset from LOI.

b. Upon detection of a leak condition in the power junction box, the PLC will generate a latched leak alarm for display on the LOI and the PLC will immediately stop the pump. The pump will not be permitted to start while the leak alarm is active. The latched leak alarm shall be manually reset from LOI.

c. Each pump is equipped with RTDs for monitoring pump bearing temperature, motor stator temperature, and motor winding temperature for each phase. All RTD temperature values shall be displayed on the LOI. Upon detection of a high temperature condition, the PLC shall generate a high temperature alarm for display on the LOI. Upon detection of a high-high temperature condition, the PLC shall generate a latched high-high temperature alarm for display on the LOI and the PLC shall immediately stop the pump. The pump will not be permitted to start while the high-high temperature alarm is active. The high-high latched temperature alarm shall be manually reset from LOI.

d. The alarm settings for pump interlocking logic are shown below:

RTD	**Warning/ Alarm Limit**	**Shutdown Limit**	**Shutdown Pump Required if Shutdown Limit Reached?**
Motor Winding Temperature (RTD)	130^0 C	140^0 C	Yes
Lower Bearing Temperature (RTD)	90^0 C	120^0 C	Yes
Motor Junction Chamber Temperature (RTD, One per Phase – 3 Total)	90^0 C	105^0 C	Yes
Vibration Detection (VIS-10)	15 mm/s	25 mm/s	Yes
Leakage Detection in Power Junction Box	---	I>22mA	Yes

e. In addition to hardwired control circuits, each VFD shall be monitored by the PLC via a MODBUS communication link. Provide PLC and VFD programming in order to display the following VFD parameters on the LOI and HMI workstation graphic screens (for each pump):

Drive Output Current
Drive Output Voltage
Drive Output Torque

Coordinate soft point tagnames with Owner/Engineer.

6. Provide a hardwired backup pump control system to monitor and control the pumps of a PLC or control system failure. The backup control system will only be available for pumps in “Auto” (Remote) at the VFD. Pump start and stop functionality will be initiated by a programmable current relay connected to a bubbler system measuring wetwell level. Wetwell level will be displayed on the current relay display.

a. Pump control shall transfer to the backup system if the PLC fails, or the high-high float is activated and at least one pump is not running at full speed. If the full speed contact is active on at least one pump, the backup controls shall not be activated.

b. Backup pump control shall be enabled/disabled via a selector switch on the face of the PLC control panel. This switch shall be monitored by the PLC, and an alarm shall be generated for display on the LOI graphic screen when the system is disabled.

Once the backup control system is activated, it will remain in control of the pumps until the system is manually reset via a pushbutton at the PLC control panel. Once the reset button is pressed, control of the pumps will be restored to the PLC.

c. Once in backup control, the pumps will start and stop based on wetwell level settings configured in the current relay. Configure the VFDs to operate the pumps at a constant speed (preset speed setting) while backup control is active.

Configure the programmable current relay to operate the backup pump control system using the following settings:

Lead Pump Start setting: Elevation: -1.14 ft.
Lag Pump Start setting: Elevation: 1.86 ft.
Lag 2 Pump Start setting: Elevation: 3.86 ft.
All Pumps stop setting: Elevation: -6.77 ft.

d. Lead/Lag/Lag 2/ Standby shall be selected via a four position selector switch at the pump control panel. Selections shall include the following combinations:

Lead	**Lag**	**Lag 2**	**Standby**
P-1	P-2	P-3	P-4
P-2	P-3	P-4	P-1
P-3	P-4	P-1	P-2
P-4	P-1	P-2	P-3

Note: The maximum number of pumps running simultaneously is three (3) pumps.

E. Daily Flow Monitoring and Totalization

1. Provide the following logic for the NRPS PLC:
Program the NRPS PLC to calculate daily flow totals based on the number of pulsed effluent flow signals received by the I/O counter module. The PLC will multiply the number of pulse counts by a constant volumetric value (gal/kgal) to calculate the daily flow total. Coordinate with Owner/Engineer for the pulse duration configuration/volumetric value.
Program the NRPS PLC to reset the pulse counter to 0 each day at 23:59 hours and move the value for today’s running flow total to the PLC register(s) reserved for yesterday’s daily total flow.
Program the NRPS PLC to calculate daily influent flow totals based signals received by the Parshall flume level transmitters.
Program the NRPS PLC to store daily totalized flow values. Program the PLC to store the previous 31 days totalized flow values in a first-in, last-out queue. Arrange the historical daily totalized flow values in contiguous registers in the PLC. The LOI shall be

configured to display the current day's running total, as well as the previous 31 days totalized flow values.

2. Provide the following logic for the Master Polling PLC at RTP:

Program the Master Polling PLC to receive the current running daily flow total and the previous 5 days totalized flow values.
Provide logic to generate an alarm for display on the HMI graphics if totalized flow data has not been updated after a 24 hour period has elapsed.

F. Screenings System (I-5)

1. General: shall be a non-PLC based, hard-wired, relay-based logic with dry contacts have control over the screening equipment and relay output signals to the PLC SCADA system. Refer to specification Section 11331 – Mechanically Cleaned Bar Screen for process controls and system operation.

2. Instrumentation

Ultrasonic Level Transmitters: There are two (2) ultrasonic level transmitters associated with the barscreens. These are the primary level indication for the barscreen system. Level sensing elements include one (1) upstream and one (1) downstream of Barscreen No. 1 (LIT-056A) and one (1) upstream and one (1) downstream of Barscreen No. 2 (LIT-057A). The level transmitters are for control of barscreen motor speed (or number of starts), level indication and trending.

Submersible Float Level Switches: There are two submersible float level switches (LSH-016A & LSH-016B) located at the Upstream Screening Channel. These are the secondary level indication for the barscreen system. The level switches are used for indication and control. Channel level above high will open the lag screen slide gates (upstream and downstream) and start the lag screen. Channel level above high-high will alarm "High Upstream Screening Channel Level" and is alarmed at VCP-100.

3. Bar Screen Isolation Gates (SG-3, 4, 5 & 6)

There are four motor operated on/off isolation gates (SG-3 through 6) for the Screening System (refer to Section 11285 – Hydraulic Gates). Bar Screen No. 1 (MS-1) has a motor operated on/off inlet (SG-3) and outlet (SG-4) isolation gate. Bar Screen No. 2 (MS-2) has a motor operated on/off inlet (SG-5) and outlet (SG-6) isolation gate. Flow through each bar screen is controlled by the isolation gates.

Local Control: The gate can be opened and closed from the local gate operator using the Local-Off-Remote and the Open-Stop-Close selector switches. When the gate operator is selected to Local, the gate can be opened and closed using the gate operator Open-Stop-Close selector switch. Power On and High Torque indicating lights are provided on the local gate operator.

Remote-Manual Control: When the gate operators for SG-3 through 6 are selected to Remote and Manual the gates can be manually opened and closed, by the operator, from the VCP-100 (unless otherwise noted).

Remote-Auto Control: When the gate operator is selected to Remote, and Auto is selected from the VCP-100, the gate is monitored and controlled by VCP-100. The operator must assign one bar screen as lead from a position switch (Screen 1 or 2). When the gates associated with the lead bar screen is selected to Remote-Auto, the outlet side gate will open first for a pre-set time until the water levels are equal on each side of the screen. Once the water levels are equal, the inlet gate will open permitting raw wastewater to flow to the associated bar screen. When the gates associated with the lag bar screen is selected to Remote-Auto, the gates will open in the same manner as described earlier (outlet, delay, inlet). The PLC will provide a run permissive to VCP-100 for operating the Lag Screen. Gate Fault, Gate Opened, Gate Closed, and Remote status for each gate is displayed at VCP-100.

4. Screening System

The Screening System is a part of a vendor supplied Influent Screening System Control Panel (VCP-100) and will be located in the Electrical Room, unless otherwise noted. The Influent Screening System operating status and alarms are transferred from the vendor control panel to the NRPS PLC and are displayed at VCP-100 (refer to Section 11331 - Input/Output List for a minimum list of data points required).

The Screening System shall run in Manual or Automatic Mode. In manual mode, the Screening System and associated components can be operated manually either at the local push button stations or remotely via selector switches at VCP-100. In automatic mode, the Screening System and associated components shall be operated via relay logic with operator adjustable positions, timers, and selector switches at VCP-100. Refer to Section 11331 for Sequence of Operations.

The Screening System shall NOT operate if the following conditions occur:
Conveyor No. 1 is not running or has failed
Conveyor No. 2 is not running or has failed

5. VCP-100 Output to NRPS PLC

The Influent Screening System Control Panel (VCP-100) shall send the following output signals to the NRPS PLC:

a. VCP-100 Power
b. E-Stop Common
c. Lead Screen (Screen No. 1 or No. 2)
d. Screen No. 1 RUN
e. Screen No. 1 FAIL
f. Screen No. 1 Differential LEVEL (4-20 ma signal)
g. Screen No. 2 RUN
h. Screen No. 2 FAIL
i. Screen No. 2 Differential LEVEL (4-20 ma signal)
j. LSH-016A High ALARM
k. LSH-016B High-High ALARM
l. Screenings Washer/Compactor RUN

m. Screenings Washer/Compactor FAIL
n. Wash water main valve (WCV-1) OPEN
o. Wash water drain pan valve (WCV-2) OPEN
p. Screen No. 1 effluent launder wash water valve (WCV-3) OPEN
q. Screen No. 2 effluent launder wash water valve (WCV-3) OPEN
r. Screen No.1 Speed Alarm
s. Screen No.2 Speed Alarm
t. Washer/Compactor Speed Alarm

6. NRPS PLC Programming

Provide PLC logic to generate a run permissive to VCP-100 for the Screening System. The Screening System shall not be permitted to operate if either Conveyor No.1 or Conveyor No. 2 has failed or is not running.

Provide PLC logic to generate a run permissive to VCP-100 for the Lag Screen. The Lag Screen run permissive shall operate as follows:

The PLC will monitor Lead/Lag Screen selection made at VCP-100. When the gates associated with the Lead screen is selected for Remote-Auto, the outlet side gate will open first for a pre-set time until the water levels are equal on each side of the screen. Once the water levels are equal, the inlet gate will open permitting raw wastewater to flow to the associated Lead Screen.

The Lag Screen and associated gates will operate in the same manner as the Lead Screen when it receives a run permissive from the PLC.

Provide PLC logic to initiate the Lag Screen run permissive upon the following conditions:

a. Lead Screen Alarm signal is active for a pre-set time period.
b. Raw Influent Flow (FI-082) rises above 12 MGD for a pre-set time period.
c. High-High Level (LSH-016B) is active for a pre-set time period.

Provide PLC logic to disengage the Lag Screen run permissive (and associated gates) and return to standby when all of following conditions are met:

d. Lead screen Alarm signal is cleared.
e. Raw Influent Flow (FI-082) falls below 12 MGD for a pre-set time period.
f. High-High Level (LSH-016B) is off for a pre-set time period

G. Grit Removal System (I-5)

1. General: This process equipment will be monitored and controlled by vendor control panel VCP-200 unless otherwise noted. Refer to specification Section 11326 – Vortex Grit Removal System for process controls and system operation. The Grit Removal System shall NOT operate if the following conditions occur:

Conveyor No. 1 is not running or has failed
Conveyor No. 2 is not running or has failed

2. Grit Removal System

There is a Grit Removal System includes a Grit Concentrator (GC-1), a combination Grit Classifier/Dewatering Escalator (GRC/DWE-1) and two (2) grit pumps (GRP-1 & 2), and wash valves (GCV-1, 2, 3,4 & 5) and is controlled by a vendor supplied control panel (VCP-200) located in the Electrical Room. Local Control: The Grit Removal System operation is operator selectable to be continuous, on a timer or manually via local hand selectors.

3. Grit Pumps

Grit Pump Motor Running, Grit Pump Motor Fault, On status for both pumps is displayed at VCP-200. Local Control: Provided by VFD and E-stop provided for manual local control of each pump. Refer to specification Section 11311 – Grit Pumps for grit controls and operations.

4. Grit Washer/Classification Unit

Grit Washer/Classification Unit Motor Running, Grit Washer/Classification Unit Motor Fault, On status for Grit Washer/Classification Unit is displayed at VCP-200. Local Control: HOA and E-stop switches.

5. Washwater Valves

Open Status for five (1) Wash Valves (GCV-1 through 5) is displayed at the VCP-200.

6. VCP-200 Output to NRPS PLC

The Grit Removal System Control Panel (VCP-200) shall send the following output signals to the NRPS PLC:

a. VCP-200 Power
b. E-Stop
c. System Alarm
d. Grit Pump No. 1 RUN
e. Grit Pump No. 1 FAIL
f. Grit Pump No. 2 RUN
g. Grit Pump No. 2 FAIL
h. Grit Separation / Classification drain valve OPEN (GCV-1)
i. Grit Separation / Classification fluidizing water valve OPEN (GCV-2)
j. Grit Separation / Classification flushing water valve OPEN (GCV-3)
k. Grit Separation / Classification rinsing water valve OPEN (GCV-4)
l. Grit Separation / Classification mode: WET/DRY/REMOTE
m. Grit Dewatering Escalator RUN (signal to be used as permissive for conveyor operations as described in Specification Section 14500: Solids Conveyors.)
n. Grit Dewatering Escalator FAIL

o. Grit Dewatering Escalator SPEED (via potentiometer remote 4-20 ma signal).
p. Grit Concentrator fluidizing valve OPEN indicating light (GCV-5)
q. Grit Dewatering Escalator Speed Alarm

7. NRPS PLC Permissive

Provide PLC logic to generate a run permissive to VCP-200 for the Grit Removal System. The Grit Removal System shall not be permitted to operate if either Conveyor No.1 or Conveyor No. 2 has failed or is not running.

H. Conveyor System (I-5)

1. General: This process equipment will be monitored and controlled by vendor control panel VCP-300 unless otherwise noted. Refer to specification Section 14500 – Solids Conveyor for process controls and system operation.

2. The Conveyor system includes the following equipment: Lifting Conveyor System (CON -1) and Self-Leveling Conveyor System (CON -2).

3. The Conveyor system shall be able to operate in manual or automatic mode. In manual, the conveyors shall operate via local push button operator stations or remotely based on VCP-300 push buttons or selector switches. In automatic mode, both Conveyors will operate if either of the following conditions occur:

a. Screening Washer/Compactor (SCC-1) Auger Motor is RUNNING
b. Grit Classifier/Dewatering Escalator (DWE-1) Motor is RUNNING

CON-1 shall continue to RUN for a pre-set time after both SCC-1 and DWE-1 turn off. CON-2 shall continue to RUN for a pre-set time after CON-1 turns off.

4. Local Control: HOA, E-Stop (with pull cords) and JOG switches provided for manual local control of each conveyor.

5. The Conveyor System Control Panel (VCP-300) shall send the following output signals to the NRPS PLC:

a. VCP-300 Power
b. E-Stop
c. System Alarm
d. Conveyor No. 1 RUN
e. Conveyor No. 1 FAIL
f. Conveyor No. 2 RUN
g. Conveyor No. 2 FAIL
h. Conveyor No. 1 Speed Alarm
i. Conveyor No. 1 Speed Alarm

6. NRPS PLC Permissive

Provide PLC logic to generate a run permissive to VCP-300 for the conveyors. In automatic mode, CON-1and CON-2 shall operate when run status is detected for either the Screening Washer/Compactor or the Grit Classifier/Dewatering Escalator. CON-1 shall continue to RUN for a pre-set time after both SCC-1 and DWE-1 stop. CON-2 shall continue to RUN for a pre-set time after CON-1 stops.

I. Strainer System (I-6)

1. General: This process equipment will be monitored and controlled by vendor control panel VCP-400 unless otherwise noted. Refer to Process Piping (Self-Cleaning Strainer) – Specification Section 15200.

2. The Strainer Control Panel (VCP-400) shall send the following output signals to the NRPS PLC:

   a. VCP-400 Power
   b. System Alarm
   c. Motor RUN
   d. Motor FAIL
   e. Differential Pressure (as a 4-20 ma signal)

J. Slide Gate Monitoring

Slide Gates SG-1 through SG-11 will be interfaced with the PLC via a MODBUS communication link. Provide PLC programming/configuration to display slide gate opened, closed and fail status on the LOI and HMI workstation graphic screens.

K. Power Monitoring

In addition to hardwired circuits, utility power monitors will be interfaced with the PLC via a MODBUS communication link. Provide PLC and power monitor programming/configuration in order to display the following parameters on the LOI and HMI workstation graphic screens (for both main power feeds A and B):

Voltage A-B
Voltage B-C
Voltage C-A
Voltage A-N
Voltage B-N
Voltage C-N

Current Phase A
Current Phase A Average
Current Phase B
Current Phase B Average
Current Phase C
Current Phase C Average
Current Neutral

Power Factor Phase A
Power Factor Phase B
Power Factor Phase C
Power Factor 3-Phase

Power Phase A
Power Phase B
Power Phase C
Power 3 Phase

Reactive Power Phase A
Reactive Power Phase B
Reactive Power Phase C
Reactive Power 3-Phase

Apparent Power Phase A
Apparent Power Phase B
Apparent Power Phase C
Apparent Power 3-Phase

Power KVAR
Power KVA
Frequency

Coordinate soft point tagnames with Owner/Engineer.

PART 3 – EXECUTION

3.01 GENERAL

A. Programming shall be fully tested before the in-factory testing.

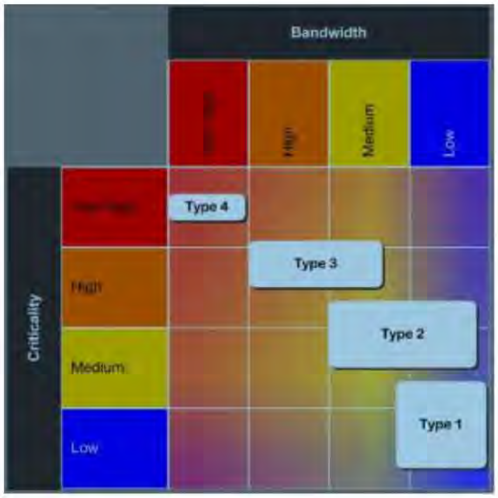
B. Programming shall be fully tested during the in-factory testing as described in Section 17143 of the specifications.

C. The System Integrator is to coordinate the PLC programming efforts with those of the Engineer in terms of creating an integrated system of the NRPS PLC, Master Polling PLC and operator interface software (HMI). The Owner/Engineer will supply the HMI programming. The System Integrator is responsible for configuration and programming of the LOI. The graphic displays and other interfaces shall be fully tested with PLC logic during the in-factory testing.

END OF SECTION 17400

Appendix R
DC Water IT Communications Hardware Standards

Communication Hardware Standards - DC Water IT – 11/14/14



3.2.1 Industrial Grade Switch.
Manufacturer: Cisco. Model: Ethernet switch – twelve 10/100bTX and two 100bFX interfaces (DIN-rail mount) with cryptographic image file.
Part #: WS-C2955C-12.

3.2.2 Switch.
Manufacturer: Cisco. Model: Ethernet switch – twenty-four 10/100bTX and two 10/100/1000bTX interfaces (rack mount) with cryptographic image file.
Part #: WS-C2960-24TT-L.

Or:
3.2.3 Industrial Grade Switch.
Manufacturer: Cisco. Model: Ethernet switch –four 10/100bTX and two Gigabit (10/100/1000bTX and/or SFP) interfaces (DIN rail mount) with cryptographic image file.
Part #: IE-3000-4TC - recommended replacement for above

> *(Optional Item – Expansion Modules)*
> Industrial Grade Switch Expansion Module.
> Manufacturer: Cisco. Model: Switching module – eight 10/100bTX interfaces.
> Part #: IEM-3000-8TM=.
>
> *And/Or:*
> Industrial Grade Switch Expansion Module.
> Manufacturer: Cisco. Model: Switching module – eight 100bFX interfaces (LC connectors).
> Part #: IEM-3000-8FM=.

Or:
3.2.4 Industrial Grade Switch.
Manufacturer: Cisco. Model: Ethernet switch –eight 10/100bTX and two Gigabit (10/100/1000bTX and/or SFP) interfaces (DIN rail mount) with cryptographic image file.
Part #: IE-3000-8TC.

(Optional Item – Expansion Modules)
Industrial Grade Switch Expansion Module.
Manufacturer: Cisco. Model: Switching module – eight 10/100bTX interfaces.
Part #: IEM-3000-8TM=.

And/Or:
Industrial Grade Switch Expansion Module.
Manufacturer: Cisco. Model: Switching module – eight 100bFX interfaces (LC connectors).
Part #: IEM-3000-8FM=.

Or:
3.2.5 Industrial Grade Switch.
Manufacturer: Cisco. Model: Ethernet switch – 24 10/100BaseTX ports and two dual-purpose Gigabit Ethernet uplinks.
Part #: CGS-2520-24TC.

(Optional Item – Interface Connectors)
Interface Connector (SFP).
Manufacturer: Cisco. Model: 1000Mbps Multi-Mode Rugged SFP.
Part #: GLC-SX-MM-RGD=.

Or:
3.1.2 Industrial Grade Router.
Manufacturer: Cisco. Model: Cisco CGR2010 w/2GE, 4 GRWIC slots, 256MB CF, 1GB DRAM, IPB (with security bundle).
Part #: CGR 2010-SEC/K9.

(Optional Item – Network Module)
T1/E1 Module (for CGR2010).
Manufacturer: Cisco. Model: 1 port channelized T1/E1 and PRI GRWIC (data only).
Part #: GRWIC-1CE1T1-PRI.

8 port Ethernet Module (for CGR2010).
Manufacturer: Cisco. Model: 8x 10/100 Fast Ethernet ports.
Part #: GRWIC-D-ES-2S-8PC

(Optional Items – Power Supply)
Power Supply (for CGR2010).
Manufacturer: Cisco. Model: High AC/DC (88-300VDC/85-264VAC) power supply.
Part #: PWR-RGD-AC-DC=.

Or:
Power Supply (for CGR2010).
Manufacturer: Cisco. Model: Low DC (24-60VDC) power supply.
Part #:

No Industrial Grade Routers to also consider:

Manufacturer: Cisco.
Model: CISCO1921/K9 Router
Model: Cisco: CISCO2911/K9 Router

End of Document

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY
(DC Water)

"SERVING THE PUBLIC - PROTECTING THE ENVIRONMENT"

PROJECT
DESIGN MANUAL
VOLUME 2 - FACILITIES DESIGN

SECTION 9 – ELECTRICAL

August 2018

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AUTHORIZATION FORM

Revision Number	Date	Content
Draft 3	7/15/00	Project Design Manual Volume 2 - Facilities Design Section 9 - Electrical
September 2014	9/17/2014	
July 2015	7/23/2015	
April 2016	4/19/2016	
August 2018	8/01/2018	Section 9 - Electrical

This 2018 version was authorized by:

Denise Edwards 12/20/2018

Denise Edwards PE, Supervisor, Electrical and Mechanical Design Date

SECTION 9 ELECTRICAL LOG OF REVISIONS (From the 2010 version)		
Paragraph	**Brief Description of Revision**	**Date**
Global	-Changed 'DC WASA'/ 'WASA' to "DC Water" -Changed 'Long Term Control Plan' to 'Clean Rivers Project' -Deleted dates for specific standards/codes and referred to the "latest version". -Revised section numbering – Calculation Requirements section is elevated to a main paragraph level.	
9.2.7 Standard Details	Added requirement for cable lengths for medium voltage circuits and all other circuits with a cable length in excess of 100 feet.	
9.3.8 Lighting	Updated illumination levels per DC Water Plantwide Lighting Guidance Document (2010)	
9.4.4 Area Classifications	Added classification criteria for Dry/conditioned, Corrosive, and Hazardous locations	
9.4.3 Electrical Design Guidelines	-Added reference to Electrical Equipment naming convention in CAD manual -Added requirement for separate electrical rooms for medium and low-voltage equipment	
9.4.9 600 volt MCC's	Updated MCC requirements for "Smart" type.	
9.4.11 Motors	Added consideration for motor space heaters for interior applications under certain conditions.	
9.4.14 Lighting Transformers	Reinstated copper windings for lighting transformers	
9.4.15 Lighting Systems	Inserted text from DC Water Plantwide Lighting Guidance Document (2010). Added LED lighting type.	
9.4.20 PEAS	-Added Plantwide Emergency Alert System (PEAS) rqmts. -PEAS rqmts replaced by electronic notifications (texts & email)	03-14-2016
9.4.25 Manholes	Allow for precast concrete structures.	
9.4.26 Grounding	Added requirements for ground system test wells	
9.4.27	Added provision for redundant power sources to all UPS	
9.3.1	Added naming convention for components in electrical studies.	05-15-2014
9.3.7	Referenced IEEE Standard 519 for harmonic studies.	05-15-2014
9.4.2.1	Added power monitoring language	05-15-2014
9.4.3	Require heaters and thermostats in all control panels; and seal all conduits at panels.	05-15-2014
9.4.3	Changed reference of nomenclature drawing from CAD Manual to Appendix A	05-15-2014
9.4.3	Location of switches to facilitate lockout	05-15-2014
9.4.3	Location and orientation of panels, monitoring, controls, actuators to be easily visible and allow for adjustments and maintenance.	05-15-2014

9.4.3	Areas with liquids vessels to be protected from flooding.	05-15-2014
9.4.5.1	Added spec items for PMTs, PLCs, and relays.	05-15-2014
9.4.10	VFDs in MCCs; driven equipment mfgr's approval; and reference IEEE Std 519 for harmonic distortion limit.	05-15-2014
9.4.11	Added requirement for lifting provisions for motors	05-15-2014
9.4.11	Addressed critical speed frequency limits.	05-15-2014
9.4.11	Added provision for sampling lube oils.	05-15-2014
9.4.11	Electric motor bearings to be permanently sealed	05-15-2014
9.4.11	Large or critical motors to be above flood levels, or operable in submerged conditions.	05-15-2014
9.4.15	Provide permanent lighting in maintenance areas.	05-15-2014
9.4.15	Install lighting to avoid shadows in task areas.	05-15-2014
9.4.15.3	Added LED type lighting for indoor application	09-16-2014
9.4.17	Updated fire alarm requirements, citing NFPA 70 and 72	05-15-2014
9.4.18	Security systems to be coordinated with Facilities; added security equipment spec items.	05-15-2014
9.4.20	Added PEAS components manufacturer name.	05-15-2014
9.4.21	Added requirements for 115v convenience outlets and 480v welding receptacles.	05-15-2014
9.4.22	Add color requirements for I&C cabling.	05-15-2014
9.4.23	Require stainless steel supports & hardware for ALL raceways.	05-15-2014
9.4.23	Raceways entering rooms to be sealed or configured to avoid water infiltration.	05-15-2014
9.4.29	Added Distributed Antenna System (DAS)	09-16-2014
Appendix A	Added Appendix A - Electrical Equipment Nomenclature	05-15-2014
9.4.4.2	Electrical enclosure requirements in corrosive locations. Sealing penetrations between corrosive areas and other rooms.	07-23-2015 12-31-2015
9.4.23	Addressed drainage for conduit systems in moist areas Fire stopping for electrical penetrations	07-23-2015 12-31-2015
9.3.3	Changed reference standard to IEEE Std 141	08-06-2015
9.3.4	Changed reference standard to IEEE Std 551	08-06-2015
9.3.5	Added reference to IEEE Std 242	08-06-2015
9.3.6	Added reference to ANSI / NEMA Z535.4	08-06-2015
9.3.7	Defined point of common coupling (PCC)	08-06-2015
9.4.3	- Feed control power panels separately from lighting & power panels; and feed from two separate sources via ATS. - GPS or NTP time synchronization on all protection relays. - Provide insulating floor mats at MCCs & switchgear	12-21-2015 12-21-2015 10-28-2015
9.4.5	Provide sync-check relays in unit substations	10-28-2015
9.4.8	- Sync-check relays in MCCs - Identify source MCCs on control panels.	10-28-2015
9.4.9	- Sync-check relays in MCCs - Identify source MCCs on control panels.	10-28-2015
9.4.12	Control panels for motors shall have clearly legible labels identifying each source MCC.	10-28-2015
9.4.30	Added requirement for sync-check relays. Added control provisions for sync-check relays	12-09-2015 04-19-2016

9.4.11	Added safety disconnect requirements, switches, grounding kits, & auxiliary contacts at MCCs; Provide independent power source for motor heaters: Provide code required warning sign For motors > 45HP, driven by VFD/ASD, provide insulated bearings to avoid induced shaft current.	07-30-2018 07-30-2018 07-30-2018 07-30-2018
Table 2-9-3	Added Tunnels and Galleries for lighting levels in Process Areas	08-07-2018

SECTION 9 - ELECTRICAL
TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

ACRONYMNS AND ABBREVIATIONS

ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASD	adjustable speed drive
ATS	automatic transfer switch
AWG	American wire gauge
AWTP	Advanced Wastewater Treatment Plant
CAD	computer-aided design
CCR	Central Control Room
CCTV	closed-circuit television
CFA	Central Fire Alarm
CHP	combined heat and power
CMF	Central Maintenance Facility
COF	Central Operations Facility
CPT	control power transformer
DAS	Distributed Antenna System
DC Water	District of Columbia Water and Sewer Authority
DCU	distributed control unit
DP	design package
EPA	Environmental Protection Agency
EPACT	Energy Policy Act
EPR	ethylene propylene rubber
FA	forced-air
fc	foot candles
FR	flame-resistant
FREP	flame-resistant ethylene propylene rubber
GFCI	ground fault circuit interrupter
GPS	global positioning system
HID	high-intensity discharge
HMI	Human Machine Interface
HO	high output
HOA	hands-off-auto
hp	horsepower
HPS	high pressure sodium
HVAC	heating, ventilation, and air conditioning
Hz	hertz
I/O	input/output
IBC	International Building Code
ICEA	Insulated Cable Engineers Association
IEEE	Institute of Electrical and Electronics Engineers
IES	Illumination Engineering Society
IESNA	Illuminating Engineering Society of North America
IGBT	insulated gate bipolar technology
IRIG	Inter-Range Instrumentation Group
IT	Information Technology
kAIC	kilo-ampere interrupting capacity
kV	kilovolts
kVA	kilovolts amperes
kVAR	kilovolt-ampere reactive
kW	kilowatts
kWh	kilowatt hours
LED	light-emitting diode
LEED	Leadership in Energy and Environmental Design
LOTO	Lock Out Tag Out
MCC	motor control center
MCM	thousand circular mils
MCP	motor circuit protector
MM	multimode (fiber)
MHz	megahertz
MVA	megavolts amperes
NEC	National Electrical Code
NEMA	National Electrical Manufactures Association
NFPA	National Fire Protection Association
NTP	network time protocol
O&M	operation and maintenance
OLED	organic light emitting diode
OSHA	Occupational Safety and Health Act
OUC	Office of Unified Communications
OWS	Operator Work Station
PCC	point of common coupling
PCS	Process Control System
PEAS	Plantwide Emergency Alert System
PF	power factor
PLC	programmable logic controllers

PMT	Power Monitoring Transmitter
PPE	personal protective equipment
PTZ	pan/tilt/zoom
PVC	polyvinyl chloride
PWM	pulse-width-modulated
RVMS	Reduced Voltage Motor Starter
SCADA	Supervisory Control and Data Acquisition
SCC	Security Command Center
SSL	solid state luminaires
TCP/IP	transmission control protocol/internet protocol
TVSS	transient voltage surge suppression
UL	Underwriters Laboratories
UPS	Uninterruptible Power Supply
V	volts
VAC	volts alternating current
VDC	volts direct current
VFD	variable-frequency drive
VoIP	voice over internet protocol
XLPE	cross-linked polyethylene

PROJECT DESIGN MANUAL
VOLUME 2 – FACILITIES DESIGN

9. ELECTRICAL

9.1 INTRODUCTION

This section presents the general technical guidance for the electrical design to be provided for all District of Columbia Water and Sewer Authority (DC Water) facilities. It is the intent of this section to provide the designer with appropriate guidelines to insure safe and reliable electrical system operation, energy conservation, maximum safety, reliability, flexibility, ease of operation and maintenance (O&M), provision for future expansion, long service life and low life-cycle cost.

The design of electrical systems shall conform to all applicable national, state and local codes and standards as well as industry practices and requirements from electric and telephone companies, such as National Electrical Code (NEC), Pepco, Institute of Electrical and Electronics Engineers (IEEE), Underwriters Laboratories (UL), National Electrical Manufacturers Association (NEMA), National Fire Protection Association (NFPA), Occupational Safety and Health Act (OSHA), etc.

Included in this section are the design requirements for medium and low-voltage substations, switchgear, transformers, motor control centers (MCC), variable frequency drives, panelboards, motors, wire and cable, lighting systems, lightning protection systems, surge suppression systems, and grounding systems.

The electrical requirements outlined in this section are general in nature with specific equipment design requirements found in equipment specifications. These requirements shall apply to all design packages (DP) produced for DC Water. Any specific electrical design requirements for each DP shall be identified in the individual DP conceptual design reports and will supplement the requirements and guidelines outlined in this section.

9.2 REQUIRED DRAWINGS AND FORMATS

All drawing and diagrams will be prepared in accordance with the computer-aided design (CAD) formats for various types of electrical drawings provided in DC Water Drafting Standards (CAD) Manual: The following types of drawings shall be provided:

- General Notes and Symbols
- Electrical Site Plans
- Medium-voltage Single Line Diagrams
- Medium-voltage Equipment Elevations
- Unit Substation Single Line Diagrams
- Unit Substation Equipment Elevations
- MCC Single Line Diagrams
- MCC Equipment Elevations
- Power and Control Plans
- Lighting Plans
- Grounding Plans
- Communication, Security and Fire Plans
- Security and Fire Protection System Riser Diagrams

- Medium-voltage Circuit Breaker Wiring Diagrams
- Medium-voltage Three Line Diagrams
- Equipment Wiring Diagrams
- Riser Diagrams
- Panel Schedules
- Lighting Fixture Schedules
- Conduit and Wire Schedules
- Standard Details

The drawings and diagrams to be provided are described below. The extent of the electrical work in the DP will dictate those drawings which are to be prepared for the work. In addition, electrical work as shown on the contract drawings shall be arranged in order from the highest voltage to the lowest voltage and generally follow the sequence of other disciplines.

9.2.1 Plan Drawings

Develop power plan drawings in order to show all electrical equipment and associated devices including power feeders using a mechanical, civil or architectural area background. Verify coordination with all other disciplines for both new and existing work. Verify acceptable routing and location of equipment with special attention to structural elements; piping; heating, ventilation, and air conditioning (HVAC) ducts; and flood protection.

- Provide Site Plans to identify the routing of cable across site areas. Indicate routing of electrical ductbanks. Provide cross-section details of the ductbank to identify duct size and duct identification number. The standard construction detail of the ductbank should be shown on separate detail drawings. Show concrete pad mounted equipment with references to structural drawings for pad details. Show building penetrations in sections with all dimensions identified.

- Power plans are used to show the medium and low-voltage conduit and tray runs from the loads to the distribution equipment. Where existing raceways are to be used, identify these raceways in light line weight or with notes. Show all cable tray runs while calling out special tray transitions or configurations as required. The purpose of these drawings is to:

  - Show the required equipment configuration and associated raceway routing to ensure that the installer locates raceways in accessible and acceptable areas.

  - Identify the spatial requirements of conduit and tray routing.

- Home runs may be shown for 120 VAC feeders to equipment where special routing of raceways is not required. The home runs shall specify panel designation, conduit and wire requirements.

- Use power plans (minimum scale: 1/4” = 1’-0”) to show all electrical equipment, panels, disconnect switches, and associated controls and instrumentation devices. Plans are also required to identify junction and oversized pull boxes, with conduit and tray identification numbers. For short conduits which are less than 20 feet in length, show conduits with size and wire denoted directly on the plan. Unique raceway identifications are not required for these short raceways.

- Detail plan drawings at a minimum ¼-inch scale are to be provided for electrical rooms and substation areas. Equipment is to be shown to scale and be based on typical catalog data to be assured that sufficient floor; wall or aisle space exists to meet NEC and maintenance requirements.

9.2.2 Single Line Diagrams and Equipment Elevations

Provide single line diagrams to show the electrical power system distribution systems from the point of origination.

- For single line diagrams involved with DPs at the Blue Plains Advanced Wastewater Treatment Plant (AWTP), the point of origination shall be the Area Substation. To understand the electrical distribution system at the DC Water Blue Plains AWTP and its associated redundancy, the designer is required to review the plant single line diagrams. All electrical system modifications shall be required to maintain the independence and redundancy of the existing electrical system.

- When using existing electrical distribution switchgear or MCCs to power equipment in DPs, the existing equipment single line diagram and front view elevation shall be shown. Existing equipment shall be shown in light line weight and new equipment shall be shown in heavy line weight with notes to identify the scope of the electrical modification work.

- In general, front view elevations are to be provided for switchgear, switchboards and MCCs on the same drawing as the single line diagram.

- For pumping stations or stand-alone power systems, identify the power system equipment from the incoming overhead or underground utility power source. Coordinate any new service requirements with Pepco during the design.

9.2.3 Lighting and Receptacle Plans

Develop plan drawings showing lighting fixtures, switches, and miscellaneous power receptacles. Show only panelboard circuit number next to each lighting fixture and receptacle symbol. For lighting: indicate by letter the lighting fixture type and switch designation. Show switches with letter designations.

For DPs which require additional systems such as fire alarm, security, telephone, page party, and closed-circuit television (CCTV), locate these system devices on the lighting plan where space exists. Provide separate plans for these systems where the information on the drawing cannot be easily interpreted.

9.2.4 Control Wiring Diagrams

Provide wiring diagrams to show the control requirements of electrical equipment, except for those systems that are designed by the supplier and provided to the contractor. Pre-packaged equipment supplied on a skid would be an example of equipment not requiring a wiring diagram to be provided in the DP. Provide 0 to 60 second timing relays for motor loads greater than 10 hp in size to prevent automatic re-energizing of these loads immediately after return of electrical power following an outage or require manual restart depending on system control requirements.

Utilize standard wiring diagrams per DC Water standard design details whenever possible. Modify standard wiring diagrams or provide additional wiring diagrams as required to insure correct control of all equipment powered from MCC starters, local starters and variable-frequency drives (VFDs). For design consistency, all wiring diagrams shall be drafted in a format similar to the standard wiring diagrams included in DC Water's standard details.

Provide wiring diagrams for switchgear and MCC breaker interlocks, protection and control.

NOTE: Breaker control devices such as indicating light and control switches are not to be shown on the single line diagrams for switchgear and MCCs.

9.2.5 Fire Alarm, Communication and Security System Riser Diagrams

The following systems shall be depicted on individual riser diagrams. Wiring diagrams are not to be provided for these systems.

- Fire alarm system
- Telephone system
- Security system
- Closed circuit TV system

In addition to showing the above systems on risers, locate the equipment devices on the building or facility lighting plans to indicate where they will be installed. For equipment which requires 120 VAC power supplies, show home runs on the plan drawings with panelboard and circuit number designations.

Conduit and wire sizes will not be identified on the riser diagrams for these systems but will be the responsibility of the system supplier.

9.2.6 Instrument Riser Diagrams

For DPs which are provided with considerable process and monitoring instrumentation systems, provide instrument riser diagrams. Show all instruments with instrument identification numbers in a block diagram format with equipment area locations identified. Show all power and instrumentation conduit runs from instrumentation devices to equipment control panels, consoles, computer system devices and power panels as required. For probes and elements which are pre-wired, show an empty 1-inch conduit with pull string to allow for the installation of the probe/element and associated cable. Where instruments are clustered in a general area, show junction boxes and pull boxes to reduce the number of long conduit runs. Label all boxes and conduits with unique project identification numbers. Show all instruments and associated junction and pull boxes on the plan drawing identified in paragraph 9.2.1 without showing system conduits.

9.2.7 Standard Details

To provide details of the electrical work in the DPs refer to the standard design, construction and wiring details in DC Water Standard Details. These details identify an approved method of depicting equipment, raceway and cable installations, equipment wiring and standard tables to help insure standardization of facility design.

Standard tables and schedules are provided for panelboards, equipment area classification tables, electric heaters, conduit identifiers and associated wire sizes, and lighting fixtures to assist the designers in the preparation of the DPs.

Conduit and wire schedules shall include cable lengths for medium-voltage circuits and all other circuits with a length in excess of 100 feet.

9.3 CALCULATION REQUIREMENTS

DC Water has standardized on the Power Analytics (formerly EDSA Micro Corporation) Paladin® DesignBase™ electrical system design and simulation software platform. Specifications prepared for DPs shall require the electrical contractor to perform final short circuit, device coordination, and arc flash hazard studies using the Paladin® DesignBase™ software platform by Power Analytics, and shall be in accordance with the latest IEEE and American National Standards Institute (ANSI) standards. Electronic copies of all database files and system models prepared for the studies shall be provided as part of the electrical system studies submittal.

The following electrical calculations will typically be required, depending on the specific design package. Refer to Section 1, General, of this volume for a discussion on the format of calculations.

- Load study
- Primary cable, breaker and bus-sizing calculations
- Short-circuit study
- Protective device time-current coordination study
- Arc flash hazard study
- Electrical equipment heat releases
- Lighting
- Engine generator sizing (for stand -alone facilities including pump stations)
- Cable pulling studies
- Harmonic studies

9.3.1 Naming Convention

As a first step in performing the studies, develop a detailed model of the electrical distribution system within the DesignBase software. Every bus, branch, and node within the electrical system model is assigned a name. The naming convention will identify, standardize, and categorize the model components using standard abbreviations and stay within the maximum number 24 characters allowed by the software. Components located far down in the electrical distribution are difficult to include as the numerous levels of equipment needed to define the full path may exceed the number of characters allowed. Component types are listed in Table 2.9.1. Abbreviations used in the naming convention are shown in Table 2.9.2. Each component name can have up to five identifiers separated by dashes as shown below:

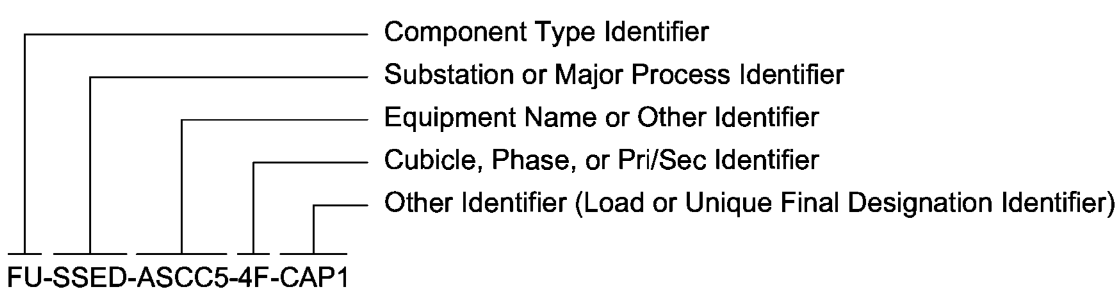

Table 2-9-1. Electrical Component Types

Description	Abbreviation
Breaker (Low Voltage)	LBK
Breaker (High Voltage)	HBK
Bus Bar	BUS
Capacitor	CAP
Constant kVA Load	LD
Feeder	FD
Fuse	FU
Generator	GEN
Induction Motor	IMT
Non-Contributing Bus	NC
Panelboard	PNL
Relay	RLY
Swing Bus	SWB
Switch	SW
Synchronous Motor	SMT
Transformer	TX

Table 2-9-2. Abbreviations Used for Naming Electrical Components

Description	Abbreviation
Air Scour Switchgear	ASSG
Area Substation	ASS
Central Maintenance Facility	CMF
Central Office Facility	COF
Centrifuge	CFG
Chemical Building	CHEM
Combined Heat and Power	CHP
Degritting and Grinding	DGRT
Dewatered Sludge Loading Facility	DSLF
Dual Purpose Sedimentation Basin	DPB
Enhanced Nitrogen Removal	ENR

Description	Abbreviation
Filtration	FLT
Grit and Screens Loading Station	GSLS
Main Substation	MAIN
Multipurpose	MLTP
Multiservice Substation	MSUSS
Nitrification Blower Building.	NBB
Nitrification	NIT
Phase	A, B or C
Primary	P or PRI
Primary Sedimentation	PSED
Pump	PMP
Raw Waste Water Pump Station	RWWPS
Return Sludge Pump	RSP
Secondary	S or SEC
Secondary Blower Building.	SBB
Secondary Sedimentation	SSED
Solids	SLD
Solids Processing Building	SPB
Station Service	STNSVC
Switchboard	SB
Switchgear	SWG
Transformer Primary	TXP
Transformer Secondary	TXS
Tunnel Dewatering Pump Station	TDPS
Unit Substation	USS
Warehouse	WHSE

9.3.2 Load Study

A load study will be completed on each new and existing facility to determine service requirements, feeder cable sizes and equipment bus sizes. The load study can be either computer-generated or hand-calculated. The load study will be a stand-alone calculation that will be developed during the preliminary design stage and substantiated during final design. Coordinate all preliminary load calculations with the Authority's electrical department to ensure that the new load is not overloading an existing bus due to other proposed or in-process design packages.

Use the following demand factors in the load study:

Item	Demand Factor
Motor	0.90
Device	0.90
Unit Heater	1.00
Lighting Transformer	0.85

No diversity factor shall be applied to the demand load.

9.3.3 Primary Cable, Breaker and Bus-Sizing Calculation

The standard power cable construction that should be used on all projects is a single copper conductor with insulation rated 90 degrees C for 5 kV cables and 75 degrees C for 600 V cables and below. The ampacity of these conductors should be based on Tables 310-16 and 310-27 from the NEC. When the NEC tables do not cover the cable voltage and cable construction being used, use the Insulated Cable Engineers Association (ICEA) ampacity tables.

Base the size of a conductor on the ampacity and short circuit it must carry and the voltage drop it will experience. As a general rule, base the sizing of conductors for feeder circuits on the connected load and base the voltage drop on the demand load. There will no diversity taken on the load calculations. It should be noted that, at the engineer's discretion, the demand load will sometimes be used to size the main bus when the overall load of the facility is large and it is not possible in actual practice to operate the facility above the demand load.

Voltage drop shall be calculated using the methodology and voltage drop formulas from the latest ANSI / IEEE Standard 141 *Recommended Practice for Electric Power Distribution for Industrial Plants (IEEE Red Book)*. The impedances for the cables should be taken from a cable manufacturer's handbook or from a textbook when not available from the NEC. Note in the design calculations the source of impedances used. Determine the cable short-circuit withstand capabilities from the short-circuit study.

9.3.4 Short-Circuit Study

Perform a short-circuit study on each new and existing facility to determine service requirements, to check feeder cable sizing, and equipment bus bracing. The short-circuit calculation shall be in accordance with ANSI/IEEE Standard 551 *Recommended Practice for Calculating AC Short-Circuit Currents in Industrial and Commercial Power Systems*. The short-circuit study will be a stand-alone calculation and will be developed during the preliminary design of a project and finalized during the final design. The specifications shall require the electrical contractor to submit a final study based on the devices submitted for approval during the shop drawing submittal phase of the construction.

When the short-circuit level on a 480 volt MCC bus or 480-volt power panel bus, is 25,000 amperes and higher, then specify current-limiting breakers at all buses. The use of current-limiting breakers is to protect the branch circuit cables and the loads fed by these cables from being damaged as a result of a short circuit.

9.3.5 Protective Device Time-Current Coordination Study

The electrical design shall provide adequate and overlapping zones of protection for electrical equipment and operating personnel. Effective protection coordination shall be planned to minimize power outage in case of electrical faults.

Perform a protective device time-current coordination study, in accordance with the latest IEEE Standard 242 *Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book),* on that portion of the electrical system which is being affected by the design package. Carry the coordination study to the first existing breaker or over current device on the 15 kV, 5 kV or 480 V electrical systems to show that all breakers and fuses are coordinated. Include the requirement for the electrical contractor to submit a final coordination study, in the specifications for the project for which it was developed.

9.3.6 Arc Flash Hazard Study

The DP shall include a requirement for an arc flash hazard study. The study shall provide a detailed assessment of the potential energy at each point in the system that would be released in the event of an arcing fault within the equipment. This potential arc flash energy shall be calculated at each point in the system so that workers may be adequately protected, using properly rated personal protective equipment (PPE) whenever conditions require that work be performed on the electrical equipment while it is in an electrically energized condition.

The study shall determine the flame-resistant (FR) protective level of the PPE that the worker must wear. Require that Arc Flash Warning labels be provided by equipment manufacturers in accordance with the Arc Flash Hazard Study for each piece of electrical equipment. A single warning label shall be provided for each switchgear cubicle based on the maximum energy level for the recommended settings of the protective devices associated with that cubicle. Product safety signs and labels shall be in accordance with ANSI/NEMA Z535.4 *American National Standard for Product Safety Signs and Labels*. Warning labels shall be in accordance with NFPA 70E *Standard for Electrical Safety in the Workplace,* and shall include the equipment designation (cubicle designation), circuit breaker designation, and feeder designation.

Arc flash boundary, incident energy at specified working distance and risk category shall be determined based on the procedure described in IEEE 1584 *Guide for Performing Arc Flash Hazard Calculations.*

9.3.7 Harmonic Studies

Perform preliminary harmonic studies for busses which are to be connected to VFDs. Harmonic studies shall follow the procedure described in IEEE Standard 519 - *Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*. The immediate upstream element should be defined as the point of common coupling (PCC). Specify filters and contactors or isolation transformers should the studies identify the need for harmonic reduction techniques. The specifications shall require harmonic analyses by the Contractor prior to equipment submittal and in-field acceptance harmonic measurement testing upon completion of construction.

9.3.8 Electrical Equipment Heat Releases

To assist the HVAC designer in insuring that adequate ventilation is provided for electrical rooms, prepare a calculation summary of the electrical equipment heat releases. The heat release should be calculated for minimum load during winter for heating requirements and maximum heat load for summer to determine cooling requirements. Electrical rooms should be designed to maintain 85 to 95 degrees F maximum temperature.

Utilize published heat release data from equipment manufacturers for input data. Include lighting and other heat release data as applicable.

9.3.9 Lighting

Provide calculations for the lighting design selected for the design package. The illumination levels listed in Table 2-9-3 are suggested levels and should not be considered as the sole lighting design criterion. Other design criteria should be considered as recommended in Illuminating Engineering Society of North America (IESNA) Lighting Handbook, latest edition. This includes flicker and strobes, luminance of room surfaces, light distribution on the task plane (uniformity), direct glare, reflected glare, shadows, daylighting integration and control, etc. Some design criteria may require deviation from the suggested illumination levels.

Table 2-9-3. Suggested Illumination Levels

Area	Typical Illumination Levels (foot-candles)
Offices	50
Control Rooms / Laboratories	50
Electrical Rooms	40
Process Areas (areas with pumps, chemicals, mechanical equip, blowers, filters, generators), Tunnels, and Galleries	30
Locker Rooms, Toilets, and Stairs	20
Corridors	10
Storage Rooms – Active	15
Storage Rooms – Inactive	15
Exterior Lighting (Roadways)	0.7 – 1.0
Exterior Lighting (Tank Process Areas)	2 – 3
Exterior (walkways, parking lots)	0.7 – 1.0
Task Lighting (Exterior) where operators perform routine duties at night	10 – 20
Security Buildings (Guardhouses)	30
Building Exteriors (Active)	5
Building Exteriors (Building Surroundings)	1

Use the following lighting factors:

Item	Percent
Ceiling Reflectance	50
Wall Reflectance	50
Maintenance Factor	75

In general, determine illumination of all interior building areas by using the lumen method of calculation. Use the point-to-point method of calculation only when special task lighting is required or for site lighting.

For building exteriors, lighting calculations are not required for entrance fixtures. However, point-to-point lighting calculations are required for flood lighting, both off-building and pole-mounted, and for street and parking area lighting. Use of fixture manufacture templates and programs is acceptable to show proper design. Exterior lighting will meet the requirements of the Illumination Engineering Society (IES).

The lighting designer shall coordinate with the structural engineer who shall design the street light and parking area light pole bases for the soil type and wind load at the project site.

9.3.10 Engine-Generator Sizing

Provide a separate calculation for each generator required including temporary generators that are required by the contractor to perform work on existing electrical systems. The maximum voltage dip on a generator system will not exceed 20 percent. Use autotransformers or solid-state reduced voltage starters for reduced voltage starting of the large motors powered by the generator. When a generator system provides power to variable frequency drive units, the generator must be appropriately sized to carry these units, and the harmonics generated by these units must be accounted for in the sizing.

9.3.11 Cable Pulling Calculations

Perform cable pulling calculations for:

- Medium voltage feeders pulled through underground raceway systems and through conduits of 200 feet or greater in length.
- Low voltage cables 500 MCM or greater in size and where distance between pull points is greater than 350 feet.

Specify that during construction, the electrical contractor shall be required to perform these calculations and any additional calculations where the design conditions of the cable system warrant, based on the final design of the raceway systems and the cable parameters of the cables to be provided to verify acceptable installation.

9.4 TECHNICAL GUIDELINES

All designs based on information contained in Section 9 shall adhere to the overall drawing format and scale requirements in the Project Design Manual Volume 4, DC Water CAD Manual, and DC Water Standard Details, which are available from DC Water's Department of Engineering and Technical Services.

9.4.1 Codes and Regulations

Use the latest applicable following codes and regulations for the design of electrical systems:

- National Electrical Code
- Life Safety Code
- District of Columbia Electrical Code
- District of Columbia Energy Conservation Code
- Energy Code, Federal: American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)/Illumination Engineering Society (IES) 90.1
- DC International Building Code (IBC) Supplement
- Industrial Standards:
  - Institute of Electrical and Electronics Engineers (IEEE)
  - Underwriters Laboratories (UL)
  - American National Standards Institute (ANSI)
  - National Electrical Manufacturers Association (NEMA)
  - Insulated Cable Engineers Association (ICEA)
  - Environmental Protection Agency EPA-430-99-74-001; Design Criteria for Mechanical, Electric, and Fluid System and Component Reliability
  - National Fire Protection Association, NFPA 820; Recommended Practice for Fire Protection in Wastewater Treatment Plants
  - Leadership in Energy and Environmental Design (LEED) Program
  - Illuminating Engineering Society of North America (IESNA) Lighting Handbook

9.4.2 Energy Conservation

Energy conservation shall be universally implemented in the design and operation of the plant. Premium efficiency motors, transformers, lighting and energy-consuming appliances shall be specified as much as possible. The design shall comply with Federal [Energy Policy Act (EPACT) '92] and State (DC Energy Conservation Code) energy conservation codes.

9.4.2.1 Energy Management and Power Monitoring

Means for monitoring and managing energy shall be built into major electrical equipment and computer control systems. The standard microprocessor-based Power Monitoring Transmitter (PMT) shall be the Shark 200 as manufactured by Electro Industries. Separate Power Monitoring Transmitters shall be provided separately for process and non-process control.

Provide Power Monitoring Transmitters for the following equipment:

- Medium-voltage switchgear incoming and outgoing feeders and tie circuit breakers.
- Medium-voltage MCC incoming and outgoing feeders, tie circuit breakers, and individual motor starters.

- Low-voltage switchgear incoming and outgoing feeders, and tie circuit breakers.
- Low-voltage MCC incoming and tie circuit breakers.
- All motors 100 hp and above, unless directed otherwise.

9.4.3 Electrical Design Guidelines

The following information identifies minimum requirements for electrical installations at DC Water facilities. The designer shall review all electrical guideline specifications to ensure that the electrical design meets both the general guidelines identified herein and the precise specification requirements.

In general, the following criteria are to be followed:

- Design all floor mounted electrical equipment to be secured to a raised concrete housekeeping pad.
- Install electrical equipment in air-conditioned rooms to the extent possible.
- Provide separate electrical rooms for medium-voltage power distribution equipment and low-voltage power distribution and control equipment.
- Provide adequate working spaces for ease of maintenance.
- Minimum size of conduits is to be 3/4 inch.
- Use copper conductors for all cables.
- Conduit routing to double-ended equipment will be via different paths so that a major failure in one section will not result in a total electrical supply failure. Underground duct sizes for 15 kV power feeders to be 6 inch. Underground duct sizes for 5 kV power feeders to be 6 inch. Minimum underground duct sizes for control cable to be 2 inch. Provide separate ground cable in the concrete envelope and spare ducts in all underground ductbank designs.
- All control power shall be fed from panels that are separate from the lighting and power panels.
- Control power panels must be fed from two separate sources via an automatic transfer switch (ATS).
- Locate instrumentation and control wiring in separate ducts from power wiring.
- All equipment enclosures in exterior and process applications to be NEMA 4X, stainless steel.
- Specify permanently fixed nameplates on all enclosures and at all control switches and indicating lights.
- Provide heaters and thermostats in all control panels, regardless of whether located in heated space or not, unless directed otherwise on case-by-case basis.
- Seal all conduits at panels. Electrical equipment, e.g., all switchgear, MCCs, etc., shall be named in accordance with the standard Electrical Equipment Nomenclature as shown in Appendix A, “Electrical Equipment Nomenclature.”
- All electrical switches required to lock out an electrically- powered item of equipment shall be in reasonable proximity to each other to facilitate the lockout procedure.
- Ensure that all local equipment monitoring, control, and actuators [such as panels relayed to the process control system (PCS)] are oriented to provide easy visibility and allow convenient access for adjustments or dismantling for maintenance or replacement by local personnel.
- MCCs or control panels where equipment can be controlled shall accommodate density and flow measurement indicators at eye level.
- Provide global positioning system (GPS) or network time protocol (NTP) time synchronization on all protection relays.
- Where personnel will be standing for operations and maintenance of MCCs, control panels, and switchgear, provide insulating floor mats for safety.
- All areas having pipes, tanks, or other liquid-containing vessels shall have specific measures to

prevent damage to electrical equipment in the event of an uncontrolled release of liquid. Mounting motors above the potential flood level is one alternative.

9.4.4 Area Classifications

9.4.4.1 Dry, Conditioned Locations

Dry, conditioned locations are defined as interior locations which are not subjected to requirements for washdown due to potential spillage of process materials, chemicals, or other similar situations and the temperature and corrosiveness of that location's air has been properly conditioned.

Materials, equipment, and incidentals in areas identified as dry and conditioned shall meet NEC and NEMA requirements for such areas. Enclosures installed in dry, conditioned locations shall meet NEMA 1 requirements as a minimum. Enclosures installed in dusty locations shall meet NEMA 12 requirements as a minimum.

9.4.4.2 Corrosive Locations

Corrosive locations are defined as any area of the plant, interior or exterior, subject to potential concentrations of H_2S or other corrosive conditions due to exposure to sewage, corrosive chemicals, or gases. Materials, equipment, and incidentals in corrosive areas shall meet NEC and NEMA requirements for corrosive locations.

Installation of panel enclosures in corrosive locations should be avoided or minimized as much as possible. Panel enclosures, when feasible, should be installed in environmentally controlled electrical and control rooms. Otherwise, panel enclosures shall be high strength NEMA 4X, 316 SS with gasketed doors and sealed panel mounted operators. Selection of gasket material is critical. If composite fiberglass enclosures are proposed by the PDE, they shall be subject to evaluation and approval by DC Water.

Specifications shall require contractors to provide proper sealing of all new and modified panels, and require inspections to verify that seals are implemented during construction. Specifications shall also require all conduit penetrations between corrosive areas and adjacent rooms, as well as voids within the conduits, sealed to prevent migration of corrosive gasses. This sealing shall be inspected by DC Water prior to scheduling of any Operational Demonstration testing of equipment. All electronic devices shall be corrosion protected by using sealed relays, anticorrosive coating for microchip and cards, etc. All circuit boards and control equipment shall have conformal coating applied by the original manufacturer. Connectors will still need to be sealed.

Where additional corrosion protection may be needed, gas purging of enclosures may be considered. If gas purging is deemed warranted, a purging system should be designed for positive pressure using filtered air or nitrogen and appropriate pressure reducers, pressure gauges, alarm pressure switches, and electrical alarms. Panel enclosures with gas purging systems shall have appropriate enclosure protection vent and enclosure warning nameplate and shall be in accordance with NFPA 496 *Standard for Purged and Pressurized Enclosures for Electrical Equipment*. See NFPA 496 for typical alarm and indicator configurations. Any reduction in space classification will be dependent on the level of pressurization.

9.4.4.3 Hazardous Locations

Hazardous locations are defined as those areas classified as such in conformance with the latest edition of NFPA 820 – Standard for Fire Protection in Wastewater Treatment and Collection Facilities.

Materials, equipment, and incidentals in areas identified as hazardous shall meet NEC and NEMA requirements for the Class and Division designated.

9.4.4.4 Other Locations

All other areas shall be designated as a Corrosive Location.

9.4.5 Medium- and Low-voltage Unit Substations

The DC Water Blue Plains AWTP utilizes a three-bus, 13.8 kV Area Substation power distribution network with power circuit breakers within metal-clad switchgear, and combined heat and power (CHP) generation facilities, and 13.8 kV to 4.16 kV transformers to feed 4.16 kV Unit Substations and associated 4.16 kV and 480 V switchgear. To understand the electrical distribution system at the DC Water Blue Plains AWTP and its associated redundancy, the designer is required to review the plant single line diagrams. Designs for unit substations shall include solid state synchronism check (sync-check) relays as noted in paragraph 9.4.30.

9.4.5.1 Medium-voltage Switchgear

Switchgear units shall be metal clad type in accordance with ANSI/IEEE C37.20.2 and shall be for use on either 13,800 volts or 4,160 volts, 3-phase, 3-wire, 60 Hz grounded system.

Use tin-plated copper for the bus with insulation materials of high dielectric strength, high-tensile strength, and long creepage path. Buses must be braced and capable of withstanding a momentary short circuit, as required by the short-circuit study.

Each lineup shall have a momentary rating at least equal to the lowest momentary rating of the circuit breaker and be provided with a full-length copper ground bus.

Use vacuum-interrupter type of circuit breaker with the required ampere rating and a minimum interrupting capacity of 350 MVA or higher, as determined by the short-circuit study. The circuit breakers shall be drawout type, electrically operated. Circuit breaker of equal rating shall be completely interchangeable. Incoming line circuit breakers shall be electrically interlocked with one another and with the bus tie circuit breaker.

In general, locate breakers in the lower section of the switchgear for ease of removal and provide appropriate metering, protective relaying and control devices in the upper switchgear sections. Switchgear shall be designed for incoming sections and bus tie sections in the center of the lineup and with load breaker sections on the ends for future expansion. Provide adequate space for future switchgear expansion.

Each incoming line, outgoing feeder, and tie breaker will be equipped with the standard microprocessor based PMT unit for local display and with computer interface capabilities for transmitting meter data to a remote computer. All breakers and protective devices shall be supplied with spare open closed and trip status contacts for remote annunciation.

Protective relays shall be Multilin 750 Feeder Management Relays for incoming, feeder, and tie breakers and Multilin 745 Transformer Management Relays for feeders protecting transformers, Multilin 469 for motors, or specified otherwise by DC Water or with its approval. Provide differential protection for transformers and switchgear bus. All protective relays, PMTs, and programmable logic controllers (PLCs) wherever possible shall be time synchronized via GPS Inter-Range Instrumentation Group (IRIG).

All protective relays and PMTs should provide a signal either to Supervisory Control and Data Acquisition (SCADA) or PCS to alert whenever they fail or malfunction.

Switchgear control power shall be 125 VDC from a battery system with redundant power supply to the battery charger from separate busses through an automatic transfer switch.

Provide a separate power distribution control panel or switchgear section for remote main breaker and tie breaker control switches, open, closed, and tripped indicating lights, and mimic diagram for safe breaker operation by operations staff.

Each switchgear shall be provided with a ground and test device with remote control and storage cubicle.

Control wiring within the switchgear shall be standard switchgear wire with fire-resisting braid, no smaller than No. 14 American wire gauge (AWG), and terminated with ring type connectors.

Indicating lights shall be light-emitting diode (LED) type with red and green indicating lights showing closed and open position of the breakers, respectively, and amber lights indicating automatic trip of breakers or high transformer temperature.

Under and over voltage trip (27/59) should trip circuit breakers without lock out relay (86).

9.4.5.2 Low-voltage Switchgear

Switchgear completely self-supporting structure of required number of vertical sections bolted together to form one metal-enclosed switchgear for use on either 480 volts, 3-phase, 3-wire, 60 Hz grounded system. Switchgear frame suitable for use as floor sills in indoor installations. Switchgear assemblies conforming to NEMA Standard SG-5, *Power Switchgear Assemblies*.

For outdoor switchgear, provide walk-in type weatherproof switchgear enclosure with gasketed doors mounted on heavy steel frame. Provide each unit with louvered openings top and bottom with screens and filters.

Main bus and riser bus shall be tin-plated copper supported with high impact, non-tracking insulating material, and braced to withstand mechanical forces exerted during short circuit conditions, as required by the short-circuit study. Contact surfaces of main bus joints and all tap connections silver plated.

Each lineup shall have a momentary rating at least equal to the lowest momentary rating of the circuit breaker and be provided with a full-length copper ground bus.

Provide fused circuit breakers with rear-mounted current-limiting fuses in series. Equip breakers with an open fuse lockout device visible from front of breaker to indicate which fuses are blown. Lockout device shall also trip all three phases of breaker when fuse is blown and prevent circuit breaker from being reclosed on single-phase condition. Current-limiting fuses readily accessible for maintenance without removing circuit breaker from equipment. The circuit breakers shall be drawout type, electrically operated. Circuit breaker of equal rating shall be completely interchangeable. Incoming line circuit breakers shall be electrically interlocked with one another and with the bus tie circuit breaker. Switchgear shall be designed for incoming sections and bus tie sections in the center of the lineup and with load breaker sections on the ends for future expansion. Provide adequate space for future switchgear expansion.

Each incoming line, outgoing feeder, and tie breaker will be equipped with the standard microprocessor based PMT unit for local display and with computer interface capabilities for transmitting meter data to a remote computer. All breakers and protective devices shall be supplied with spare open closed and trip status contacts for remote annunciation.

Overcurrent trip devices of 3-phase construction and solid-state components to give long time, short time, and instantaneous and ground fault tripping characteristics. Circuit breakers and trip devices as integral unit, self-contained to include necessary power supply, transformers and tapped current level-sensing transformers. External source of power not required to trip breaker. Trip devices adjustable for each operating characteristic. Where required, provide circuit breakers with ground fault tripping by means of separate set of current sensors. Ground fault setting shall be adjustable.

Control wiring within the switchgear shall be standard switchgear wire with fire-resisting braid, no smaller than No. 14 AWG, and terminated with ring type connectors.

Indicating lights of shall be LED type. Red and green indicating lights showing closed and open position of the breakers, respectively. Blue lights indicating automatic trip of breakers or high transformer temperature.

9.4.5.3 Neutral Grounding Resistor

Transformers rated 4,160/2,400 volts on the secondary shall have the neutral grounded through a grounding resistor and enclosed with galvanized expanded-metal screening.

The grounding resistor shall consist of a standardized assembly of edge wound stainless steel resistor elements in a spread-metal enclosure mounted on a rigid or aluminum free-standing structure, at least 8-feet high. The resistor assembly shall be mounted within the enclosure on insulators rated for the system voltage. The grounding resistor shall be sized to limit the ground fault current.

9.4.5.4 Outdoor Power Transformers - Liquid-Filled Type

Outdoor substations shall be provided with 13,800/4, 160-volt mineral-oil filled power transformers and shall be 100 percent or full redundant to handle the full substation load.

- Use self-cooled units with a 55degrees C rise and 80 degrees C maximum hotspot rise with side-wall-mounted, high-voltage and low-voltage bushings.
- Provide the units with a throat connection to the primary switch and a throat connection to the secondary circuit breaker bus duct.
- The insulation system must allow continuous loading at 112 percent of 55 degrees C kVA rating with a temperature rise of 65 degrees C.
- Equip the 13,800/4,160-volt transformer's high voltage bushings with bushing-type current transformers for differential relaying protection.
- Use copper for the transformer delta primary and wye secondary windings. Provide an externally operated, no-load tap changer with four ±2 percent full-capacity taps, two above and two below the rated high voltage, with provision for padlocking the tap changer.
- Provide concrete pads with oil collection and drainage systems. Design the system such that a high temperature alarm at the transformer will automatically close the drainage motor operated valve to contain oil for cleanup.
- Provide concrete fire wall as barriers between transformers to help prevent the spread of fire.
- Minimum accessories to include: oil thermometer, liquid level gauge, pressure vacuum gauge, and

pressure relief valve.

9.4.5.5 Power Transformers - Dry Type

Provide substation style dry type transformers:

- Outdoor substation applications.
- Indoor substation applications. Dry type transformers located outdoors shall have primary and secondary copper coils encapsulated by the cast epoxy resin process. Indoor units shall have vacuum impregnated copper coils.
- Mount the outdoor units within outdoor, type-3R ventilated enclosures.
- Mount the indoor units within ventilated enclosures.
- All transformers will be designed, manufactured, and tested in accordance with the applicable NEMA, ANSI, and IEEE standards. Allow for the future addition of forced-air (FA) cooling equipment with all cable and bus connections designed for the FA rating.
- The temperature rise must not exceed 80/115 degrees C by resistance method at full-rated kVA.
- Use copper for the transformer delta primary and wye secondary windings.

9.4.6 Bus Ducts

Use a feeder type of bus duct that has low impedance and is totally enclosed. The bus duct must:

- Be ventilated indoors and non-ventilated outdoors.
- Be designed for 15 kV, 5 kV or 600 volts, 3-phase, 3-wire, 60 Hz service and be designed and tested in accordance with ANSI/IEEE C37.23.
- Have an internal ground, capable of carrying the rated short-circuit current of the bus.
- Have the ampere ratings indicated on drawings and short-circuit ratings not less than the rating of the equipment to which it is connected.
- The temperature rise shall not exceed 65 degrees C above 40 degrees C ambient at continuous ampere ratings.
- For bus bars, use copper with a minimum conductivity of 98 percent and silver-plated at all electrical contact surfaces. Bus bars must be completely insulated over their entire length with UL-listed insulation material. Specify bus mounting systems using high-strength, insulated supports with high impact resistance, high track resistance, and flame resistance. Provide flexible joints in straight bus runs at approximately 50-foot intervals. At each end of the run, provide suitable terminations. Provide each joint with an easily removable, preformed, flame-retardant boot. Provide an outdoor/indoor transition section with a vapor barrier in each run. Provide 15 kV and 5 kV outdoor sections with strip heaters to prevent the formation of condensation.
- For the enclosure housing, use galvanized sheet steel with ANSI 61 light gray finish. Use 316 stainless steel hardware protected against corrosion. The enclosure must be of welded construction with removable bolted covers for access to joints after installation.

Provide each bus run with a permanent nameplate in the outdoor and indoor sections. The nameplate must show the following data:

- Rated voltage
- Rated continuous current
- Rated frequency
- Rated impulse-withstand voltage

- Rated 60 Hz withstand voltage
- Rated momentary current
- Manufacturer's name

9.4.7 15 kV Load-Interrupter Switch

Design outdoor transformer primary load-interrupter switch for 13.8 kV, 3-phase, 3-wire, 60 Hz service, with a short-circuit rating suitable to the system to which it is connected. The switch must comply with ANSI, IEEE, and NEMA standards.

The medium-voltage load interrupter will be a load-break type that is rigidly connected to the transformer's air terminal chamber. Provide a three-pole switch that is gang-operated from a stored energy mechanism; the switch will have two positions and be air-insulated with a continuous current rating as required.

Between the secondary circuit breaker and switchgear, provide a Kirk key interlock that will prevent opening of the switch when the breaker is closed.

9.4.8 Medium-voltage Motor Control Centers

Units must comply with ANSI/NEMA ICS-2. Motor controllers will be the fused-disconnect and vacuum-contact or combination type. Use full-voltage non-reversing, NEMA Class E2 motor starters. Monitoring and protection will be provided by a Multilin 469 Motor Management Relay. Provide differential protection for motors larger than 500 hp.

Incoming main breakers, tie breakers, and each starter will be equipped with the standard microprocessor based PMT unit for local display and with computer interface capabilities for transmitting meter data to a remote computer.

Main and ground buses will be of high-conductivity insulated tin-plated copper bars, suitably rated, with all joint and terminal pads tin-plated. Starter units will be required for use on a 4,160 volt, 3-phase, 3-wire, 60 Hz grounded system. Interrupting capacity will be as required by the short-circuit study.

MCCs shall include sync-check relays as noted in subsection 9.4.30.

MCCs shall be identified by labeling at each control panel that each MCC serves.

MCC lineups shall be designed for incoming sections and bus tie sections in the center of the lineup and feeder sections on the ends for future expansion. Provide adequate space for future MCC expansion.

9.4.9 600-volt Motor Control Centers

All MCCs will be 480 volt, 3-phase, 3-wire, 60 Hz systems with a copper ground bus and a short-circuit bracing as required by the short-circuit study but no less than 42,000 amperes symmetrical. Use tin-plated copper for all buses. All MCCs will be NEMA Class II S, Type B, front only, or back-to-back mounting, as shown on the Contract Drawings, with an enclosure constructed of NEMA 1 gasketed in an electrical room, and NEMA 12 to limit dust where applicable in other locations.

Provide main incoming circuit breakers with ground fault tripping by means of separate set of current sensors, or integral ground fault tripping as part of the solid-state trip unit in the Main Breaker. Ground fault setting shall be adjustable. Circuit breakers for combination motor starters will be of the magnetic type only [motor circuit protector (MCP)] or devices with equivalent characteristics. Furnish and install feeder breakers rated for a minimum of 65 kAIC, or 100 kAIC as indicated on the Contract Drawings. Provide current-limiting breakers for branch circuits up to 400 amperes where indicated on the Contract Drawings.

MCC lineups shall be designed for incoming sections and bus tie sections in the center of the lineup and feeder sections on the ends for future expansion. Provide adequate space for future MCC expansion.

Provide the standard Electro Industries microprocessor based PMT unit for local display and with computer interface capabilities for transmitting meter data to a remote computer at each MCC incoming main breaker and tie breaker (refer to Paragraph 9.3.2.1.) Input to the metering units shall be 120 VAC (via 480-120 V voltage transformers) and current transformer input for measuring power.

MCCs shall be "Intelligent" (Smart) type, utilizing intelligent devices designed to provide control, monitoring, improve predictive maintenance and to provide enhanced diagnostic and protective functionality. MCCs shall include sync-check relays as noted in subsection 9.4.30. Each MCC line-up shall include a Human Machine Interface (HMI) for display of real-time diagnostics, MCC documentation, and graphical views of individual MCC unit device data and critical status information.

Identification of Source MCCs shall be documented as an attribute in equipment asset lists, and also labeled at each control panel that each MCC serves.

Networking of all signals at the MCC to and from the PCS via an Ethernet connection is required. Modbus over Ethernet protocol is currently available from Emerson, check for other Ethernet protocols available during design. The Smart MCC devices shall have direct Ethernet connections without the need for a gateway. It must be possible to add or remove devices from the network without interrupting other devices on the network. Networks must be connected to a distributed control unit (DCU) rack. Network connections to a remote input/output (I/O) rack is not possible. If network connections are routed between buildings, the connection shall be via fiber optic cable. The design shall utilize a network switch with integral fiber optic connections.

Provide cabling and Port configuration to all spares and spaces. Provide at least two spare ports per network.

The Ethernet network and MCC layout shall be designed to provide for redundancy and reliability required to match redundancy requirements of the process equipment. This may be accomplished by the design of each MCC incorporating multiple networks back to the PCS to prevent multiple process units being affected by a single network interruption. As a minimum, it is expected that each MCC shall have all the devices on each side of the Bus Tie connected to dedicated networks.

Switches shall be managed type, industrial grade and rated for the area and environment. MCC networks shall be fully configured at the factory; therefore, the design shall indicate all configuration requirements for the network components and switches and shall provide for complete specifications of the network equipment and wiring.

Each MCC networks shall incorporate a minimum of two (2) redundant power supplies, (located in separate cell units for replacement of a supply if it fails) for a total of four power supplies per network. Power supplies shall be fed from an Uninterruptible Power Supply (UPS) with an automatic by-pass. The UPS shall be fed from two separate power sources.

The MCC network shall incorporate an HMI that allows the operator/technician full access to all devices on the MCC network. All software shall be provided without any requirement for a license and fully supported by the MCC manufacturer. The design shall incorporate all tools and software for the Owner to maintain, troubleshoot, calibrate, expand, reconfigure and set all devices provided with the MCC. The intent is for the Owner to perform as many of these tasks without the need to open any doors.

All network devices (i.e., switches, power supplies, etc.) shall be installed completely separated from any power bus, power cables, or other equipment. This may be accomplished by installing any network equipment in its own bucket. There shall be a method to provide physical separation of the network cables from the power conductors.

A witnessed factory test of the complete MCC will be accomplished prior to shipping the MCC to the site. This test will include a functional test of the MCC network. The MCC manufacturer will configure all devices and points that will allow it to communicate with the Emerson Ovation PCS.

For each piece of equipment, the MCC network will at a minimum communicate the inputs/outputs shown in Table 2-9-4 through the networked components:

Table 2-9-4. Inputs/Outputs for the MCC Network

MCC Equipment	Information to be Communicated	Notes
Main Breakers	Discrete Values - Close, Tripped	
Tie Breakers	Discrete Values - Close, Tripped	
Feeder Breakers	Discrete Values - Close, Tripped	
Motor Controllers	Discrete Values – Typical Process Control and Monitoring Through PCS	
	Analog Values – Amps (3)	For all Continuous Loads and Loads ≥ 10 hp
	Analog Values – Volts (3), Amps (3), kW, PF	Loads ≥ 150 hp
VFDs	Discrete Values – Typical Process Control and Monitoring Through PCS	
	Analog Values - Volts (3), Amps (3), kW, kVAR, PF, kVA, kWh, frequency, torque	

The minimum vertical size for any MCC compartment with a motor starter shall not be less than 12 inches. The Designer should take great care to assure there is ample space in all buckets to allow for the maintenance and replacement of parts.

Each Design Package shall include at least one vertical MCC Section which incorporates all of the I/O and communication elements that have been specified for the Project for installation in DC Water's Electrical Technology training center. The "Training" MCC shall be permanently installed by the contractor. The Designer shall coordinate requirements for training with the delivery of the training MCC.

9.4.10 Variable Frequency Drives

Variable frequency drive units shall be the insulated gate bipolar technology (IGBT) and pulse-width-modulated (PWM) type. For motors, up to 300 hp, they are to be powered at 480 VAC. For motors from 500 hp to 2500 hp, they are to be powered at 4,160 volts. The voltage selected for motors in the range from 300 to 500 hp shall be determined based on available bus and load capacity of the power system at the point of connection.

- All VFD units for motors up to 200 hp shall be included in the MCCs and shall be provided by a single manufacturer.
- VFD units shall use microprocessor-based logic control, all units 50 hp and larger shall be 18-pulse design to minimize system harmonics.
- VFD units rated 50 hp or greater shall include phase shifting transformers.
- VFD units for motors greater than 200 hp shall be provided by the driven equipment manufacturer to ensure fully coordinated equipment and control system.
- All VFD units shall be coordinated, approved, and certified by the driven equipment manufacturer to be compatible and coordinated with the driven equipment.
- The VFD manufacturer will coordinate the requirements of the VFD units with the requirements of the driven equipment and provide all equipment, including filter and reactors, to limit the total voltage and current harmonic distortion to less than 5percent and limit each individual voltage harmonic to less than 5 percent, on the immediate distribution supply bus or PCC.
- A harmonic analysis shall be performed by the VFD manufacturer to verify the above harmonic requirements.
- The Total Demand Distortion should be used for current harmonic distortion limit as described in IEEE Standard 519 - IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
- For motors which are located greater than 200 cable feet from the VFDs, specify output filters at the drives to limit voltage spikes on the motor insulation system.

Coordinate VFD equipment design with HVAC designers to insure adequate cooling is maintained due to the large heat rejection from transformers and electronics within the drive unit enclosures. Use NEMA Type 1 enclosures when locating VFD units in electrical rooms. It is recommended that VFDs not be located in process areas since NEMA Type 4 enclosures will be required and internal air conditioning is to be specified within the VFD enclosures.

9.4.11 Motors

All motors rated 2 hp or greater up to 350 hp shall be specified to operate on a 460 volt, 3-phase 3-wire system.

Specify energy-efficient and corrosion resistant motors for all continuous duty applications. Motors must meet the requirements of NEMA: MG1-12.53b and be tested for motor efficiency using IEEE-112A, Test Method B.

Motors with capacities above 300 hp will be rated 4,000 volts, 3-phase, unless otherwise required by specific applications, and will meet the requirements of MG1-20 and 21 and driven equipment specifications.

Provide inverter duty rated motors when controlled from VFDs in accordance with NEMA MG-1-31.40.4.2.

Power factor correction capacitors shall be provided at the motor terminal boxes for motors greater than 20 hp, except for those motors controlled from Variable Frequency Drives. Motors which are controlled from reduced voltage starters shall have the power factor correction capacitors controlled via a contactor in the MCC and placed on line only after starting and when the motor is operating at full voltage.

Provide safety disconnect switches for all motors up to 480V. Provide safety disconnect switches, grounding kits, and auxiliary contacts for these applications to allow all power at the motor to be disconnected when the safety switch is in the open position. For motors larger than 480V provide safety disconnect switch to de-energize primary source of power to motor starting contactor/VFD/Reduced Voltage Motor Starter (RVMS). MCC/VFD/RVMS should be provided with special receptacle to provide test power (120VAC) from outside source when the control power transformer (CPT) is disabled.

Specify space heaters in motors for all exterior applications. For interior applications, determine the need for motor space heaters on a case by case basis, depending on ambient conditions surrounding the motor, such as potentially damp conditions or high humidity or similar conditions. Heaters shall be controlled from a motor starter contact, and be energized when the motor is not energized. Heaters shall be powered from external reliable sources, independent of the power to the motor control circuits, to keep the space heater powered when the motor control circuit and/or the motor is out of service or lockout-tagout (LOTO) for long periods. However, with multiple power sources in the motor control circuit/control panel, it shall require installation of a permanent Mandatory Warning Sign in accordance with NEC-430.75(A) & NFPA79-5.3.5.4 which require a clear warning sign indicating in detail all power sources and means of disconnection.

Include the following provisions for maintainability of motors, as a minimum, but not limited to:

- Provide all electric motors with suitable means, such as lifting eyes, to facilitate attachment of lifting chains or cables.
- Critical speed of all rotating members and the critical speed frequency of the motor shall be at least 25 percent above the maximum motor operating speed or 25 percent less than the minimum motor operating speed.
- All oil-lubricated equipment, including motors, shall have provision to allow sampling of lube oil for analysis.
- Electric motor bearings shall be the permanently sealed type except where not appropriate for the specific motor. All motors rated 45 hp or greater which are driven by VFD/adjustable speed drive (ASD) shall be furnished with insulated bearings at both driving and nondriving ends to eliminate the damaging effect of induced shaft current.
- Install large or critical equipment motors and actuators above grade and above potential flood levels, or otherwise select motors and actuators that can operate in a submerged condition

9.4.12 Power and Lighting Panelboards

Panelboards will be factory-assembled deadfront-type units complete with bolt-on branch circuit breakers and a main circuit breaker. Power panelboards will be rated 480 volts, 3-phase, 3-wire, 60 Hz, 42,000 amperes interrupting current minimum, with a full-capacity, separate ground bus. Panels shall include clearly legible labels identifying each source of power.

Lighting panelboards will be rated 208/120 volts, 3-phase, 4-wire, 60 Hz, 10,000 amperes interrupting current minimum, with full-capacity, separate neutral bus, and ground bus. Panelboards will conform to NEMA, UL, and NEC requirements.

Use copper with a 98 percent minimum conductivity for all buses. Enclosures will be NEMA 1, unless otherwise indicated.

Feeder breakers supplying lighting and receptacle loads in outdoor and damp areas shall be ground fault circuit interrupter (GFCI) type breakers.

9.4.13 Transient Voltage Surge Protection

Provide transient voltage surge suppression (TVSS) components either integral to or in combination with the electrical distribution system equipment. The distribution system includes switchboards, MCCs, 480-volt distribution panels and 120 volt panelboards.

The components shall provide protection for electrical and electronic devices against the damaging effects of surges, transients and electrical line noise.

9.4.14 Lighting Transformers

Use energy efficient, dry-type transformer units with separate windings, 220 degrees C insulation system. Windings shall be copper Transformers will have, in the high voltage winding, two 2.5 percent full capacity taps above rated voltage, and four 2.5 percent full capacity taps below rated voltage. Single-phase transformers will be rated 480-120/240 volts, 60 Hz. Three-phase transformers will be rated 480-208/120 volts, 60 Hz, with delta-connected primary and wye-connected secondary windings. Temperature rise shall not exceed 80 degrees C.

Transformers will be designed, manufactured, and tested in accordance with applicable ANSI, NEMA, and IEEE standards, and bear the UL label.

9.4.15 Lighting Systems

9.4.15.1 General

Lighting systems shall be designed to meet the goals of providing and addressing worker safety, public safety, security of buildings, and energy efficiency. It is the policy of DC Water to provide the minimum amount of lighting necessary to accomplish these goals in a uniform manner, consistent with the goals of energy efficiency, cost effectiveness, and site specific appropriateness.

Generally, plant lighting systems, both inside and outside the plant, shall serve to provide adequate lighting levels during normal and emergency conditions, should have low energy consumption, have minimum environmental impact, be aesthetically pleasing, use long life fixtures requiring low maintenance, provide easy access to fixtures, have instant relight or dimming capability in certain areas, be controlled manually or automatically depending on the site specific requirements, include emergency and exit lights with backup power, and use fixtures with low life cycle and O&M costs. Due to evolving technologies (e.g., LED lighting, etc.), designer shall verify with DC Water the latest criteria and requirements for each project.

The following lighting guidelines are general in nature and should be considered in all new lighting designs and lighting replacement designs:

- Lighting should provide a sense of personal safety in active areas of the site, and allow for an even distribution of illumination in commonly used vehicular and pedestrian areas.

- Exterior lighting should be aimed, located, designed, fitted and maintained so that it primarily illuminates the task intended.
- Lighting designs should evaluate and take into consideration any incidental lighting that may exist or be provided from other adjacent lighting fixtures. For example, street lighting may provide incidental sidewalk lighting in high pedestrian use areas.
- Buildings should be illuminated at night for reasons of safety. Illumination of buildings at night for recognition of architectural features must be approved by DC Water prior to incorporation into any final project design. Generally, architectural and landscape lighting should only be used to enhance or embellish lighting levels of ground level pedestrian areas.
- Parking lot lighting should be designed to provide the minimum lighting necessary to ensure public safety and convenience and to avoid glare onto adjacent non-DC Water facilities and properties.
- Light glare and light trespass should be controlled by shielding or aiming fixtures in a manner that maximizes lighting for its intended use while minimizing glare and trespass to adjacent surroundings.
- Provide all areas requiring periodic maintenance service, and including tunnels and galleries, with permanent lighting fixtures providing an illumination level suitable for maintenance work. This lighting should be switchable to conserve energy when not needed.
- Lighting shall be installed to avoid large shadows in the area the light is intended to illuminate (e.g., do not locate light on wall directly behind a pipe).

9.4.15.2 Environmental Issues

The mercury content of fluorescent and high-intensity discharge (HID) lamps requires proper treatment in the specifications. Upgrade projects must have demolition work specified to include disposal of fixtures and ballasts in the proper manner, conforming to all the appropriate EPA regulations.

9.4.15.3 Types of Lighting

The various types of lighting to be considered ***for indoor use*** are:

- Incandescent – to be rarely considered for use because of other fixtures with better illumination and longer life. Consider replacing all incandescent fixtures with T8/Compact fluorescent fixtures.
- LED - Solid-state luminaires (SSL) that use LED or organic light-emitting diode (OLED) with U.S. EPA Energy Star and UL labels. Existing areas with non-LED luminaires should be replaced with the approved equivalent LED or OLED luminaires, whenever available.
- Fluorescent – should be limited to a mounting height of 10 feet. T8/Compact Fluorescent tied to occupancy sensors should be considered. Consider using T5 High Output (HO) fluorescent fixtures for high bay applications. Tube and subcompact fixtures can be used in:
  - Offices
  - Laboratories
  - Electrical and Mechanical Rooms
  - Task Lighting
  - Staircases (consider not switching staircases because of safety concerns)
  - Low bay industrial areas, basements, tunnels
- Mercury Vapor – should not be considered or used. Consider replacing all mercury vapor fixtures with high pressure sodium (HPS) or pulse start metal halide.
- High Pressure Sodium – consider use in:
  - Galleries

  - Process areas
  - Every third fixture installed with quartz instant relight
  - Consider switchable T8/Compact fluorescent fixtures for task lighting, as required.
  - Use 208 or 277 volt HPS fixtures when mounting heights are greater than 12 feet above finished floor. Consider use of 480 volts if long distance is incurred resulting in voltage drop.
- Metal Halide – consider when color rendition is important.
- Consider use of dual intensity lighting with motion sensors and photo cells when appropriate.

For ***outdoor lighting***, use LED lighting in general, high pressure sodium, or metal halide when appropriate, and consider the following:

- Roadways
  - Type: Holophane Mongoose style, 1 fixture per pole
  - Source: LED
  - Lighting level: 0.7 – 1.0 fc
  - Distance apart: approx. 200 feet
  - Control: 1 photocell per fixture

- Tank Area
  - Type: Holophane High Mast style, 6 – 8 fixtures per pole, 60-foot pole
  - Source: LED
  - Lighting level: 2 – 3 fc
  - Distance apart: approx. 225 feet - 250 feet
  - Control: 1 photocell per fixture

- Task Area Lighting
  - Type: To suite task requirements
  - Source: Metal Halide, LED, Compact Florescent
  - Lighting level: To suite task requirements
  - Distance apart: To suite task requirements
  - Control: Occupancy sensor or occupancy control desired, energy efficiency

Consider use of dual intensity lighting with motion sensors and photo cells when appropriate.

9.4.15.4 Interior Lighting Controls

Interior lighting controls should be used to reduce the amount of energy used to light the facility. In general, the use of automatic lighting controls should be carefully evaluated and used only when appropriate. Safety concerns may dictate the need to keep lights on; under certain circumstances, this is acceptable. Lighting controls may consist of the following:

- On/off controls using standard toggle switches to control groups of lights. If circuiting is done carefully, half of the lamps in each fixture can be switched together, or every other fixture can be switched together, or lighting near the windows can be separated so they can be independently turned off.
- Occupancy sensors to turn on lights when movement is detected. This option has limited use, for administrative areas only.
- Manual dimming controls to reduce the lighting levels. This option provides users with the flexibility to instantly control the lighting levels in a given space.

- Plant wide centralized controls for controlling the lights of an entire facility. This option may not be appropriate for process areas within the plant because of the nature of the operations of the facility.

9.4.15.5 Outside Lighting Controls

Although outside light fixtures can have individual photocells, or have multiple fixtures controlled by a time clock, the preferred method of control is for multiple fixtures controlled by individual photocells, using lighting contactors. Outside lighting controls should be coordinated with the security requirements of the facility. Spare photocells should be included, along with manual override of the photocell control via hands-off-auto (HOA) switches.

9.4.15.6 Emergency and Exit Lighting

The purpose of exit lighting design is to light the exit points of a facility, during normal operation and power outages. The purpose of emergency lighting design is to light the paths to the exits not illuminated during normal operation, but illuminated during power outages.

Exit lights shall be LED type, with 6-inch letters and 90-minute backup power supply via individual batteries. Lights shall be located over doors and along the exit path as required, directing personnel to the exits. Emergency lights may be included in the exit light fixture when both are located in the same area, to reduce the number of devices to be installed.

9.4.15.7 Installation Concerns

Coordinate the location of light fixtures so that their light output is not impeded by ducts, pipes, conduits, etc. The design should be coordinated as much as possible to avoid obstacles, but should also include words about coordination of the light fixture location with all existing and new mechanical or electrical work.

9.4.16 Lightning Protection Systems

Provide a lightning protection system on all buildings that are not within an existing cone of protection from other protected buildings. All systems shall be designed to NFPA 780, Lightning Protection Code. Connect the lightning protection system to the plant ground system using dedicated downleads. Specify lightning protection components in accordance with UL 96, Standard for Lightning Protection Components and lightning protection systems to be installed and listed in accordance with UL-96A, Installation Requirements for Lightning Protection Systems.

9.4.17 Fire Alarm Systems

Provide an electrically operated, electrically supervised Fire Alarm System for all buildings. The System shall include, but not be limited to: Master Control Panel, Local Control Panels, power supplies, fire alarm initiating and indicating devices, access control system interface, conduit, wire, fittings, and accessories required to provide a complete operating system. All systems shall be designed to NFPA 70, NFPA 72, and any other applicable safety standard required by the local authority having jurisdiction.

At Blue Plains, DC Water has installed a Central Fire Alarm (CFA) system of the Notifier make with the capability to monitor each fire alarm device from the central system. Furnish and install new system, compatible with existing system so that each addressable device may be monitored from remote by CFA. Fire alarm system installed in each building shall be connected and integrated with existing CFA.

Intercept existing fiber loop to insert new building systems using minimum six strand multimode (MM) fiber cables. All fiber/cables shall be installed in exclusive conduits even in gallery.

Modify existing CFA software to integrate new control panels and devices with the system after linking each new building fire alarm system to the CFA. Add graphics of new buildings showing floor plans of each building indicating locations of all fire alarm devices. Modification to the system software shall be made by contractor in both fire alarm Operator Work Stations (OWSs) located at Central Control Room (CCR), Security Command Center (SCC), and Central Operations Facility (COF). Provide electronic copy of the modified/updated software/program/graphics to the owner as part of service manual. Modify CFA Annunciator panel installed at guard house to include new buildings.

9.4.18 Security Systems

The DC Water AWTP employs a computerized Card Access Control System. All new or modified facilities constructed at the Plant that include process Control Rooms where plant control system operator workstations are present shall be controlled access. Coordination with the Department of Security is required prior to designing and/or installing any Card Access Control System device for any DC Water facility.

The existing Card Access Control System is manufactured by Software House, and the card readers are manufactured by HID®. Design Packages to include applicable Card Access Control System specifications and ensure that the installed system will properly interface with the current system.

Controlled access rooms shall have proximity card readers for card access to the room, electrified locks (electric strikes or electromagnetic locks, depending on door elevation and application), motion sensors, and door position switches. Electromagnetic locks shall be wired for failsafe operation for undelayed egress, shall have a mechanical request-to-exit switch wired to physically interrupt power to the lock, and shall be connected to the building fire alarm system to provide free egress during fire emergencies.

9.4.19 Telephone Systems

The DC AWTP employs a voice over internet protocol (VoIP) telephone system with telephone units connected directly to the Plant Enterprise transmission control protocol/internet protocol (TCP/IP) network. Provide telephone handsets for new control rooms, process areas, electrical rooms, offices, and maintenance areas as required. Handsets shall be Alcatel-Lucent model IP Touch 4038. Provide Alcatel-Lucent model OmniTouch 4135 IP Conference units for new conference rooms.

9.4.20 Plantwide Emergency Alert System

The DC Water Blue Plains AWTP has been employing a Plantwide Emergency Alert System (PEAS) to alert DC Water and Contractor staff regarding emergencies through announcements and sound alarms on the PEAS. The system was designed to cover all existing buildings, process areas, open spaces, galleries, and DC Water and Contractor trailers on the plant site. Head end equipment consisting of Central Tone Generator and Remote Paging unit are installed in the CCR at the Central Maintenance Facility (CMF). The Plant was divided into five zones for PEAS addressing.

The PEAS is now supplemented with a more convenient electronic-based notification system which issues email alerts and mobile phone text alerts to all DC Water and Contractor personnel enlisted in the system. Therefore, future projects including new construction and renovation of existing facilities are generally not required to include PEAS hardware of transformers, amplifiers, speakers, and associated wiring. **However, the designer shall verify the latest requirements of DC Water for each project**.

9.4.21 Wiring Devices

Provide general-use, snap-type switches that are totally enclosed in a composition case with an insulated mounting yoke and side-wired, binding screw-type terminals. Switches will be single-pole, 2-pole, 3-way, or 4-way units that are rated 20 amperes at 120/277 VAC. For flush receptacles, use the single or duplex grounding type in a composition case with an insulated mounting yoke and side-wired, binding screw-type terminals that are rated 20 amperes, 125 volts.

Weatherproof receptacles rated 20 amperes, 125 volts, will consist of a single receptacle with spring-loaded, soft-gasketed hinged covers with stainless steel springs.

Receptacles for corrosive areas (NEMA 4X) will be similar to the weatherproof receptacle but with a cover similar to Crouse-Hinds Catalog No. WLRS-1-S752.

Provide receptacles with matching plugs and combination disconnect switches in all process areas, NEMA 4 rated when subject to hose-down, and NEMA 4X when subject to chemical exposure. Devices shall be watertight, gasketed cast-metal enclosures with covers similar to Crouse-Hinds Catalog No. ARRH33 and APJ3385, Style 2.

Receptacles in Class 1, Groups C and D hazardous areas will be 20 amperes, 125 volts, explosion-proof, delayed-action units with angle covers and spring-closed flaps and a mating plug similar to the Crouse-Hinds CPS series.

Comply with the following requirements for receptacles:

- All convenience 115 volt electrical outlets in process maintenance areas, and all interior outlets, shall have GFCI protection.
- Provide GFCI type receptacles outdoors and in wet areas.
- Provide convenience 115 volt electrical outlets for maintenance power tools, located no more than 50 feet from any powered equipment item. Specify/indicate the location of each convenience outlet on layout drawings.
- Provide welding receptacles when specifically required by the DP. These receptacles shall require a plug ground contact to engage with the receptacle ground contact before phase contacts engage. Upon plug withdrawal, the ground contact will remain engaged until after the phase contacts disengage.
- Provide 480-volt welding receptacles for maintenance equipment. Provide at least two welding receptacles on each floor, including the roof. Specify/indicate the number and locations of welding receptacles on layout drawings.
- Welding receptacles shall have mechanical interlock or other means to positively prevent disconnecting the plug from the receptacle under load.

9.4.22 Wire and Cable

9.4.22.1 Medium voltage Cable

Use 15 kV and 5 kV shielded cables with a single copper conductor. Cables must be insulated with ethylene propylene rubber (EPR) to a 133 percent insulation level. Extruded strand screen, 5 mils bare copper tape helically applied shield. Outer jacket shall be polyvinyl chloride (PVC), sunlight resistant, suitable for wet or dry locations and installation in cable tray, and a 105 degrees C continuous operating temperature. Use insulation thicknesses in accordance with ICEA S-93-639/NEMA WC74 and S-97-682, AEIC CS8, CSA C68.3 and UL 1072.

9.4.22.2 Low-voltage Cable

For power circuits with capacities up to 600 volts, use type XHHW-2 wires and cables rated for 600 volts, 90 degrees C in wet or dry locations. Use single-conductor, stranded-copper wires and cables with extruded cross-linked polyethylene (XLPE) insulation.

Provide power cable identification as follows:

System Voltage	Neutral	Phase A	Phase B	Phase C
208/120V	White	Black	Red	Blue
240/120V	White-Gray Stripe	Black-Blue Stripe	Red-Blue Stripe	None
480/277V	Gray	Yellow	Brown	Orange

9.4.22.3 Control Cable

For control, indicating, metering, or alarm circuits, use single- and multi-conductor control cable with No. 14 AWG stranded tin-coated copper conductors having Class B and C stranding and 600 volt PVC, or EPR insulation.

Use type flame-resistant ethylene propylene rubber (FREP) multi-conductor cable in cable tray applications.

Control and instrumentation wire to terminate directly onto clamping yoke screw connection type terminal blocks. Terminal blocks shall be single high density.

9.4.22.4 Instrumentation Cable

Shielded cable for instrumentation wiring, use Class B, 7-strand concentric copper conductors, size No. 16 AWG. Conductors will be insulated individually with color-coded polyethylene or PVC. Use twisted, individually shielded pairs twisted with varying lay (if more than one pair), covered with cable tape and copper or aluminum-coated mylar shielding tape and stranded tinned-copper drain wire, and overall tape overlapped to provide 100 percent coverage with stranded tinned-copper drain wire (if more than one pair). Use PVC for jackets. Cables will be rated 600 volts and 90 degrees C.

Fiber optic cable and raceway systems shall be installed to manufacturer's design criteria.

9.4.23 Raceway Systems

Specify all underground concrete ductbanks, and conduits installed in floor slabs or through slabs, with Schedule 40 PVC conduits. Provide transitions to above grade or thru wall penetrations with PVC coated rigid steel conduits. All exterior, above grade conduit installations shall use PVC coated rigid steel conduits and accessories. Specify stainless steel supports and hardware for all raceways.

Interior conduit systems shall be rigid steel except in chemical areas and wet areas where PVC coated rigid steel conduits and accessories shall be used.

Conduit wiring systems shall be designed with provisions to expel any accumulations of moisture from rain or condensation. Electrical cables and conduit entering rooms shall be configured and sealed to reduce likelihood of water entering through cable or conduit openings; this includes sealing of all wall and floor openings made for cable and conduit penetrations, to prevent water migration between adjacent spaces. Provide means for draining where appropriate. All exterior conduit systems, and interior conduits in locations subject to hose down or within 10 feet of process equipment, or subject to condensation due to cooled spaces, shall be installed with controlled slopes for drainage, and provided with drip legs and auto drains at low points. Provide conduit drains also for explosion proof circuits.

In accordance with NEC, openings around electrical penetrations through fire-resistant rated walls, partitions, floors or ceilings shall be fire stopped using approved methods to maintain the fire-resistance rating. Fire stopping includes three elements: the fire-rated walls, partitions, floors or ceilings being penetrated; the cables, cable trays or conduits that make up the object creating the penetration; and the materials and methods used to seal the penetrations to prevent the spread of fire and smoke. Design packages shall address fire stopping and require inspection and approval during construction.

Provide separate and dedicated raceways to maintain segregation of wiring that is associated with different redundant buses. Redundancy of raceways and busses includes loads at switchgear and MCCs and related conduits, boxes and cable trays. Maintain segregation of all raceways of different service voltages and provide separate raceways for control, instrumentation and power wiring.

Conduits shall be provided with engraved plastic tags placed near each end of run at each box that the run passes through, fastened with stainless steel wire or plastic wire tie-wraps. Conduit tags shall be made from a black and white plastic laminate producing white lettering on a black background.

Install pull wires in all empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200-lb. tensile strength.

9.4.24 Pull and Junction Boxes

Provide NEMA-4X polyvinylchloride boxes for use as junction boxes and provide NEMA-4X high impact strength fiberglass-reinforced polyester boxes for use as device boxes, pull boxes, and terminal boxes in chemical areas. Provide NEMA-4X 316 stainless steel pull and junction boxes in outdoor locations, in process areas, and in damp or wet locations. Provide NEMA-1 or NEMA-12 sheet metal pull and junction boxes in air conditioned rooms (NEMA-12 where dust or dirt may be present).

Each box shall have the volume required by the NEC for the number of conductors and terminals enclosed in the box.

9.4.25 Manholes

For typical manhole construction details for medium-voltage and low-voltage applications, use the DC Water standard detail for cast-in-place manholes. Precast manholes are acceptable provided that the PDE provides specific requirements and loadings for each manhole application. Design loads shall consist of dead load, live load, impact loading, loads due to ground water and lateral soil pressure, and any other loads which may be imposed upon the structure.

The use of precast concrete structures may not be suitable for certain project site conditions. Manufacturer's design of precast concrete products shall conform to the requirement specified by the PDE, and shall be designed, stamped and signed by an engineer with a current structural engineer's license from the District of Columbia prior to submission to the Construction Manager for review.

Precast concrete products shall include all components and accessories required by the DC Water cast-in-place manhole standard detail. Pulling eyes or irons and the precast concrete wall and structure to which it is attached shall be capable of holding a working load of 10,000 pounds of pure tension with a safety factor of 2.0.

Design oversized manholes to accommodate the space required for splicing of medium-voltage cables. The design should make provisions to keep these manholes dry.

9.4.26 Grounding Systems

For all electrical equipment, provide a grounding system that will be continuous throughout the facility and in accordance with the NEC, Article 250. Connect ground rods outside each major structure to the ground bus of the main electrical distribution equipment. For grounding of all other pieces of electrical equipment, use a grounding conductor installed at the raceway feeding that piece of equipment. Include grounding conductors completely inter-connecting water supply pipe, ground rods, ground grid, substation, switchgear and MCC ground buses, other distribution equipment, and other groundable equipment.

To provide isolation from the noise found on the main system, separate the grounding system for computers from the main grounding system by installing separate ground conductors to separate ground triad rods and tie the two ground systems at one point at the exterior ground rods.

Provide two grounding connections for transformers, switchgear, and MCCs to the ground loop. Connect motors of 100 hp and above directly to the ground loop in addition to the ground conductor in the raceway. For grounding of all other electrical equipment, use a grounding conductor installed in the raceway feeding the equipment.

Buried and concealed ground connections are to use exothermic welding. Accessible connections to structural members shall be by exothermic welding process or by bolted connector. Connections to equipment or ground bus shall be by bolted connectors.

Provide a minimum of two ground system test wells for each ground loop. The test well shall consist of an H20 rated 10" x 17" precast utility box with concrete cover at finished grade for access to one of the ground loop ground rods. The ground rod shall be enclosed by an 8-inch diameter soil pipe filled with crushed rock to a depth of 3'-10". Top of soil pipe shall be 1'-10" below grade.

9.4.27 Redundant Power Sources for UPS

Where possible, all new designs should include two independent power sources in conjunction with UPS. If two utility sources are used, they should feed an Automatic Transfer Switch on the line side of the UPS. Coordinate electrical design with instrumentation and controls.

9.4.28 Process Video Monitoring System

At Blue Plains, DC Water has installed a Process Video Monitoring system of the Pelco make with capability to monitor all video cameras located at different locations on the plant. Head end equipment is at CCR in the CMF and has capability to monitor all cameras from CCR as well as local area cameras at area control centers.

Provide sufficient number of cameras to monitor process activities that would require an operator to observe regularly. All cameras shall be color, day/night, pan/tilt/zoom (PTZ) with stainless steel enclosures, provide excite cameras for classified areas. Outdoor/process area cameras shall have heater and shades. Consolidate all local cameras for local viewing and storage in the control room. Link local system to central system at CCR. Modify equipment/programming at CCR to enable integration of new system with existing system for viewing/storing video of minimum 4 cameras at same time from CCR.

9.4.29 Distributed Antenna System

At Blue Plains, DC Water has installed a Distributed Antenna System (DAS) which provides 700/800 MHz coverage extension of the District's Office of Unified Communications (OUC) radio network to the areas not normally well serviced, including underground tunnels and galleries. The DAS provides continuity of radio communications among various DC Water staff wherever they may be at Blue Plains, and also allows police, fire, and emergency communications with their respective units even when they enter tunnels. The DAS receives signals at a master antenna on the roof of the Central Office Facility, where the 'head-end' equipment is also located. From there signals are propagated through fiber cabling to multiple antennas located throughout the underground tunnels and galleries and buildings on the plant site. Each service location is typically equipped with a wall-mounted remote optical unit and an amplifier, and cabling distributed to individual wall-mounted or ceiling-mounted omni-directional antennas. The DC Water Information Technology (IT) department will determine whatever DAS equipment and extensions may be needed for or within any new buildings at Blue Plains, during the building design phase. Therefore, design submittals which include new buildings are to be reviewed by the IT department to determine the needs for DAS antenna equipment space and conduit provisions for feeding the individual antennas. The PDE shall include required equipment space and conduits in the building design. Upon completion of building construction, DC Water will separately procure and install the required DAS equipment and fiber.

9.4.30 Synchronous Check Relays

Electrical switchgear for area substations, unit substations, and MCCs at Blue Plains shall include solid state synchronism check (sync-check) relays to monitor voltages on both sides of circuit breakers and determine that proper phase angle and voltage exist prior to closing the circuit breakers. Control provisions must be included so that in close transition scheme, when the new source breaker is closed, it should automatically trigger the opening of a selected breaker after a preset time, and if the old selected breaker failed to trip, the transfer system must immediately trip the new source breaker.

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APPENDIX A.

ELECTRICAL EQUIPMENT NOMENCLATURE (DRAWING)

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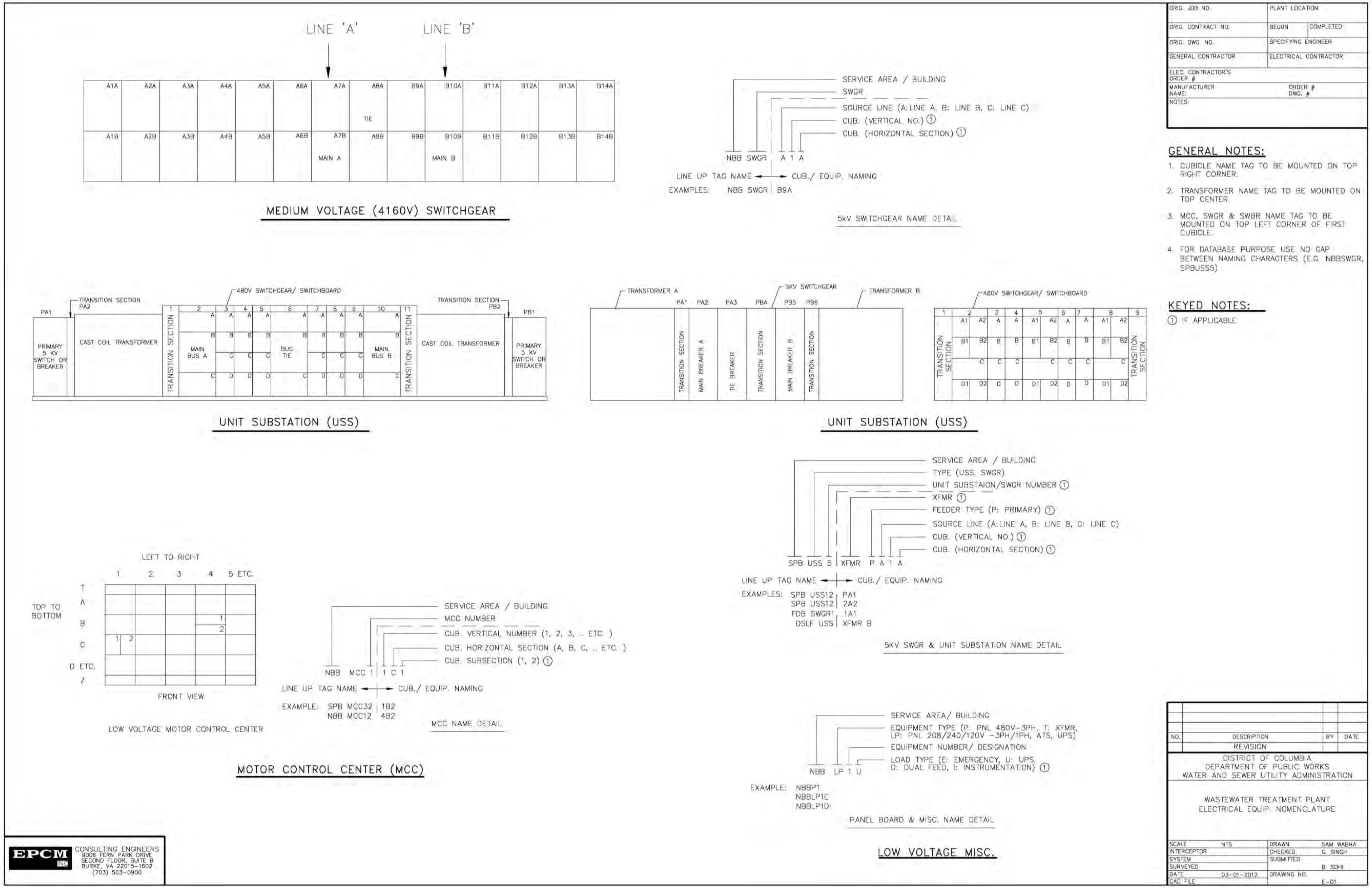
LINE 'A'
LINE 'B'
MEDIUM VOLTAGE (4160V) SWITCHGEAR
SERVICE AREA / BUILDING
SWGR
SOURCE LINE (A: LINE A, B: LINE B, C: LINE C)
CUB. (VERTICAL NO.) ①
CUB. (HORIZONTAL SECTION) ①
LINE UP TAG NAME ← → CUB./ EQUIP. NAMING
EXAMPLES: NBB SWGR | B9A
5kV SWITCHGEAR NAME DETAIL
GENERAL NOTES:
1. CUBICLE NAME TAG TO BE MOUNTED ON TOP RIGHT CORNER.
2. TRANSFORMER NAME TAG TO BE MOUNTED ON TOP CENTER.
3. MCC, SWGR & SWBR NAME TAG TO BE MOUNTED ON TOP LEFT CORNER OF FIRST CUBICLE.
4. FOR DATABASE PURPOSE USE NO GAP BETWEEN NAMING CHARACTERS (E.G. NBBSWGR, SPBUSS5)
KEYED NOTES:
① IF APPLICABLE
UNIT SUBSTATION (USS)
UNIT SUBSTATION (USS)
SERVICE AREA / BUILDING
TYPE (USS, SWGR)
UNIT SUBSTAION/SWGR NUMBER ①
XFMR ①
FEEDER TYPE (P: PRIMARY) ①
SOURCE LINE (A: LINE A, B: LINE B, C: LINE C)
CUB. (VERTICAL NO.) ①
CUB. (HORIZONTAL SECTION) ①
EXAMPLES: SPB USS12 | PA1
SPB USS12 | 2A2
FDB SWGR1 | 1A1
DSLF USS | XFMR B
5KV SWGR & UNIT SUBSTATION NAME DETAIL
LOW VOLTAGE MOTOR CONTROL CENTER
SERVICE AREA / BUILDING
MCC NUMBER
CUB. VERTICAL NUMBER (1, 2, 3, .. ETC.)
CUB. HORIZONTAL SECTION (A, B, C, .. ETC.)
CUB. SUBSECTION (1, 2) ①
EXAMPLE: SPB MCC32 | 1B2
NBB MCC12 | 4B2
MCC NAME DETAIL
MOTOR CONTROL CENTER (MCC)
SERVICE AREA/ BUILDING
EQUIPMENT TYPE (P: PNL 480V-3PH, T: XFMR, LP: PNL 208/240/120V -3PH/1PH, ATS, UPS)
EQUIPMENT NUMBER/ DESIGNATION
LOAD TYPE (E: EMERGENCY, U: UPS, D: DUAL FEED, I: INSTRUMENTATION) ①
EXAMPLE: NBBP1
NBBLP1E
NBBLP1DI
PANEL BOARD & MISC. NAME DETAIL
LOW VOLTAGE MISC.
DISTRICT OF COLUMBIA
DEPARTMENT OF PUBLIC WORKS
WATER AND SEWER UTILITY ADMINISTRATION
WASTEWATER TREATMENT PLANT
ELECTRICAL EQUIP. NOMENCLATURE
EPCM CONSULTING ENGINEERS
E-01

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DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY
(DC Water)

"SERVING THE PUBLIC - PROTECTING THE ENVIRONMENT"

PROJECT
DESIGN MANUAL
VOLUME 2 - FACILITIES DESIGN

SECTION 10 – OPERATION
AND MAINTENANCE STANDARDS

August 2018

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AUTHORIZATION FORM

Revision Number	Date	Content
March 2013	March 2013	Section 10, Operation and Maintenance Standards
August 2018	August 2018	Section 10, Operation and Maintenance Standards

This 2018 version was authorized by:

11/30/2018

David Parker PE, Senior Technical Advisor, Department of Wastewater Engineering Date

SECTION 10, OPERATION AND MAINTENANCED STANDARDS LOG OF REVISIONS (Revisions from 2010 version)		
Paragraph	**Brief Description of Revision**	**Comments**
Global	- Changed ‘DC WASA’ to “DC Water”.	2010
General	Moved the former Section 10, Specifications, to Volume 1.	03-01-2013
General	Renamed the former Section 11, Miscellaneous, to this new Section 10, Operation and Maintenance Standards.	03-01-2013
General	Moved Demolition, , and Value Engineering content to Section 1, General.	03-01-2013
General	Moved Construction Cost Estimating to Vol. 2, Section 1- General.	03-01-2013
10.1	Updated Specification section references.	03-01-2013
10.3	Added Standard Operating Procedures (SOPs) requirements.	03-01-2013
10.4	Added recent O&M Manual requirements.	03-01-2013
10.4.1	Added direction for PDE to verify with DC Water the exact scope of O&M manual contents required by the PDE for each project.	03-01-2013
Table 2-10-1	Changed the outline scope of O&M Manual table of contents from partial coverage to the entire manual.	03-01-2013
Global	Minor edits through entire section	08-07-2018

SECTION 10 - OPERATION AND MAINTENANCE STANDARDS
TABLE OF CONTENTS

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

ASS	Area Substation
CAD	computer-aided design
CW	chilled water
DC Water	District of Columbia Water and Sewer Authority
DCRA	Department of Consumer and Regulatory Affairs
DDOE	District of Columbia Department of the Environment
DPSB	Dual Purpose Sedimentation Basin
ENRF	Enhanced Nitrogen Removal Facilities
EPA	Environmental Protection Agency
HAZOPS	Hazard and Operability
hp	horsepower
HVAC	heating, ventilation, and air conditioning
I&C	Instrumentation and Controls
I/O	input/output
LCS	Local Control Station
LOTO	lockout/tagout
MCC	Motor Control Center
MSDS	Material Safety Data Sheet
NPDES	National Pollutant Discharge Elimination System
O&M	operation and maintenance
P&ID	Process and Instrumentation Diagram
PCS	Process Control System
PDE	Project Design Engineer
pdf	portable document format
PFD	Process Flow Diagram
PM	preventative maintenance
PPE	personal protective equipment
PRV	pressure reducing valve
PSL	Primary Sludge
PSW	process services water
PTSL	primary thickened sludge
SMP	Standard Maintenance Procedures
SOC	Standard of Care
SOP	standard operating procedure
USS	(Process) Unit Substation

PROJECT DESIGN MANUAL
VOLUME 2 – FACILITIES DESIGN

10. OPERATION AND MAINTENANCE STANDARDS

10.1 INTRODUCTION

This section includes guidelines and requirements for operation and maintenance standards, and Operation and Maintenance (O&M) Manuals. Wastewater treatment plants and pump station facilities that have been designed taking into consideration features that increase the flexibility, reliability, efficiency, safety, and ease of operation and maintenance have consistently met their design intent and have provided satisfactory service over the long term. Therefore, early and continuous interface with and input from the Operations and Maintenance staff from planning through construction, startup and operation of a facility is important and vital to the success of the DC Water projects.

As a project team member, the Project Design Engineer (PDE) will be responsible for the following items for each project:

- Obtain O&M related input for the design from DC Water and the Program Manager through design guidelines, orientation and review meetings, and site visits.
- Obtain O&M related input from other similar facilities as and when required.
- Consult equipment manufacturers to procure technical information to address O&M related issues.
- Prepare the following specification sections for the project:
  - 01 75 00 Operational Demonstration.
  - 01 75 20 Service Manuals, including Appendix A, listing ALL of the equipment service manuals required for the project including submittal levels and specification section references.
  - 01 79 00 Operation & Maintenance Training. The PDE will provide Appendix A, listing the title of the training classes, training audiences, hours for each session and spec section references.
- Prepare an Operation and Maintenance Manual for the unit process or system.

10.2 OPERATION & MAINTENANCE STANDARDS

10.2.1 General

This subsection includes general O&M related guidelines the PDE should follow. These guidelines are also useful as general criteria for the planning and design of DC Water facilities. Not all of the guidelines will be applicable to every project. They do not necessarily cover all O&M considerations and must therefore be supplemented and applied with professional judgment by the PDEs. The guidelines are grouped into the following ten categories:

- Process Design
- Layout and Communication
- Equipment Reliability
- Solids Handling
- Instrumentation and Control
- Maintenance
- Emergency Conditions and Safety
- Housekeeping
- Costs
- Pumping Stations

10.2.1.1 Process Design

- When possible, provide a process design that is inherently steady and has controlled mass and energy balances around each process or unit, especially solids handling units. Steady feed rates and feed compositions mean that energy input or release rates are relatively constant, transient responses are minimized, and process control is simplified. Steady feed rates result in more efficient and more economical operation.
- Process design shall accommodate variations in quantity and composition of feed streams.
- Minimize hydraulic and solids recycle streams. Recycle streams mean double treatment, and increase plant loadings and operating costs.
- Provide for built-in surge and storage capacity and self-regulation in order to minimize upsets and interaction between various process units.
- Use gravity flow wherever possible. Consider changes in layout to reduce pumping stages, especially for slurry streams. Gravity flow minimizes utility costs and does not normally break up sludge solids as much as pumping does. However, the design based on gravity shall provide adequate velocity to prevent solids deposition.
- Minimize the need for odor control systems that use fuel and chemicals. Odor control systems are often complex and costly to operate. However, a reasonably odor free environment must be maintained and the required odor control system shall be provided where necessary.

10.2.1.2 Layout and Communication

- Provide for bulk delivery and storage of supplies and chemicals.
- Provide for easy access to equipment for operations and maintenance.
- Make the layout and the communications consistent with existing operation and maintenance techniques and procedures.
- Provide alarm system, local & remote, where necessary.

10.2.1.3 Equipment Reliability

- Use O&M experience relative to reliability of each piece of equipment in DC Water and other similar facilities.
- Evaluate the reliability of each train of equipment in terms of the availabilities of each piece of equipment. Analyze the weak links or potential trouble areas in each train. Provide duplicate equipment if required.
- Consider safety in the selection of equipment.

10.2.1.4 Solids Handling

- Design process pumps to convey sludges of maximum expected concentration. Design to minimize breaking up the solids particles through excessive or unnecessary pumping of slurries.

- Design pumps, lines and sewers to handle solids loads, such as grit, rags, and other solids entering the plant, solids in coagulants such as ferric chloride; and grit and scrap metal in line. Use sump pumps that are capable of handling solids that may be washed into the drain and sump system.
- Design to minimize solids from settling out where they are not wanted and provide for easy cleanout of lines and equipment and a method for disposing of the materials removed.
- Use line strainers and bar screens at appropriate points to remove trapped solids. Strainers shall be large enough to allow adequate cycle time between cleaning.

10.2.1.5 Instrumentation and Control

- The recommended instrumentation and control (I&C) system shall be compatible with overall I&C system. Refer to Section 8 of this manual for specific guidance on coordination with the Process Control System at the Advanced Wastewater Treatment Plant at Blue Plains.
- Provide for instruments that can operate reliably in both the ambient and process environments to which they are exposed.
- Provide for manual operation of gates and valves in case of power failure.
- Provide for monitoring of recycle streams and utility consumption.
- Provide enough sampling points for reliable process monitoring and control.

10.2.1.6 Maintenance

- All equipment shall be accessible for maintenance or replacement. Use cranes, monorails, and hooks for rigging chainfalls as appropriate.
- Minimize the need for ladders or scaffolds for routine maintenance and lubrication of equipment.
- Provide quick-opening access points into equipment that requires routine inspection or cleaning. Minimize the need to disconnect pipe and conduit.
- Provide freeze protection for equipment under normal operation, scheduled shutdown, and emergency operation and shutdown. Consider alternatives to make the equipment intrinsically freeze proof, for example, by making equipment self-draining or by installing it indoors.
- Write equipment specifications to require long-life, durable equipment, such as hardened pump impellers and casings.
- Provide enough electrical outlets and welding machine receptacles.
- Consider the complexity of equipment maintenance, both routine and corrective, and the level of competence required from maintenance personnel.
- Inform DC Water and the Program Manager if the equipment requires special maintenance skills that cannot be provided by normal maintenance personnel. This will allow planning to train the existing personnel or hire new personnel as appropriate.
- Provide for standardization of equipment and the use of nonstandard lubricants wherever possible.
- Provide premium efficiency electrical motors.

10.2.1.7 Emergency Conditions and Safety

- Provide the proper type, quantity and location of fire hydrants and fire extinguishers.
- Locate various critical items such as motor control centers and instrument panels in areas where they are protected from dust, dampness and flooding.
- Provide an adequate alternative power source. The necessary lights, equipment and control systems shall be connected to this system.
- Provide protection of personnel and facilities in case of interruption of any utility.
- Provide safety exits for personnel in case of emergency.
- Design to eliminate areas where explosive or poisonous gases can accumulate, especially during power and utility outages.
- Provide isolation of process and potable water lines.
- Provide a sufficient number and proper placement of safety showers and eyewash stations.
- Provide adequate first aid equipment in the proper locations.
- Provide skid resistant walkways.
- Provide audio and visual alarm system.

10.2.1.8 Housekeeping

- Design to permit removal of waste solids and domestic trash from units without excessive costs and labor.
- Provide strategically located trash and waste collection equipment and pails.
- Provide an adequate drain and sump system to handle dirty water from all housekeeping and equipment cleaning operations, and minor flooding.
- Provide adequate sources of water for building and equipment cleaning.
- Provide adequate means for window cleaning.

10.2.1.9 Costs

- Take into account realistic O&M costs in the selection of specific equipment and processes. Compare these costs on an amortized basis with the capital costs of different equipment alternatives.
- Consider the costs of building maintenance, such as special equipment or materials required for window washing, changing light bulbs and painting and decorating.
- Consider maintenance of roads, parking areas and drainage structures including all utility manholes.

10.2.1.10 Pumping Stations

- Provide corrosion resistant sewers to handle corrosive wastewaters and sludges.
- Make adequate provision for dewatering sewers and pump stations for maintenance.
- Provide for exclusion of debris such as rocks, tires, tree branches, etc. from the wet well.

- Provide high- and low-level alarms in the wet well.
- Design to be consistent with planned standardization of pump station components throughout the system.
- Provide intrinsically odor free operation wherever possible. If chemicals are required to be used, provide backup chemical odor controls.
- Provide for flow and pressure measurement, recording and sampling.
- Provide for lifting and removal of pumps and other heavy equipment with cranes, monorails, hoists, and elevators. Provide adequate staging and work areas for maintenance.

10.3 STANDARD OPERATING PROCEDURES

DC Water has a general philosophy for developing Standard Operating Procedures (SOPs) for all unit processes and systems, as outlined below. DC Water will prepare the SOPs. The PDE shall assist by providing project-specific information and reviews.

1. Develop System/Sub-system/Equipment hierarchy.
2. Standard Operating Procedures are provided for each component within a System.
3. The SOPs will provide the steps and sequence of operation for trained operators who know how to operate the system. This will facilitate operating the system the same way by all parties and in compliance with design intent, safety, permit and other requirements.
4. The SOPs are not intended to provide every detailed step such that any non-experienced person could operate the system. The SOPs should be sufficiently detailed such that a certified operator familiar with similar systems, familiar with the O&M manual, and familiar with the installation should be able to operate the facility using the SOP.
5. For each system, the list of tasks that need to be performed to properly operate the system and the frequency of their execution should be used as a guide to determine the number, type, and level of detail within a SOP. Tasks that are performed infrequently may need to be more detailed than routine daily tasks.
6. Each system should have an **Introduction SOP**, containing (1) system overview, (2) a file map to source documents, (3) system permit interfaces, (4) personnel hazards, and (5) personal protective equipment (PPE) requirements. All other SOPs will reference the Introduction SOP in the header or preamble.
    - Source documents will include training documents and handouts, O&M manuals, detailed process schematics and other material that will enhance understanding of the system and its components.
7. **Field SOPs** are a guide to setting up and monitoring at the equipment. It will include a field monitoring check list for an equipment, process, or area to be performed by the operator in the field. It represents a Standard of Care (SOC) that any item of equipment or process should receive from an operator. Equipment checklists may be generic modified for the application, e.g., all pumps will have common field monitoring features, or duplicated within the duty station. This also can include sampling and analyses.

8. **Operating SOPs** outline procedures for performing physical actions in the field. For example, how to start/stop equipment; valve line up/changes to switch from a running pump to a standby pump, etc.
9. **Process Control System (PCS) SOPs** are guides to operating and monitoring a system in remote. It is a PCS screen monitoring checklist that is customized for the operation being monitored, and tells the operator what parameters to monitor, set point range, how many units should be on-line, what trends to be monitored, etc.
10. There will be one **Electrical SOP** for the system, which will include panels and motor control centers (MCCs).
11. **Troubleshooting SOP** is a table listing common problems with equipment/process/system/sub-system along with causes and remedies, and will focus on addressing equipment/process alarms that are observed at control panels and PCS. Process troubleshooting will be covered in the O&M manual. NOTE: Accurate and detailed process schematics are needed for each system.
12. DC Water will provide electronic version of all vendor service manuals; AutoCAD versions of all project record drawings; editable electronic versions of all previously prepared O&M materials associated with the Project or associated projects; and screen shots and other PCS related information as needed for review of the PCS SOPs.
13. SOPs will be prepared in electronic format, suitable for printing each equipment component on single 8½ by 11-inch sheets, where feasible, subject to the limitation that no lettering in SOP text will be smaller than 12 point font size. SOPs shall be transmitted and saved in their native, editable format (MS Word, AutoCAD, etc.) as well as in portable document format (pdf).

The PDE shall assist DC Water in the development of SOPs in digital format. SOPs will be developed by others and the PDE shall review the SOPs, as appropriate, for each unit process. The intent is to assure consistency with the original design intent, and to assure that all necessary SOPs for the processes are developed. The PDE shall make reasonable efforts to confirm the accuracy and clarity of each SOP, but DC Water is responsible to confirm that the SOPs are complete, accurate and consistent with the facility's operational practices.

10.4 OPERATION AND MAINTENANCE MANUALS

10.4.1 General Operation and Maintenance Manual Requirements

The Consultant shall develop an O&M Manual describing detailed means and methods of operating and maintaining the Project in compliance with the National Pollutant Discharge Elimination System (NPDES) permit requirements. The manual shall incorporate all related process systems and equipment whether included in the construction contracts or not, and shall explain the design intent of the process system and equipment as it applies to operations and maintenance issues.

Large and complex facilities like the Advanced Wastewater Treatment Plant at Blue Plains and DC Water sewer and water pump stations may require several O&M manuals. Each manual must be considered as one of a series of referenced manuals which together will cover the operation and maintenance of the entire process or system. Since the construction of DC Water facilities is an ongoing process, O&M manuals will be written at different times as the projects are authorized, constructed and brought on line. Personnel must be kept informed of the whole system as well as individual units.

For large contracts, separate O&M manuals may be written for different unit processes in the contract. A unit process is a common plant subdivision such as preliminary treatment, primary treatment, secondary treatment, enhanced nitrogen removal, digestion, gravity sludge thickening, sludge dewatering, filtrate treatment, filtration, disinfection and odor control. For a pump station, the facility itself may be considered a unit process.

The Process and Instrumentation Diagrams (P&IDs) shall be an integral part of the design process. Unit processes will be the basic subdivision of the P&IDs. The P&IDs, therefore, can be used as a tool for dividing a facility into unit processes for O&M purposes and can also be used as a guide in preparing actual O&M descriptions.

The unit process manual is the one most commonly used by operations and maintenance personnel. The manual shall contain detailed descriptions of specific equipment and controls making up each unit process. To maintain a 'single source' philosophy, detailed material that is provided elsewhere will generally not be duplicated in the O&M manual, but separate information sources should be referenced in the manual. Separate sources of detailed material may include Service Manuals, Equipment Maintenance Manuals, SOPs, Standard Maintenance Procedures (SMPs), Lockout/Tagout (LOTO) Procedures, and the Sampling and Analytical Plan. (NOTE: In 2014, it was suggested in an O&M workshop, that separate Equipment Maintenance Manuals be prepared to provide additional detailed equipment maintenance information beyond what is typically included in Service Manuals. As of September 2014, the procedure and provider of the separate Equipment Maintenance Manuals was not yet formally determined.)

The manual shall include a summary description of the various unit processes within the Project that addresses the following, as a minimum:

- **Process Systems and Equipment:**
    - Component Listing (with schematics)
    - Design Objectives
    - Performance Criteria
    - Design Intent – Overall and detailed intent of all components
    - Operational Philosophy and Operating Guidelines
    - Equipment Detail and relationship to design
    - Process and Equipment Redundancy

- **Power Distribution**:
    - Component Listing (with schematic overview)
    - Electrical – Single line diagrams, panel layouts and circuitry, down to 120 volt control panels
    - Design Intent – Overall and detailed intent of all components

- **Instrumentation and Control:**
    - Component Listing (with schematics)
    - Control Strategies
    - Design Intent – Overall and detailed intent of all components
    - Instrumentation – Set points, ranges, and limits

- **Heating and Ventilation and Air Conditioning Systems**
    - Component Listing (with schematics)
    - Control Strategies
    - Design Intent – Overall and detailed intent of all components
    - Instrumentation – Set points, ranges, and limits

- **Other:**
  - Facility Design Basis – Area and Room Hazard Classifications, heating, ventilation, and air conditioning (HVAC) basis of design
  - Safety Systems – Gas monitoring, fire protection, security

The manual shall describe routine operating procedures for the following elements applicable to each unit process:

- Start-up sequences including inspections required before initiation of sequence
- Performance monitoring requirements to confirm proper operation and guide component control adjustments
- Troubleshooting guidelines to identify non-performing components and identify probable cause
- Shut-down sequences to safely remove components from service without adverse impact on system performance
- Preparation to isolate off-line equipment piping, power, and controls for safe execution of maintenance activities

10.4.2 O&M Schematics Standards and Guidelines

O&M Manuals shall include schematics to graphically indicate the orientation and identification of unit process components and controls. Schematics shall conform to the following standards and guidelines:

1. General, all schematics
   - Provide header numbers on all schematics
   - Provide a title block per DC Water Computer-aided Design (CAD) Manual. See additional information below.
   - Provide a border that is consistent with most of the existing schematics
   - Piping, equipment and valves shall be shown in correct geographic orientation.
   - File names per DC Water CAD Manual. Names shall include the process and system.

2. Colors for processes and systems
   - Standard colors shall be used for each process and Plantwide schematic, and shall be similar to PCS colors where possible (PCS uses gray background so duplicate colors will not work on white background).
   - Use different colors for process influent and effluent.
   - Pipeline system colors will be similar to pipeline colors used in the field where possible. (Chemical piping all orange; Sludge and scum – all gray.)
   - Add notes on schematics to tell the operator where schematic colors differ from field painted colors. For example, note would state that all chemical piping is orange.

3. Equipment symbols
   - Use DC Water standard CAD symbols [DC Water Drafting Standards (CAD) Manual] for pumps, conveyors, valves and other equipment.
   - Where DC Water standard CAD symbols are not available, a standard symbol shall be created for DC Water review and approval.

4. Title Blocks:
   - Use standard title block as shown in DC Water CAD Manual
   - Service Area Title: ADVANCED WASTEWATER TREATMENT PLANT
   - Project Title:
     - Line 1: process (i.e., NITRIFICATION - DENITRIFICATION)
     - Line 2: sub-process (i.e., PROCESS DEWATERING)
     - Line 3: as needed
   - Drawing Title:
     - Line 1: schematic number (i.e., SCHEMATIC 1)
     - Line 2: schematic description (i.e., PROCESS)
     - Line 3: schematic description [i.e., SYSTEM(S)]
     - Line 4: as needed
   - Discipline: SCHEMATIC

5. Layer
   - Each process element is on a different layer with color identified.
   - Each Layer name is consistent with PCS standard label where available (e.g., PSL for Primary Sludge, and PTSL for Primary Thickened Sludge).
   - Where PCS standard labels are not available, a standard label will be created.

6. Guidelines
   - Where feasible, all systems that serve a process should be on one schematic. If not practical, related systems or systems that interface with each other should be on the same schematic.
   - Systems that span reactors and sedimentation basins should be on the same schematic.
   - Separate system schematics for East and West processes are acceptable.
   - Systems should be shown as a complete system, from a control standpoint. Large systems may have an overview (skeleton) schematic and separate detail views. For example, Nitrification process aeration system must have an overview showing all automated control valves, with separate detail schematics for post-aeration, effluent-aeration and dual purpose sedimentation basin (DPSBs).
   - Schematics should not differentiate between existing, new, and modified structures and construction.
   - Show ongoing and future construction on schematics, with a note stating when the new construction will be in service.
   - Plantwide chemical distribution schematics should be filed with other Plantwide schematics. Chemical distribution schematics should be as complete as practical, to minimize needing to refer to multiple schematics.
   - Schematics created from contract drawings should be cleaned up to eliminate construction references that are of no practical use to the operator.
   - One set of schematics for the nitrification process should be created that incorporates Enhanced Nitrogen Removal Facilities (ENRF) and all chemicals (methanol, alt carbon, polymer, and chlorine).

10.4.3 O&M Manual Format and Submittal Requirements

The Environmental Protection Agency (EPA) has issued numerous operation and maintenance publications under the Wastewater Program. The O&M manual shall be prepared generally in accordance with EPA guidance, but conformed to the contents outline in Table 2-10-1. The manual contents must be well organized so that staff can locate information quickly. Use "Chapters" rather than "Sections." If directed, some chapters may remain unused where material is provided elsewhere, or certain chapters may be developed by others. Therefore, the PDE shall verify with DC Water the exact scope of contents to be provided by the PDE for each project.

Preliminary, intermediate, and pre-final versions of the O&M Manual shall be submitted for DC Water's review and comment. Submittals shall be fully indexed, searchable pdf files, showing tracked changes between submittals. Produce the final O&M Manual as searchable pdf files and Word documents designed to be loaded on the DC Water Document Management System.

Table 2-10-1. O&M Manual Contents Outline

Cover Page, Title Page, and Master Table of Contents
Chapter 1 – Introduction • Chapter title page and Chapter table of contents. • Describe the scope of contents of the manual. • Site location map. • Overview of the role of the subject facility in the plant. • Role of facility or process within the plant – include upstream and downstream interfaces. • Purpose of the process, and the fundamental objectives. • Relationship of the process to other plant processes and the overall plant operations. • Explain the design intent and basic design and performance criteria. • Overall Process Flow Diagram (PFD). • Summary mass balance. • List of facilities in support of the process objectives. • Overview of the Process information important to various departments, including Operations, Maintenance, Electricians, Instrumentation, and Facilities. • List and identify separate related information sources, such as Service Manuals, Equipment Maintenance Manuals, SOPs, SMPs, LOTO Procedures, the Sampling and Analytical Plan, etc.
Chapter 2 – Permits and Standards • Chapter title page and Chapter table of contents • Identify all permits, standards, codes, ordinances, rules, regulations, policies, laws, consent orders, etc. that this process or system is required to satisfy, including but not limited to, NPDES, Department of Consumer and Regulatory Affairs (DCRA), District of Columbia Department of the Environment (DDOE), Elevator, Stormwater, etc. • Interface and permit dependencies – Water, Air, Solids, Other. • Purpose of the permit requirements, their benefits, and consequences of non-compliance. • Required action to be followed in the event of non-compliance. • How and why the process may affect permits, standards, etc. of other plant processes or systems.

Chapter 3 – Description, Operation and Control

- Chapter title page and Chapter table of contents

3.1 General Overview

- Introduction explaining the scope of contents of Chapter 3.
- General location plan of the process in relationship to other processes at the plant.
- General overview of the unit process system.
- Summary of the system, its major components, system function/objectives, and system location.
- What systems are directly upstream and downstream.
- Explain the benefits of optimal performance, the consequences of poor process performance, and the impact on upstream and downstream processes.

3.2 Process Description

- Detailed descriptions of each process system, sub-systems, and equipment.
- Basis of design for each process system, its components, and operational features provided.
- Discuss intended operating modes, capacities, dosages, and other key process or operational info.
- Reference design calculations as appropriate. (Do not repeat detailed design calculations and details from the design package, unless pertinent to operations decisions.)
- Equipment details: locations, purpose, functions, and features of each equipment item; and the role of each equipment item in the process.
- Operating strategies and process basis behind operating strategies, alarms, and interlocks for each system, sub-system, and equipment.
- Operating ranges, sizes, capacities, dosages, loadings, alarm set points, etc. for each system, sub-system and equipment. (Specific elevations, tank dimensions, and other similar design details are not needed in this section, but should be provided in subsequent sections.)

3.3 Equipment Controls

- Include "*This section provides basic information on the system controls. More detail on alarm and device settings, and calibration information are in the PCS O&M Manual and in Maximo*."
- Functions and strategic basis of alarms and interlocks for each system, sub-system, and equipment.
- Basic power distribution for equipment and instrumentation, area classification, etc. Reference Chapter 11 for power sources, distribution details, and electrical sources SOP.
- Control equipment and instrumentation including breakers, disconnects, control panels, MCC.
- Instrumentation and Control – general description of the control scheme/loop and features, Local control panels and functions (manual control). Front view photo/schematic/drawing of all control panels.
- ▪ Equipment redundancies, interlocks, permissive features, and alarm conditions.
- Final control descriptions from the specifications and/or PCS factory acceptance testing.

3.4 Operations

- Explain how to set up the process to operate it to meet the design intent.
- Discuss normal operating procedures, and distinctions of automatic, manual, remote, and any alternative operating modes.
- Routine observation, measurements, adjustments, and monitoring requirements necessary for effective operation.
- Discuss major tasks or functions performed infrequently (e.g., non-standard operations), i.e., of such a nature that they are not included as standard operating procedures, and will require customized job plans to be developed by DC Water. Provide sufficient information to support the development of the customized job plans. (An example is tank draining).
- Reference Chapter 8 for emergency operations for situations requiring immediate operator attention, e.g., occurrences that may result in permit violation if not addressed, etc. Include process and operational troubleshooting but not equipment troubleshooting. For equipment troubleshooting, make reference to the Service Manuals, Equipment Maintenance Manuals, and Sops. Performance metrics for each system, sub-system, and equipment.

Chapter 4 – Personnel (NOT USED)

Chapter 5 – Laboratory

- Chapter title page and Chapter table of contents.
- Make reference to the latest plant wide “Sampling and Analytical Plan” (July 2012) and its location. Items already covered in the sampling plan do not need to be repeated in the manual.
- Identify any and all process sample types and quantities to be taken along with recommended sampling locations and frequencies.
- Field analysis in support of performance metrics. Laboratory tests may be referenced, but provide details for field tests conducted by operations staff.
- Sample locations, sample/sampler types, special sampling provisions, if provided in the project.
- Online analyzers that are provided under the project.
- Provide parameters for anticipated laboratory data and explain how the data is used to achieve optimal process control.
- Include recommended forms, bench sheets, chain of custody, etc. deemed necessary for effective process documentation.
- Estimate total labor requirements for sampling and analytical work for the subject process.
- Locations of existing automatic samplers do not need to be repeated in the O&M manual. If needed, add to the plant wide sampling plan document.

Chapter 6 – Records

- Chapter title page and Chapter table of contents.
- Tabular listing and location for all available supporting documents.
- Requirements for documentation and record-keeping.
- Identify what records need to be generated.
- Address what records need to be reported.
- Address what records need to be archived.

Chapter 7 – Maintenance

- Chapter title page and Chapter table of contents.
- Overview such as "*This section provides information on system and process maintenance, and design provisions to facilitate maintenance for the[subject] system or process.*
- Clarify that detailed equipment maintenance and troubleshooting information are provided in the separate equipment Service Manuals, Equipment Maintenance Manuals, the SOP, and SMP for this system; and baseline data collected for equipment items during commissioning (amp draw, vibration analysis, etc.) is attached to the Final Service Manuals and also included with the asset information in Maximo.
- Include references to all equipment service manuals.
- Process system maintenance considerations and recommendations that would not be found in service manuals for individual equipment items, such as housekeeping, valve exercising, cleaning, polishing, painting, etc.
- Design provisions made for maintenance access, overhead and adjacent clearances, isolation valves, flushing and draining, hoisting provisions, adequate slack in power cords, easy access to seals and bearings, and equipment removal, reinstallation, or replacement.
- For each major equipment item (valves > 6 inches, pumps > 20 hp, and all devices requiring special equipment to access (scaffolding, scissor lift, etc.), provide a table listing approximate weights based on equipment used as basis for design, and provisions for removal (e.g., lifting hooks, A-frame, jib crane, etc.) Where appropriate, include a site plan markup showing location of space allocated for crane placement and staging.
- For equipment requiring special handling during major maintenance activities (e.g., high torque drive assemblies of primary clarifiers and gravity thickeners) provide detail marked up plan to indicate recommended or required locations and spaces for access, movements, clearances, staging, and orientation.
- Provide details for any asset that has special conditions (e.g., single point of failure, designed to run to failure, regulatory inspection, safety interface) that necessitate a customized job plan not used for other assets in its class.
- Provisions for worker safety at high and inaccessible points.
- List by equipment any special conditions and provisions within design for handling process fluid.
- By equipment, list provisions made to evacuate process fluid prior to dismantling for maintenance
- List of special tools required for the facility, and any special considerations related to maintenance (such as use of non-sparking tools).
- List of mandatory checks required based on special equipment provided for the project (for example required checks of pressure reducing valves (PRVs) for Cambi, nuclear meters etc.) [This is not intended to be a preventive maintenance (PM) list].
- List infrequently used valves or items installed for emergency or unusual operating modes so that these can be prioritized in a valve exercise program.
- Discuss the need to maintain process integrity of an area as appropriate while performing maintenance. (e.g., need to avoid cross-contamination of Class A Biosolids with Class B solids.
- Estimated labor requirements for recommended maintenance NOT needed in the manual: equipment manufacturer and supplier contact info; PM requirements; and equipment troubleshooting. These items are addressed separately in the Service Manuals and the Equipment Troubleshooting SOP.

Chapter 8 – Emergency Response

- Chapter title page and Chapter table of contents.
- References to existing DC Water Emergency Response Plan, Policies and Procedures, including emergency contacts and telephone numbers.
- Process specific Emergency Action and Mitigation Plans for the process and facilities.
- Procedures to maintain unit process operations or to protect facilities and equipment during emergencies.

Chapter 9 – Safety • Chapter title page and Chapter table of contents. • Area Classifications and ventilation requirements. • Listing and Location of all Process Hazards, and results of the HazOps study. • List and cite the locations of all safety features associated with the subject process including (but not necessarily limited to) smoke detectors, heat detectors, chemical vapor detectors, sensor alarms, emergency stop devices, fire extinguishers, eyewash stations, fire exit signs, telephones, radio devices, flotation rings, fire alarms, fire suppression systems, etc. • Provide location drawings for all identified safety devices and equipment located within the subject process area. • Equipment specific LOTO procedures, including electrical and valves. Make reference to existing LOTO procedures, and reference to Chapter 11 for new electrical LOTO procedures. • Describe all safety alarms, annunciation locations, and reset philosophy for each identified alarm. • List all materials needed that require Material Safety Data Sheets (MSDS). Provide MSDS Sheets in an appendix. • Identify all areas specific to the process that may require PPE such as eye, ear, hand, and head protection. • Identify all confined spaces associated with the subject process and refer to DC Water policies and procedures governing same. • Provide references to all related DC Water Safety Policies and Procedures. • Include a description of the plant Central Fire Alarm system (see Section 9 – Electrical, of the Project Design Manual, Volume 2, Facilities Design). Provide a discussion of specific provisions made in the subject process system facility.
Chapter 10 – Utilities and Support Systems • Chapter title page and Chapter table of contents. • All utilities associated with the subject process; identify their source, distribution path(s), and containment areas as applicable. • Process area drawings showing the locations of all utilities and support systems. • Estimated process and facility specific utility demands and consumption – chilled water (CW), process service water (PSW), heating, ventilation, sanitary, sewage ejectors, sump pumps, stormwater, backflow preventers, break tanks, hot water, steam, chemicals, telephone, cable, etc. • Utility capacities (provided and expected), metrics, measurement, and reporting. • Recommendations for monitoring and reporting process and facility specific utility consumption.

Chapter 11 – Electrical

- Chapter title page and Chapter table of contents.
- Floor layout/diagram showing location of MCCs and panels for each system.
- Single line diagrams for the electrical distribution system, including:
  - Plant line down to process Area Substation (ASS)
  - ASS single line down to Process Unit Substation (USS)
  - USS single line down to Process equipment and MCCs
  - MCC single line down to equipment and lighting panel transformers
  - Lighting panels and transformers. – Provide lists
  - Process specific drawings for existing system(s).
- All remote and local power source(s) for each equipment (MCC Number, Local Control Station (LCS) Number, etc.).
- Power monitoring devices for the subject process and locations thereof.
- DC Water LOTO system and process. Cross reference Chapter 9.

Appendices

- Appendices title page and Appendices table of contents
- Appendix A Process Schematics
- Appendix B Process Flow Diagrams
- Appendix C Hydraulic Profile
- Appendix D Select Drawings
- Appendix E Product Data
- Appendix F Hazard and Operability (HAZOPS) Report
- Appendix G Material Safety Data Sheets (MSDSs)
- Appendix H Asset Listing
- Appendix I Input/Output (I/O) List