MANATEE COUNTY UTILITIES

SOUTHWEST WATER RECLAMATION FACILITY ELECTRICAL MASTER PLAN

TECHNICAL MEMORANDUM MASTER PLAN FOR UPGRADES OF 5 kV AND 480V ELECTRICAL SYSTEM

FINAL
November 2014

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MANATEE COUNTY UTILITIES

SOUTHWEST WATER RECLAMATION FACILITY ELECTRICAL MASTER PLAN

TECHNICAL MEMORANDUM

MASTER PLAN FOR UPGRADES OF 5 kV AND 480V ELECTRICAL SYSTEM

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1.0 EXECUTIVE SUMMARY

Manatee County (County) owns and operates the Southwest Water Reclamation Facility (SWWRF), which is an advanced wastewater treatment facility permitted to treat 15 million gallons per day (mgd) at an annual average day flow (AADF). The process of treating the wastewater to reuse standards and high service pumping for distribution requires substantial electrical energy. The facility's operation and reliability of its process depends on the proper functioning and safe configuration of the facility electrical power system.

The objective of this technical memorandum (TM) is to evaluate the condition and configuration of the existing SWWRF electrical system with an assessment from multiple perspectives, including:

- Equipment characteristics for safe operation and safe maintenance
- Analysis of the electrical system configuration and flexibility to isolate short circuit faults,
- Analysis of equipment age, long term reliability, remaining life, impacts of corrosive environment and recommendations for future replacement.
- Spare electrical capacity to supply power for anticipated future process loads

Additionally, the assessment includes options for reducing quantities of equipment by combining functions but maintaining reliability for power distribution and standby power generation, and development of alternatives for master planning the design and construction of future equipment replacement and upgrades.

1.1 Summary of Findings and Recommendations

The summary of recommendations and the included opinion of cost can be used as a basis for capital improvement projects (CIP) budget projections and scoping of work to design and construct the vital improvements in separate construction phases.

The assessment of the existing 5 kV switchgear, 5 kV generators, substation 5 kV switches, indoor 5 kV to 480 volt transformers, 480 volt switchboards and 480 volt motor control centers revealed that:

- Most of the existing equipment installed since 1988 is reaching the end of its useful duty cycle

- Numerous pieces of electrical equipment are obsolete due to progressive changes in electrical technology and/or lack of spare parts,
- The older electrical equipment is deteriorating because it is located in electrical rooms without air conditioning, with ventilation from humid environment, and some electrical rooms like in the headworks structure is exposed to a corrosive environment with hydrogen sulfide gas.
- The 5 kV in the main electrical room does not have enough room space for the layout of new larger switchgear, while 5 kV equipment shall be continuously energized for keeping the plant in operation. Therefore, it will be necessary to increase the size of the electrical room.
- The quantity of 5kV/480 V substation transformer have increased to a total quantity of 20 units over 25 years, because the original design did not include spare capacity in transformers and 480 volts swtichboards, for supplying power to additional process loads. The maintenance of such large quantities of substation transformers represents substantial operating cost and requires significant capital for asset replacement.

Most of the electrical equipment that is over 25 years old should be replaced within 5 to 10 years (between 2014 through 2024), for assurance to maintain a reliable and safe power distribution system. The recommendations for an upgrade of the power distribution system, from a master planning perspective, are summarized in Table 1 and accounting of each opinion of cost is further itemized in Section 6.0.

Table 1 Summary of Electrical Improvements and Related Construction Cost Southwest Water Reclamation Facility Electrical Master Plan Manatee County Utilities

No	Description	Recommended Year	Total
1	Add Air Conditioning for Key Main Electrical Rooms (total of 3)	2016	$204,000
2	Intercept 5 kV Feeders at Headworks for Anoxic Basin's Transformers	2016	$221,000
3	Add Separate 5 kV Feeders for the Northeast Blower's Building	2016	$377,000
4	Remove Substations No. 5 and. 6 and Replace MCCs B1-B4	2019	$522,000
5	Replace Substations No. 7 and 8 and MCCs DW1, DW2, D1 and D2	2019	$785,000
6	Remove Substations No. 1and 2 and Replace MCCs E1 – E2	2019	$548,000
7	Remove Substations No. 9 and 10	2019	$61,000
8	Replace 480 Volts Switchgear No. 11 and 12	2019	$906,000

Table 1	Summary of Electrical Improvements and Related Construction Cost Southwest Water Reclamation Facility Electrical Master Plan Manatee County Utilities		
No	**Description**	**Recommended Year**	**Total**
9	Construct new Vault for FPL Utility Transformers	2019	$ 300,000
10	Replace 5 kV Main Switchgear including Wiring	2019	$3,013,000
11	Replace Generator's 5 kV Breakers and Controls	2019	$813,000
12	Allowance for Replacement of Misc. Panels for Outlets, Lighting and Instruments	2024	$200,000
13	Replacement of Standby 2,000 kW Generator No. 2	2022	$1,300,000
	OPINION OF TOTAL PROBABLE CONSTRUCTION COST		**$9,250,000**

2.0 BACKGROUND

Manatee County (County) owns and operates the Southwest Water Reclamation Facility (SWWRF), which is located in southwest Manatee County directly east of 66th Street West in Bradenton, FL. It is the oldest of the County's three water reclamation facilities within a predominately built-out area of the County. The SWWRF is an advanced wastewater treatment facility permitted to treat 15 million gallons per day (mgd) at an annual average day flow (AADF). In 2013, the facility treated approximately 13 mgd AADF of wastewater. The process of treating the wastewater to reuse standards and high service pumping for distribution requires substantial electrical energy with an average demand range of 125 to 200 kilowatts (KW) or kilovolt-amperes (kVA) per mgd. The facility's operation and reliability of its process depends on the proper functioning and safe configuration of the facility electrical power system.

The SWWRF purchases electric power service from Florida Power and Light (FPL) at 4,160 volts (V) by way of three (3) 1,500 kVA service transformers, which are located within a utility vault room. The voltage is stepped down from 23 kilovolts (kV) to 4,160 V, and is supplied to the plant main switchgear located in the main electrical room (adjacent to the FPL vault room).

The 4,160 V main switchgear contains two (2) input circuit breakers for redundant reliability of FPL power and has an intermediate tie circuit breaker that facilitates splitting the switchgear's electrical equipment in two separate parallel sections for the input/output of power. Also, the main switchgear contains the feeder circuit breakers that distribute 4,160 V power throughout the SWWRF, to remote substations-transformers that step down the voltage from 4,160 V to 480 V switchboards, which supply power to downstream 480 V motor control centers (MCC) and the MCCs supply power to mechanical process equipment. Also, the SWWRF has two (2) diesel fuel engine driven generators for standby power with a combined power generation capacity of 4,000 kW. These are interconnected to the main 4,160 V switchgear for the supply of continuous power to the process equipment, during and unexpected failure of the normal FPL utility power.

The configuration of the power distribution system for the SWWRF was established during the last major upgrade and expansion of the facility in 1988. Numerous additions to the power distribution system have been constructed since then following the basic configuration. At this time, evaluations and master planning for upgrades and replacement of equipment must be based around the basic configuration, with additional improvements for safer operation and maintenance, higher energy efficiency for power distribution and state of the art technology for protection of capital investment and collection of data for monitoring of electric power consumption.

2.1 Objective

The objective of this technical memorandum (TM) is to evaluate the condition and configuration of the existing SWWRF electrical system as of the year 2014 with an assessment from multiple perspectives, including:

- Equipment characteristics for safe operation and safe maintenance without impacting the SWWRF process.
- Analysis of existing electrical system configuration and flexibility to isolate short circuit faults, while critical water process equipment remains in operation.
- Analysis of long term reliability, equipment age, its remaining life and availability of spare parts from the equipment manufacturer
- Evaluate equipment condition in corrosive wastewater environment facility and humid weather in Florida that accelerates the deterioration and shortens life of metallic electrical equipment and components
- Assess electrical equipment spare capacity to supply power for anticipated future process loads according with the plant treatment capacity in millions of gallons per day (MGD) and anticipated future plant growth.

Additionally, the assessment includes options for reducing quantities of substations equipment by combining equipment function while maintaining reliability for power distribution and standby power generation, and development of alternatives for master planning the design and construction of future upgrades. The configurations for new equipment must follow the EPA guidelines for Class 1 Reliability, the 2014 requirements from applicable electrical codes, and recognized guidelines standards like NFPA-70E Standard for Electrical Safety in the Workplace.

2.2 Power Capacity of the Main Electrical Switchgear and Generators

The overall power capacity of the existing main switchgear is up to 8,636 kilovoltamperes (kVA) at 4,160 volts; however, the capacity of the system is limited by the combined supply of the FPL's 4,500 kVA electric service.

Calculations for the electrical load revealed there is an approximate connected, on duty load of 5,000 horse power (HP), which could be approximated to 5,000 kVA. The electrical load takes into account the connected equipment load as of 2014, including the anticipated designed loads from the SWWRF Nitrogen Removal project. These calculations do not include the accounting of connected load from standby equipment that exists only for process reliability. Based on educated statistical records and experience for power demand in wastewater treatment plants and judicious engineering experience and analysis of the SWWRF electrical characteristics, a power demand diversity factor of 75% might be applied to estimate the approximate power demand of: 5000 kVA x 0.75 = 3,800 kVA. The upper limit of this calculated power demand usually exceeds the actual power demand readings from electronic power meters or FPL utility meters.

Based on engineering judgment and above calculations, the existing main switchgear at 4,160 V and with 1,200 amperes bus has a power supply capacity of 8636 kVA and includes spare capacity of 227% above the calculated electrical demand load, which means the existing 5 kV switchgear capacity has been adequate for the application. However, the switchgear was not planned with spare breakers for load growth and the electrical room does not floor space for adding switchgear sections with breakers.

Also, the existing two diesel fuel engine-generators for standby power are rated for 2,000 KW or 2,500 kVA each, with a combined power generating capacity of 4,000 kW or 5,000 kVA. According to records of the SWWRF operating staff, the average running load of the facility is normally supplied with one generator, which means the average power demand is less than 2,000 kW and the combined power generating capacity of both standby generators is also adequate for their application.

2.3 Objective Criteria for Upgrades of Electrical System

The approach and criteria for design and construction of upgrading a power distribution system in a water reclamation facility should be based upon multiple guidelines and requirements , such as safety for operating and maintenance personnel, environmental responsibility required by EPA, requirements of pertinent building and electrical codes, configuration of the power distribution to process equipment in separate, parallel, or redundant power sources, to assure reliability and continuous treatment process, and convenience during maintenance. Also, flexibility and space for future additions to the SWWRF has been considered from a process perspective, and accommodated by this master plan by providing spare capacity allowance for load growth within the electrical power system.

The replacement or upgrades of electrical equipment in electrical rooms shall include layouts and arrangement for partial shutdown of power distribution, that simplify maintenance or repairs with de-energized apparatus for worker’s safety and convenience for future replacement within the room space, while critical treatment process is energized for continuous plant operation.

Additional criteria for design and construction has been identified and listed in Section 7.0 of this memorandum.

3.0 ASSESSMENT OF 5 kV SWITCHGEAR AND 480 VOLT ELECTRICAL SYSTEM

3.1 Background of Basic Power System and Subsequent Additions

Carollo Engineers performed a Repair and Replacement (R&R) assessment of the facilities assets, which included the original power distribution system. The assessment also included a review of record drawings for the 1988 project that made significant additions to the electrical power distribution system, and subsequent major improvements and electrical additions until 2014. The following is a summary of the major electrical system projects completed and/or in construction since the 1988 expansion:

- In 1992, a methane gas, co-generator system was installed to utilize methane gas generated by the anaerobic sludge digestion system and 5 kV circuit breakers were added to the main switchgear for interconnection of the co-generation system. However, the anaerobic digesters have not been operated because of aging equipment and low gas production. The County decided not to invest further capital dollars to upgrade the system, and the anaerobic digesters have been converted to aerated sludge holding tanks. Because of the methane gas is no longer available, the co-generator has been disconnected.

- In 1998, additional blowers were installed at the northeast part of the facility, for process air supply to the aeration basins. The power distribution equipment consisted of 5 kV motor control centers and 5 kV electric motors.

- In 2008, additional pumps were installed to distribute reuse water to the County's Master Reuse System and the project added two (2) 5 kV switches and two (2) substation 750 kVA transformers No. 11 and No. 12 (at the maintenance building), to power the pump's speed controllers (VFDs).

- In 2012, design was completed for a new high service pump station to distribute reuse water to the County's Master Reuse System. The project is currently under construction and will add two (2) 5 kV switches at 5 kV switchgear No. 11 and No. 12, for supplying power to two (2) 2000 kVA substations Nos. 13 and 14.

- In early 2013, design was completed on a project to convert the existing anaerobic digesters to aerobic sludge holding tanks. This project is currently under construction and will add two (2) 500 kVA transformers to step down the voltage from 5 kV to 480 V, and provide new MCCs for power to the sludge holding tank blowers and sludge holding tank mixers and related pumps.

- In 2013, design was completed on a project to convert the existing activated sludge treatment process to the Modified Lutzack-Eddinger process for nitrogen removal. This project is currently in the bidding process and construction is expected to start in middle to late 2014. The project will add two (2) 500 kVA transformers and 480 V MCC for power to the anoxic basins (converted primary clarifiers) and it will add two (2) 1,000 kVA transformers. A new 480 V MCC will be installed for supplying power to two new 300 HP aeration blowers.

All of the above listed designs added (or will add) ten (10) 5 kV/480 V substation transformers to the existing power distribution system, but the basic main 5 kV switchgear configuration has been kept intact in the main electrical room.

The connection of the above listed 10 additional substation transformers have been tapped together with existing substations to the output of existing feeder circuit breakers on the main 5 kV switchgear; as a result the malfunction of one 5 kV feeder circuit breaker could impact or shutdown power to multiple substations and process loads.

The review of documentation for the Repair and Replacement (R&R) assessment of the facilities reveals that the above designs were done without the guidelines of formal County criteria for electrical design or without an electrical master plan to guide improvements.

3.2 Overall Assessment of Electrical Equipment

Carollo Engineers made physical inspections of the configuration of the 5 kV power distribution, 5 kV standby power generators, 5 kV MCCs, and indoor 5 kV/480 V transformers, and observed equipment that has corrosive impacts due to humidity and examined related 480 V switchgear that is near the end of its useful life.

During the assessment of the existing electrical circuit breakers in switchboards, it was noticed that circuit breakers that supply power to MCCs do not comply with article 240.87 of the NFPA-70, National Electrical Code (NEC) and the Florida Building Code, which requires the subject feeder circuit breakers to include an electronic means for instantaneous tripping or “energy-reducing maintenance switching with local status indicator, that would allow a worker to set a circuit breaker trip unit to “no intentional delay.” Therefore, the circuit breakers on future new 480 V switchboards with high magnitude of inlet energy that supply power to MCCs should include adjustable electronic trip settings with manual selector switches. This will reduce the let through energy and minimize the category of arc flash on the MCCs, for the convenience of personnel to decrease arc flash risk and less quantity of protective equipment.

Table 2 includes a summary of the equipment assessment.

Table 2 Assessment of Power Distribution Equipment and Generation System
Southwest Water Reclamation Facility Electrical Master Plan
Manatee County Utilities

Equipment	Service	Physical Condition[2]	Code Violation Identified	Located in Flood Area[1]	Action Recommended
Main 5 kV Switchgear	5 kV Main Service	Fair, old	No No Arc Flash Labels	No	Replace entire switchgear and add circuit breakers for feeders to substation transformers. New switchgear layout should be in larger electrical room to facilitate future replacement Consider separate cabinets for low voltage controls of circuit breakers Add air conditioning for the electrical room
5 kV Generator Switchgear	Controls for two 5 kV Generators	Fair; Remaining half of average life.	No No Arc Flash Labels	No	Replace entire generator's switchgear and install in same room with other 5 kV switchgear. Provide separate low voltage controls in separate cabinet. Add air conditioning for the electrical room
Gen 1 - 2,000 kW	5 kV Standby Power	Good	No	No	Keep existing

Table 2 Assessment of Power Distribution Equipment and Generation System
Southwest Water Reclamation Facility Electrical Master Plan
Manatee County Utilities

Equipment	Service	Physical Condition(2)	Code Violation Identified	Located in Flood Area(1)	Action Recommended
Gen 2 – 1,825 kW	5 kV Standby Power	Good	No	No	25 years on duty. Low running hours. Future replacement may be required due to Federal Regulations for engine exhaust emissions
Substation No. 1 & No.2	Supplies power to MCC-E1; MCC-E-2; and power to miscellaneous equipment in maintenance building and Operations Control Building	Fair/ old	Not to current codes for arc flash protection	No	Remove equipment from generator room and Replace function with other combined substations (like No. 11 and No. 12) and locate transformers. outdoor on concrete pad.
MCC E-1 & MCC-E-2	Supplies power to secondary clarifiers 2,3, 5 and miscellaneous equipment in maintenance building and Operations Control Building	Fair/ old	Not to current codes for arc flash protection	No	Remove equipment and Replace function with MCCs located in 480V conditioned space
Substation No. 3 & No.4	Supplies power to headworks equipment and secondary clarifiers 3 and 4	Obsolete	Not to current codes for arc flash protection	No	Remove equipment and replace function with other combined substations (like No. 5 and No. 6) and locate transformers outdoor on concrete pad.

Table 2 Assessment of Power Distribution Equipment and Generation System
Southwest Water Reclamation Facility Electrical Master Plan
Manatee County Utilities

Equipment	Service	Physical Condition[2]	Code Violation Identified	Located in Flood Area[1]	Action Recommended
480 V MCC- HW-1 and HW-2	Supplies power to headworks equipment and secondary clarifiers 3 and 4	Obsolete	Not to current codes	No	Remove equipment and replace function with equipment located in available conditioned space of MCC in electrical room for anoxic basins
Substation No. 5 & No.6	Supplies power to previous aeration and daft equipment	Obsolete	Not to current codes for arc flash protection	No	Remove equipment and replace function combined with newer outdoor transformers that will be part of the SWWRF Nitrogen Removal project.
480 V MCCs B-1 through B-4 and MCC-1	Supplies power to previous aeration and daft equipment	Fair/ old	Not to current codes	No	Remove equipment and replace function with only two MCCs of larger capacity, to be located in conditioned space
Two 5 kV Motor Control Centers for Aerations Blowers	5 kV Power to Aeration Blowers	Good, Reliable	No Arc Flash Labels	No	Keep 5 kV equipment until end of its useful life. Disconnect existing interconnection with 5 kV feeders for substations Nos. 2, 3, 5, and 6. Add separate source of 5 kV power from the main 5 kV switchgear Add Arc Flash labels

Table 2 Assessment of Power Distribution Equipment and Generation System
Southwest Water Reclamation Facility Electrical Master Plan
Manatee County Utilities

Equipment	Service	Physical Condition[2]	Code Violation Identified	Located in Flood Area[1]	Action Recommended
Substation No. 7 & No.8	Supplies power to digesters and dewatering process equipment	Obsolete	Not to current codes for arc flash protection	No	Remove equipment and Replace function combined with outdoor transformers that are part of the 2013 Digester Modifications Project
480 V MCCs D1; D-2 and DW-1; DW-2	Supplies power to previous digesters related pumps and dewatering process equipment	Obsolete/old	Not to current codes for arc flash protection	No	Replace equipment with two MCCs, to be located in conditioned space
Substation No. 9 & No.10	Supplies power to deep well 350 hp pumps	Fair/Old	Not to current codes for arc flash protection	No	Replace equipment using outdoor pad mounted transformers
480 V Switchboards No. 9 and No. 10	Supplies power to deep well 350 hp pumps	Fair/old	Not to current codes for arc flash protection	No	Remove equipment. Consider combined function with two new switchboards No. 11 and No. 12, to be located in conditioned space
Substation No. 11 & No.12	Supplies power to deep well 350 hp pumps	Good	No arc flash labels	No	Keep 5 kV/480 V transformer equipment and add air conditioned to room space

Table 2 Assessment of Power Distribution Equipment and Generation System
Southwest Water Reclamation Facility Electrical Master Plan
Manatee County Utilities

Equipment	Service	Physical Condition(2)	Code Violation Identified	Located in Flood Area(1)	Action Recommended
480 V Switchboards No. 11 and No. 12	Supplies power to deep well 350 hp pumps	Good	Not to current codes for arc flash protection	No	Consider combined function with two new switchboards No. 11 and No. 12, to be located in conditioned space
5 kV Transformers No. 13 & No.14	Supplies power to 480 V switchgear that feed 350 hp VFDs for water reuse pumps	New	None	No	Interconnect with separate 5 kV feeders from main 5 kV switchgear and remove feeders from substation No. 11 and No. 12.
480 V Switchboard No. 13 & No.14	Supplies power to VFDs and high service 350 hp pumps for water reuse	New	None	No	None

Notes:
(1) Determinations of condition made by visual observation
(2) Additional specific assessment of each key electrical apparatus has been included with pertinent issues and recommendations and they are shown on figures with photographs in Appendix A.

3.3 Observations of Existing Electrical System and Equipment Location

The major components of the 5 kV and 480 V electrical systems are located at the center of the SWWRF site, where there is no significant electrical loads and small substation-transformers are situated throughout the facility, as shown in Figures 1, 2 and 3 (Electrical Partial Site Plan I, Electrical Partial Site Plan II, and Electrical Partial Site Plan III).

The existing 5 kV electrical equipment interconnection for power distribution is arranged as shown on the existing electrical one-line diagram in Figure 4. This figure shows the main 5 kV switchgear with two input power sources from the utility FPL and a third power source from the standby power generators is connected to one half-section of the 5 kV switchgear. Each main 5 kV switchgear section supplies power to downstream transformers and switchboards that supply power to numerous MCCs. The multiple water process equipment on duty and its redundant equipment like pumps, aeration blowers, and miscellaneous loads are distributed between different MCCs, for maintaining continuous treatment process while partial electrical equipment might be shutdown for repairs.

The assessment of the original electrical system configuration reveals that main 5 KV switchgear and small 5 kV transformers capacity were not planned with respective spare 5 kV breakers and spare transformer capacity for plant growth or changes. As a result, previous projects added a substantial quantity of other small substation-transformers and the practicality of such small equipment may be questionable from an operation and maintenance perspective.

3.4 Evaluation of Main 5 kV Switchgear Configuration

The existing electrical one-line diagram on Figure 4 shows that output power from the cabinet with generator's 5 kV breaker is routed via an overhead electrical busway, which interconnects to only one end of the main 5 kV switchgear. Detailed analysis of this configuration revealed a possible single point of failure, If the 5 kV half section of the main switchgear, where the generator interconnects would require momentary maintenance, then the facility reliability would substantially decrease since there is no readily available means to quickly interconnect the generator power to the other half of the switchgear during an FPL utility failure event. This switchgear configuration with possible single point of failure should be improved upon replacement of the entire 5 kV switchgear.

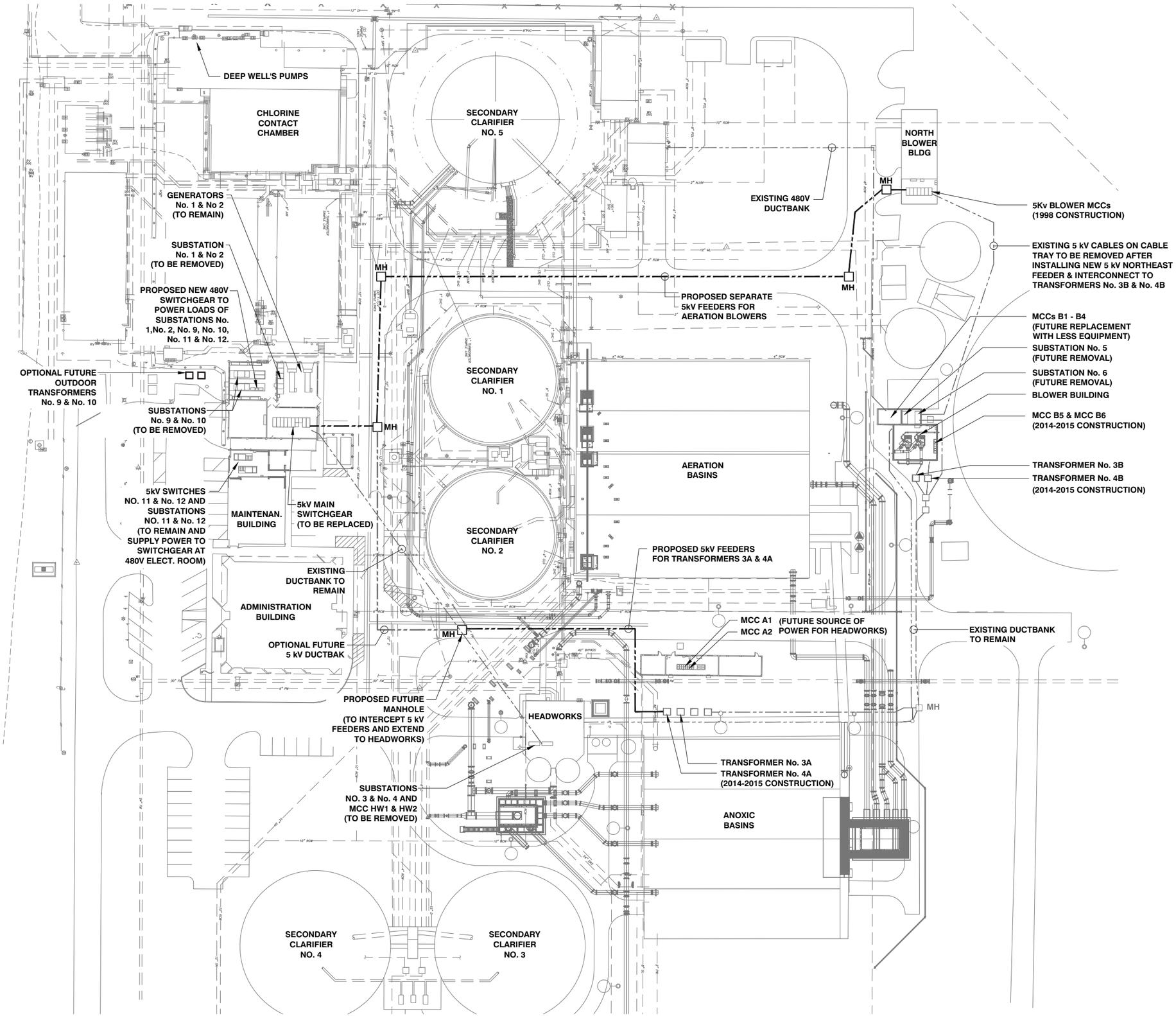

FIGURE No. 1
ELECTRICAL PARTIAL SITE PLAN I

MANATEE COUNTY - SWWRF
ELECTRICAL MASTER PLAN

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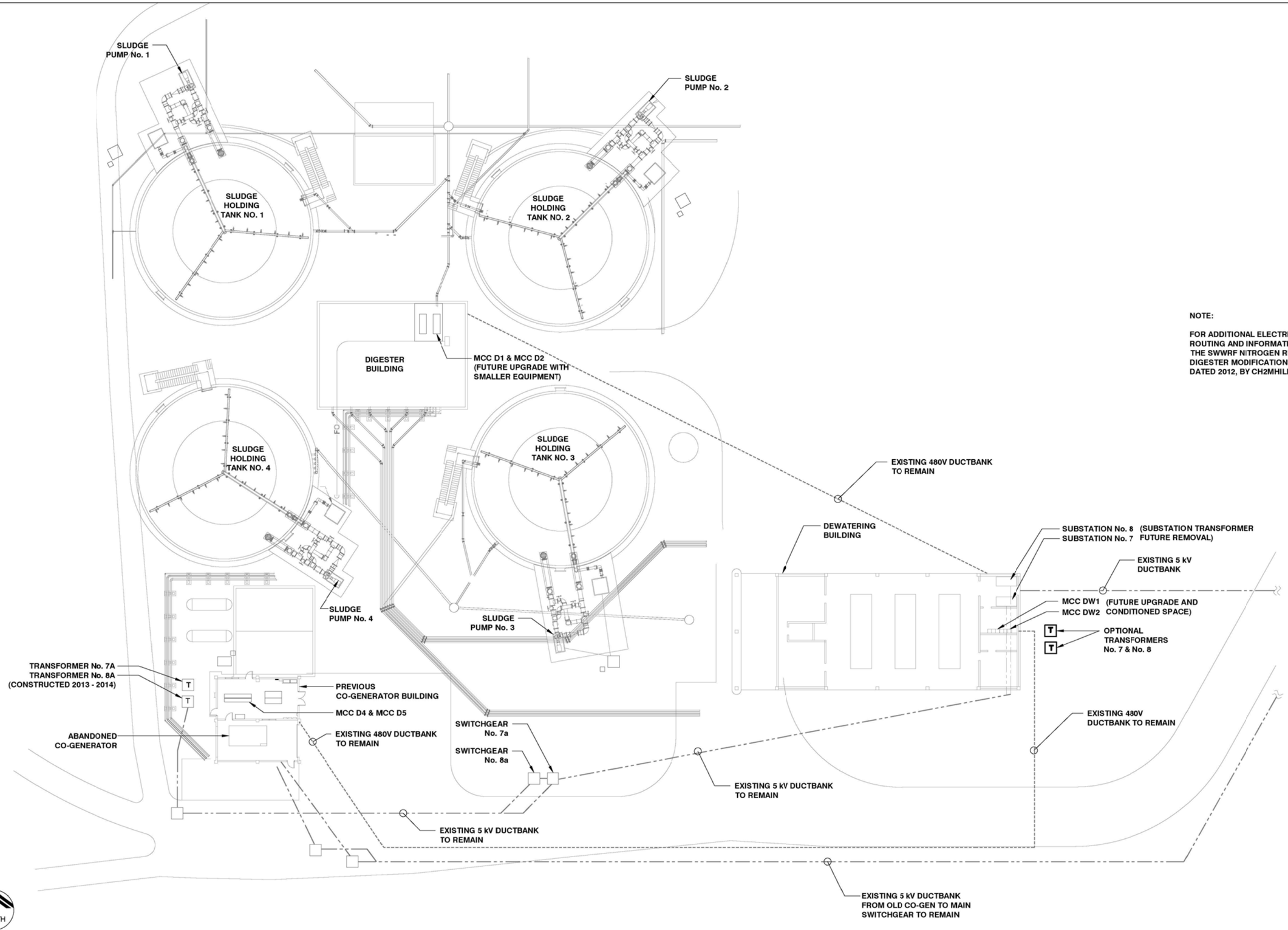

NOTE:

FOR ADDITIONAL ELECTRICAL DUCT BANK ROUTING AND INFORMATION, REFER TO THE SWWRF NITROGEN REMOVAL AND DIGESTER MODIFICATIONS DRAWINGS, DATED 2012, BY CH2MHILL

FIGURE No. 2
ELECTRICAL SITE PLAN 2 OF 3

MANATEE COUNTY - SWWRF
ELECTRICAL MASTER PLAN IMPROVEMENTS

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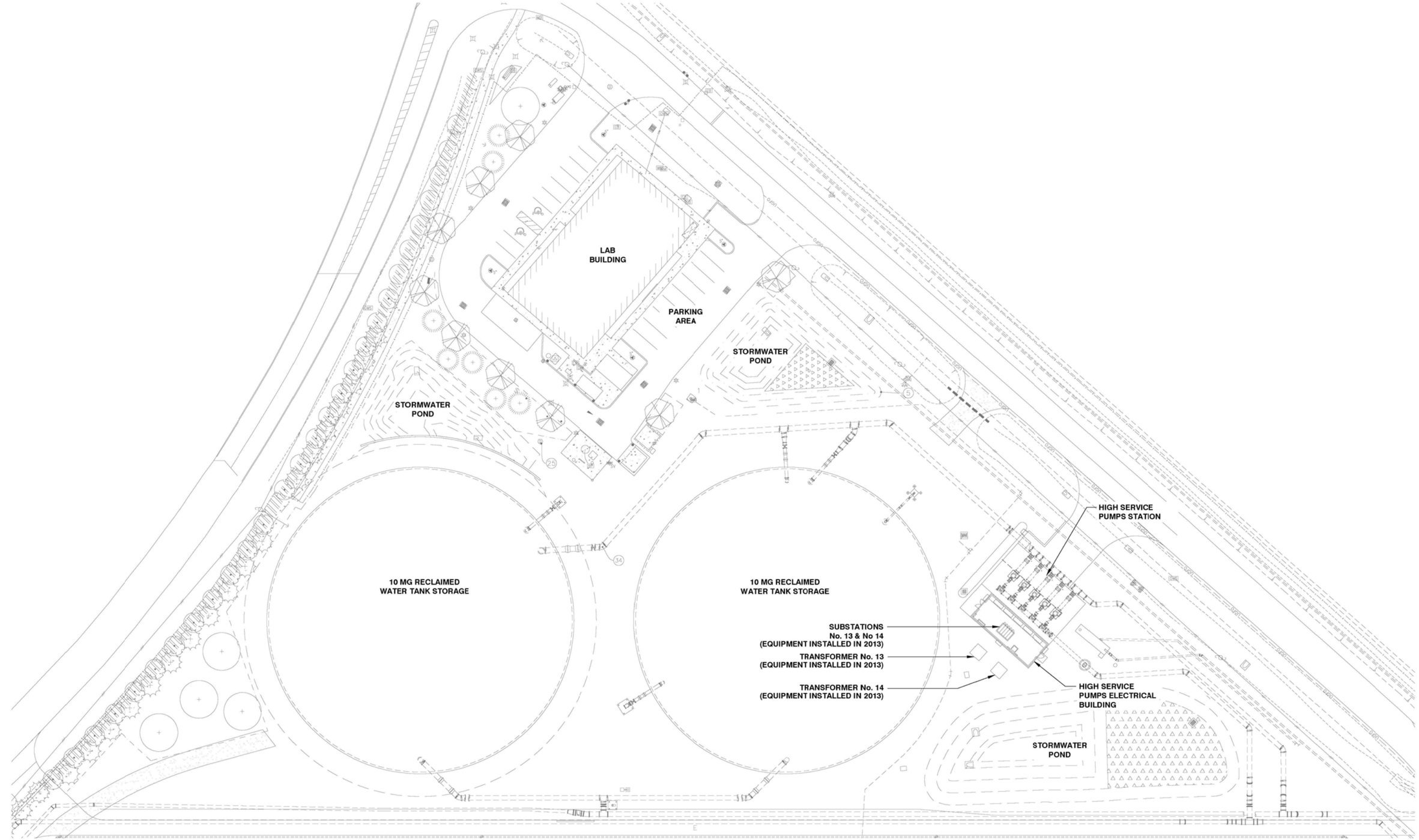

NORTH

0 15' 30' 60'

FIGURE No. 3
ELECTRICAL SITE PLAN 3 OF 3

MANATEE COUNTY - SWWRF
ELECTRICAL MASTER PLAN IMPROVEMENTS

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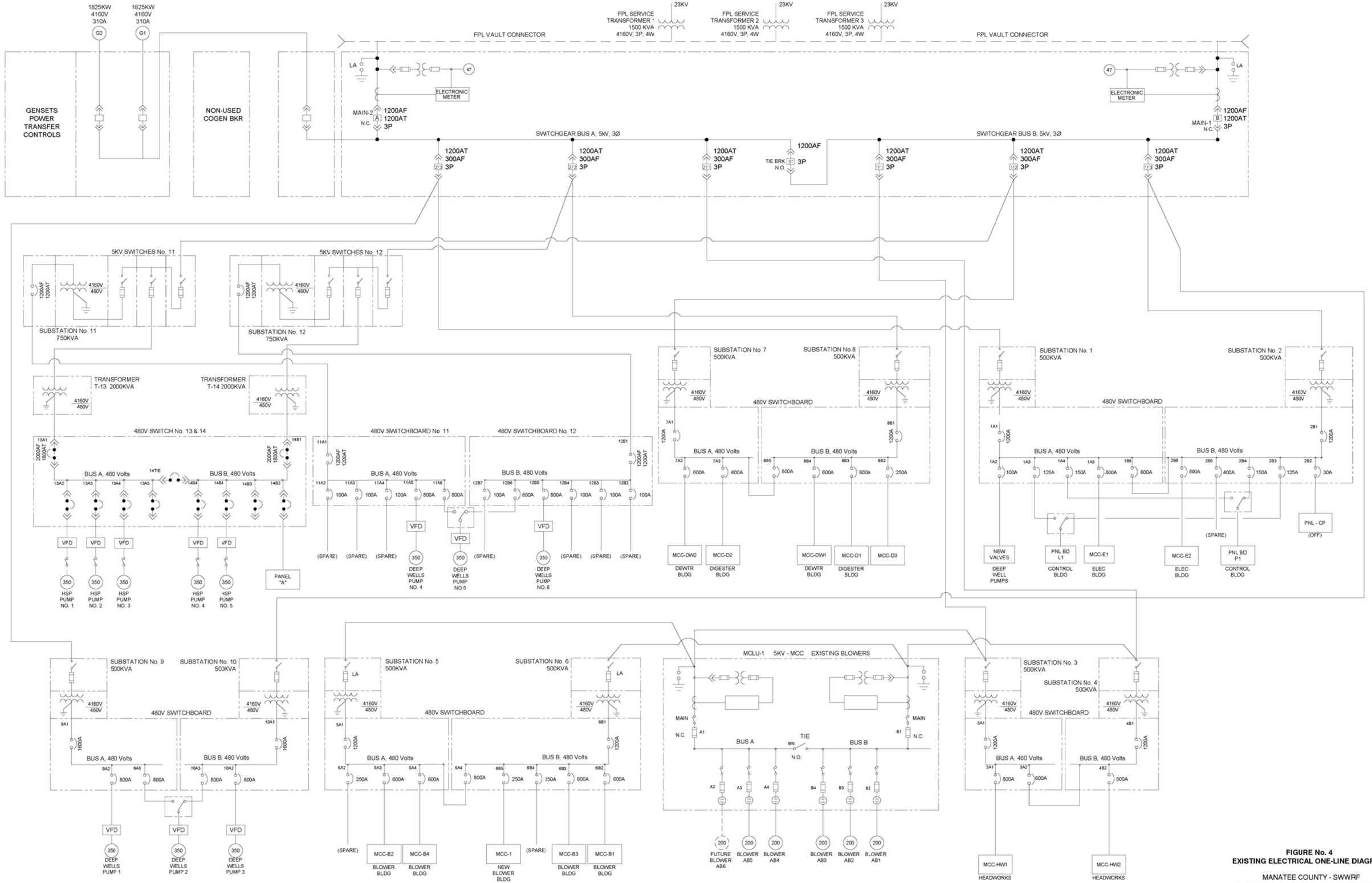

FIGURE No. 4
EXISTING ELECTRICAL ONE-LINE DIAGRAM

MANATEE COUNTY - SWWRF
ELECTRICAL MASTER PLAN IMPROVEMENTS

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3.5 Evaluation of Generator's Interconnection and Main 5 kV Switchgear.

The one line diagram on Figure 4 shows that the output from the generator's 5 kV control panels or switchgear does not include a circuit breaker for the protection of the overhead electrical busway that interconnects to the main 5 kV switchgear. This configuration may be a potential condition for single point of failure and it shall be improved upon replacement of the entire 5 kV switchgear.

3.6 Assessment of Non-Necessary Electrical Substation-Transformers

The existing electrical one-line diagram on Figure 4 shows that the existing power distribution configuration includes most of the aeration system blowers operating at 4,160 V and two substation transformers Nos. 13 and 14 supply power to the high service pumps for water re-use that replaced the previous deep well pumps. These two processes (aeration and effluent pumps) represent most of the SWWRF significant electrical loads perhaps as much as 60 percent (%) of the facility energy demand and their load's are independent of other transformers in the plant.

However, otherpower distribution equipment contains 18 substation transformers, (No. 1, 2, 3, 3A, 4, 4A, 5, %A, 6, 6A, 7, 7A, 8, 8A,9, 10; 11 and 12) for stepping down the voltage from 4,160 to 480 V in a process area with approximately 40% of electrical loads, such as the headworks, the secondary clarifiers, the administration building lighting and control panels, air conditioning loads in the main 5 kV switchgear electrical room and the maintenance building electrical room, and the VFDs for speed control of effluent transfer pumps. A new design should consider deleting eight (8) substation transformers and combine their function with less transformers as shown in Figure 5. The benefit of fewer transformers would represent less capital cost for equipment replacement, less energy losses of non-loaded substation-transformers and less operating energy costs.

The proposed electrical one-line diagram shown in Figure 5 includes fewer 5 kV to 480 V transformers for the above-mentioned areas.

3.7 Assessment of Incident Energy and Risks of Arc Flash Hazards

Concurrent with this master plan assessment under a separate assignment, Carollo has performed additional engineering studies to determine the possible magnitude and category of arc flash energy on the 480 V switchboards. The study results show that the feeder's molded case circuit breakers with fixed tripping characteristics might not meet the code requirements of the 2011 NEC –240-87, which requires breaker's features for instantaneous tripping during maintenance for devices that supply power to the remote MCCs. Therefore, some existing MCCs have an available high magnitude of incident energy during short circuits events and their category of arc flash may require that personnel wear sophisticated personal protective equipment (PPE) during maintenance or repairs.

GENERAL NOTES:

1. ELECTRICAL EQUIPMENT TO BE LOCATED IN AIR CONDITIONED SPACE.
2. PROPOSED SCHEME DECREASES QUANTITY OF 5KV/480V SUBSTATION TRANSFORMERS FROM 20 TO 8 (OR 10).
3. CAPACITY OF TRANSFORMERS AND SWITCHBOARDS TO BE INCREASED IF NECESSARY AT DESIGN PHASE.

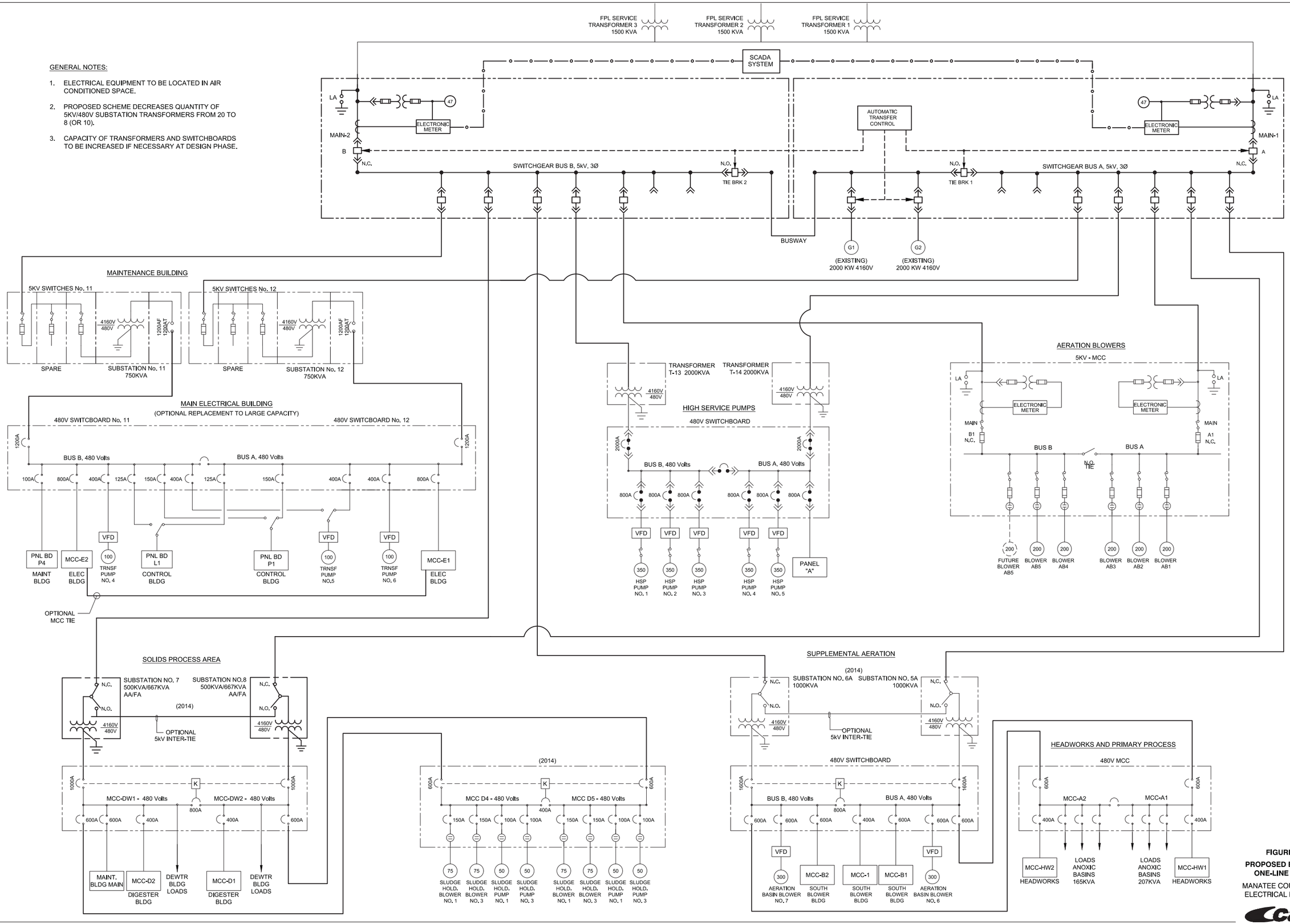

FIGURE No. 5
PROPOSED ELECTRICAL ONE-LINE DIAGRAM
MANATEE COUNTY - SWWRF
ELECTRICAL MASTER PLAN

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4.0 SHORT TERM IMPROVEMENTS OF 5 kV AND 480 V SYSTEM

4.1 Add Air Conditioning to Main Electrical Room for 5 kV/480 V Switchgear

The deteriorating and progressive corrosion of existing 5 kV switchgear and 480 V MCCs is due to humid Florida weather and the corrosive environment at the water reclamation facility. The remaining useful life of electrical equipment could be stop from further deterioration if air conditioning is installed in electrical rooms as soon as possible. In addition to the air conditioning equipment, the electrical rooms will require internal improvements for closing ventilation louvers, replacement of doors, new insulation for walls and ceilings and ideally redundant energy efficient air conditioning equipment.

The schedule for the subject improvements should be within two (2) years or by 2016. The opinion of probable construction cost is shown with the summary of findings and recommendations on section 6.0, paragraph 6.1.

4.2 Reconfigure Underground 5 kV Feeders to Headworks and Anoxic Basins

The existing indoor 5 kV substation transformers Nos. 3 and 4 and related MCCs contain very small electrical loads and their large electrical load capacity is not justifiable for the connected loads at the headworks. The source of electric power for the headworks equipment and the secondary clarifiers No. 3 and No. 4 can be obtained from the new 480 V electrical equipment that will be constructed as part of the SWWRF Nitrogen Removal project.

The schedule for the subject improvements should be as soon as a new headworks structure is constructed, perhaps within 4 years or prior to 2018. The opinion of probable construction cost is shown with the summary of findings and recommendations on section 6.0, paragraph 6.2.

4.3 Reconfigure Underground 5 kV Feeders for Aeration System

Existing 5 kV underground feeders that supply power from the main electrical room towards the south and east part of the facility carry a substantial portion of the electrical loads, including headworks, primary clarifiers, and aeration system. Also, the design of the Nitrogen Removal System will be adding to the same 5 kV feeders 4 more outdoor (substation) transformers for the anoxic basins and two aeration blowers. A failure of these 5 kV feeders could cause a major operational impact and possible failure of the primary and secondary treatment processes.

The addition of another set of 5 kV underground feeders is recommended for separation of aeration loads from other loads. The proposed 5 kV feeders would be routed towards the northeast part of the plant via additional underground electrical ductbanks and manholes.

The schedule for the subject improvements should be as soon as possible or within 4 to 5 years or sooner. The opinion of probable construction cost is shown with the summary of findings and recommendations on section 6.0, paragraph 6.3.

5.0 PROPOSED RECONFIGURATION OF ELECTRICAL SYSTEM

5.1 Proposed Configuration of the 5 kV Power Distribution System

A new configuration of the main 5 kV switchgear is recommended and it should include two (2) tie breakers, plus the connection with the standby generator's breakers should be on a third electrical bus section located between the tie breakers. Each section of the proposed 5 kV switchgear for power distribution should include circuit breakers dedicated for protection of each remote major substation transformer, as necessary to improve reliability and avoid the existing condition that multiple transformers receive power from a single 5 kV circuit breaker.

The operating low voltage controls of the 5 kV switchgear should be located if possible in separate cabinets, away front the boundary of high voltage hazard, for minimizing the risk of exposure to possible arc flash hazards.

The protective relays associated with each 5 kV circuit breakers shall be electronic type, with state of the art features that facilitate diagnostics for troubleshooting and communication with a power quality monitoring system.

The proposed 5 kV switchgear configuration and the scheme for power distribution are shown in the power line diagram in Figure 5.

5.2 Improvement in Existing Main 5 kV Switchgear Room

The necessary footprint space for the new 5 kV switchgear will required more room space than existing due to the following reasons:

- The existing switchgear was not originally laid out with a configuration that facilitates equipment replacement, by removing portions of the switchgear while keeping the existing process equipment in continuous operation.
- The existing switchgear must be maintained energized, while new switchgear is installed and the load cable feeders become relocated from the old to the new switchgear.
- The main electrical room shall have space for the layout of the new 5 kV generator's breakers located adjacent to the main 5 kV switchgear.
- The electrical room shall have ample space for required working clearance in front and in back of the 5 kV switchgear, as well driveway clearances for maneuvering equipment for heavy lifting of switchgear breakers and parts.
- Considerations for future plant growth should include cabinet spaces for the additions of future 5 kV circuit breakers.
- Changes in equipment technology and safety regulations for protection of O&M personnel should include additional planning and provisions for ample electrical room space.

The replacement of existing 5 kV switchgear will require larger electrical room than existing and the construction of a separate electrical building will required substantial capital due to the relocation of numerous underground conduits and wiring. Therefore, the analysis of the available real estate around the main electrical building reveals, that the least cost option would be to use the adjacent room space of the existing electric utility transformer vault and construct a separate small building/vault for FPL service transformers.

The proposed 5 kV switchgear layout is shown in Figure 6 and the proposed location for a new FPL transformer vault is shown in Figure 7

5.3 Improvements of 480 volts Equipment at Main Electrical Building

The original configuration of the 480 volts system at the main electrical building include four (4) 500 kVA substations (No.1, No.2, No. 9 and No. 10) with 480 volts switchboards that supply power to two (2) motor control centers (MCCs), previous effluent-deep well pumps and miscellaneous panels for receptacles and lighting. Due to the limited capacity of such 4 original substations, as additional pumps were needed, two additional substations and switchboards (No. 11 and No. 12) were installed to resolve the needed capacity at the time. As a result, the configuration of 6 substations and switchboards has filled the electrical room with multiple small capacity equipment, but no substantial provisions have been included for spare capacity neither convenience for future equipment replacement.

The master planning for the replacement of existing 480 volts equipment shall include a broader perspective, considering less quantity of transformers to be located outdoors and only two 480 volts switchgear(s) that will replace the function of 6 existing switchboards, plus provisions for ample spare capacity and future loads.

The indoor substations/transformers No. 11 and No. 12 located in the maintenance building were recently installed and their condition as of 2014 appears very good and reliable with expected life cycle of additional 25 years. These transformers could supply power to a set of double-ended switchgear scheme with plenty power capacity for the present connected 480 volts loads on the main electrical and administrative building.

If future process loads would require increase capacity of transformers No. 11 and No. 12, then future larger transformers could be installed outside of the main electrical building.

The proposed scheme of the 480 volts switchgear in the main electrical building is shown on the one line diagram in Figure 5 and the respective electrical room layout is shown on Figure 6.

5.4 Replace Indoor Substations with Outdoor Pad Mounted Transformers

Most of the existing indoor 5 kV to 480 V substations transformers consist of three key components: a 5 kV fusible switch, a 500 kVA dry type transformer, and a 480 V – 1200 Amperes switchboard. The advantages of indoor power transformers are the protection from humidity, corrosion, and nature events like hurricanes.

GENERATOR
No. 2

GENERATOR
No. 1

480 VOLTS ROOM

PROPOSED
OPTIONAL MCCs

SEPARATE
GENERATORS AND
SWITCHGEAR LOW
VOLTAGE
CONTROLS

SWITCHBOARD
12

SWITCHBOARD
11

POSIBLE LOCATION
OF MCCs OR VFDs

VFD
TRANSFER
PUMP No 1
100 HP

VFD
TRANSFER
PUMP No 2
100 HP

VFD
TRANSFER
PUMP No 3
100 HP

MAIN
5KV SWITCHGEAR
ROOM
(EXTENSION)

CLEAR ACCESS WAY

5'-0"

10'-6"

CLEAR ACCESS WAY

MCC E1

MAIN
5KV SWITCHGEAR
ROOM

PROPOSED 5 Kv
SWITCHGEAR

MCC E2

PHASE II
WORK

OVERHEAD
BUSWAY

PHASE I
WORK

PROPOSED 5 Kv
SWITCHGEAR

MAIN 2
LOAD BREAKERS
LOAD BREAKERS
LOAD BREAKERS
LOAD BREAKERS
TIE 2
TRANSITION

TRANSITION
GEN No. 2
GEN No. 1
TRANSITION
TIE 1
LOAD BREAKERS
LOAD BREAKERS
LOAD BREAKERS
LOAD BREAKERS
MAIN 1

MAINTENANCE SHOP

(RESERVED SPACE FOR
FUTURE SWBD.)

5kV SWITCHES
No. 11

SUBSTATION
No. 11

480V
BRK.

480V
BRK.

SUBSTATION
No. 12

5kV SWITCHES
No. 12

GENERAL MASTER PLANNING OBJECTIVES

1. ELECTRICAL EQUIPMENT ROOMS WITH AIR CONDITIONING.
2. CONSIDER ARC FLASH RESISTANT 5KV SWITCHGEAR.
3. ELECTRICAL ROOMS WITH AMPLE SPACE FOR EQUIPMENT REPLACEMENT AND MAINTAINING WRF PROCESS IN CONTINUOUS OPERATION.
4. OUTDOOR 5KV/480V TRANSFORMERS (EXCEPT RE-USE OF EXISTING INDOOR UNITS)

NORTH

0 2' 4' 8'

FIGURE No. 6
MAIN ELECTRICAL BUILDING
PROPOSED EQUIPMENT LAYOUT

MANATEE COUNTY - SWWRF
ELECTRICAL MASTER PLAN

carollo

FIGURE No. 7
PROPOSED FP&L VAULT AND SWITCHGEAR LOCATION

MANATEE COUNTY - SWWRF
ELECTRICAL MASTER PLAN

carollo

However, the disadvantages are higher replacement cost, considerable space requirements in electrical rooms and exhaustion of heat losses into the room that result in higher capital and operating facility costs due to the need for air conditioning equipment and other temperature sensitive equipment in the room.

In today's market for outdoor transformers, the corrosion issues can be prevented with stainless steel enclosures and manufactured with thick metal resistant to high wind loadings. Therefore, the replacement of power transformers should consider the option to locate transformers outdoors and utilize the electrical rooms space for location of temperature and humidity sensitive equipment with provisions of air conditioning.

The planning for the replacement of existing substations throughout the plant shall consider less quantity of indoor transformers to be replaced with units located outdoors.

The proposed scheme of the multiple 480 volts systems is shown on the power one line diagram in Figure 5.

5.5 Proposed Location of Major 5 kV to 480 Volts Substations

The master planning for the location of new substations should not be based on replacing existing equipment at their present location. The quantity and location of the transformers shall be based on the power demand and pertinent location of major process equipment throughout the SWWRF. Additional review of the major process loads location reveals the following:

- The aeration blowers loads represent the largest power demand equipment and these loads will continue being supplied by the 5 kV motor control centers located at the Northeast side of the plant. Therefore, these 5 kV loads are independent of 480 volts.
- A set of two backup 300 HP aeration blowers will be installed as part of the project for nitrogen removal .The project will add two (2) 1,000 kVA transformers and 480 V MCC for the blowers and (2) 500 kVA transformers and 480 V MCC for power to the anoxic basins (converted primary clarifiers). The future master planning for the replacement of such equipment should consider only two (2) transformers with sufficient capacity for both the 480 volts aeration blowers and the anoxic basins, including the loads of the nearby headworks.
- The 480 volts effluent pumps for the County's Master Reuse System represent the second largest power demand and it is supplied by two (2) 2000 kVA substations Nos. 13 and 14 that were recently installed.
- The process 480 volts loads for the secondary clarifiers, RAS pumps, the effluent transfer pumps, the disinfection equipment, and the loads in the electrical building and control building could be supplied with two (2) transformers in lieu of 6 units.

- The sludge holding tanks and dewatering treatment process is located in a separate area, where power can be supplied with only two (2) transformers in lieu of 4 existing units.

5.6 Replacement of Power Feeders and Branch Wiring

The replacement of major 5 kV and 480 volts switchgear, substations-transformers and motor control centers would require the replacement of most field wiring interconnected with the equipment, because most of the wiring is over 25 years old and the condition of the wire insulation is decaying with time. An estimated opinion of construction cost for replacement of field wiring is included in each of the recommended items in section 6.0

5.7 Requirements for Temporary Power during Equipment Replacement.

The future electrical designs for implementing the replacement of existing electrical equipment shall include reliable schemes for temporary power and clear resolutions for construction phasing and constraints, in order to maintain continuous power for process equipment. An estimated opinion of construction cost for temporary wiring is included in each of the recommended items in section 6.0

5.8 Recommended Power Monitoring and Protection System.

The functionality of the electrical power system is essential for reliability of the SWWRF treatment process and high service pumping, so the new 5 kV and 480 V equipment should include state of the art features in power quality meters, protective devices for transient voltage surges caused by lightning, and electronic relays for the fast tripping of circuit breakers due to possible short circuits or overloads. The design of the new 5 kV and 480 V equipment should be interconnected with the existing facility SCADA system, for SWWRF operation staff to continuously monitor normal status and/or any alarm conditions.

Most of the modern electronic power meters and protective relays include communication features such as “Ethernet protocol” that would easily communicate and transfer electrical system data to the SCADA system via the existing process logic controllers (PLCs).

6.0 SUMMARY OF FINDINGS AND RECOMMENDATIONS WITH OPINIONS OF PROBABLE CONSTRUCTION COST

The summary of recommendations and the included opinion of cost can be used as a basis for capital improvement projects (CIP) budget projections and scoping of work to design and construct the vital improvements in separate construction phases.

The assessment of the existing 5 kV switchgear, 5 kV generators, substation 5 kV switches, indoor 5 kV to 480 volt transformers and 480 volt motor control centers revealed that:

- Most of the existing equipment installed since 1988 is reaching the end of its useful duty cycle
- Numerous pieces of electrical equipment are obsolete due to progressive changes in electrical technology and/or lack of spare parts,
- The older electrical equipment is deteriorating because it is located in electrical rooms without air conditioning, with ventilation from humid environment and some electrical rooms like adjacent to the headworks structure is exposed to a corrosive environment with hydrogen sulfide gas..
- The 5 kV switchgear layout in the main electrical room does not have enough room space for the layout of new larger switchgear, while 5 kV equipment shall be continuously energized for keeping the plant in operation. Therefore, it will be necessary to increase the size of the electrical room.
- The quantity of 5kV/480 V substation transformer have increased to a total quantity of 20 units over 25 years, because the original design did not include spare capacity in transformers and 480 volts switchboards, for supplying power to additional process loads. The maintenance of such large quantity of substation transformers represents substantial operating cost and may require significant capital for asset replacement.
- Most of the electrical equipment that is over 25 years old should be replaced within 5 to 10 years (between 2014 through 2024), for assurance to maintain a reliable and safe power distribution system.

The recommendations for an upgrade of the power distribution system, from a master planning perspective, are summarized as follows:

6.1 Add Air Conditioning to Main Electrical Rooms

The addition of air conditions in key electrical rooms has been included with the list of short term improvements, in section 4.0, paragraph 4.1

These improvements should be implemented in three key electrical rooms: the two (2) rooms located adjacent to the generator room and the FPL vault; and the room located adjacent to the maintenance building. The recommended improvements should be constructed within two years or by 2016, and the planning level cost estimate is $203,018, as shown in Table 3.

Table 3	Probable Construction Cost - Air Conditioning for Main Electrical Rooms Southwest Water Reclamation Facility Electrical Master Plan Manatee County Utilities	
No.	**Description**	**Total**
1	Remove existing wall louvers for ventilation	$5,000
2	New insulation ceilings and walls	$15,000
3	New insulated doors	$15,000
4	Air condition equipment & ductwork for three electrical rooms	$60,000
5	Acoustic panels or improvements in ceiling insulation	$12,000
6	Wiring and conduits	$6,000
7	Subcontractor Field and Project Management	$7,000
	TOTAL DIRECT COST	**$120,000**
	Contingency (25%)	$30,000
	Subtotal	**$150,000**
	General Conditions(1) (10%)	$15,000
	Subtotal	**$165,000**
	Contractor Overhead, Profit & Risk (±15%)	$25,000
	Subtotal	**$190,000**
	Sales Tax (2) (±6%)	$4,000
	SUBTOTAL PROJECT COST	**$194,000**
	Owner's Reserve for Change Orders (5%)	$10,000
	TOTAL PROJECT COST	**$204,000**

Notes:
(1) Includes bonds, mobilization, insurance
(2) Based on 50% of Total Direct Cost

6.2 Intercept 5 kV Feeders at Headworks and Extend to New Transformers for the Anoxic Basins

The interception of the underground 5 kV feeders outside of the headworks structure has been included with the list of short term improvements, in above section 3.0, paragraph 3.2, because the existing indoor 5 kV substation transformers Nos. 3 and 4, and MCCs HW-1 and HW-2 are in poor and decaying condition due to excessive corrosion.

The schedule for the subject improvements should be coordinated with the new headworks structure that is scheduled for construction in 2018. The planning level cost estimate is $221,000 as shown in Table 4.

6.3 Add Separate Underground 5 kV Feeders for Aeration Blowers

The addition of the separate underground 5 kV feeders for the northeast aeration blower building has been included with the list of short term improvements, in above section 4.0, paragraph 4.3.

Table 4	Probable Construction Cost - Intercept 5 kV Feeders for Anoxic Basins Southwest Water Reclamation Facility Electrical Master Plan Manatee County Utilities	
No.	**Description**	**Total**
1	Intercept existing 5: Electrical Underground Ducts and Cables	$15,000
2	Conflicts with Mechanical, Excavation & Shoring; Forms for Manhole	$15,000
3	New cast in place 7'x7'x 6.6" manhole; Backfill and Patch for Underground Work	$15,000
4	Trench and PVC conduit, ductbank work	$25,000
5	Extend conduits and cables to transformers No. 3A and 4A (for Anoxic Basins)	$20,000
6	5 kV – 3# 500 KCM – Type MV-105 Cables & Terminations	$30,000
7	Electrical Subcontractor Field and Project Management	$10,000
8	Supply power from Anoxic Basins Electric Building to headworks and Clarifiers No. 3 – No. 4 would be included in future headworks structure	N/A
	TOTAL DIRECT COST	**$130,000**
	Contingency (25%)	$33,000
	Subtotal	**$163,000**
	General Conditions (1) (±10%)	$16,000
	Subtotal	**$179,000**
	Contractor Overhead, Profit & Risk (±15%)	$27,000
	Subtotal	**$206,000**
	Sales Tax (2) (±6%)	$4,000
	SUBTOTAL PROJECT COST	**$210,000**
	Owner's Reserve for Change Orders (5%)	$11,000
	TOTAL PROJECT COST	**$221,000**

Notes:
(1) Includes bonds, mobilization, insurance
(2) Based on 50% of Total Direct Cost

The proposed 5 kV feeders should be routed towards the northeast part of the facility via additional underground electrical ductbanks and manholes.

The schedule for the subject improvements should be as soon as possible or within 4 years or by 2018 and the planning level cost estimate is $377,000, as shown in Table 5.

Table 5 Probable Construction Cost - Separate 5 kV Feeder for Aeration Blowers Southwest Water Reclamation Facility Electrical Master Plan Manatee County Utilities		
No.	**Description**	**Total**
1	Add 4" exposed conduits from 5 kV main switchgear to outside manholes	$25,000
2	Conflicts with Mechanical, Excavation & Shoring; Forms for Manholes	$30,000
3	Three precast 6'x7'x 6.6" manholes; Backfill and Patch for Underground Work	$45,000
4	Trench and PVC conduit, ductbank work	$55,000
5	Add 4" exposed conduits to exist 5 kV motor control center	$20,000
6	5 kV – 3# 250 KCM – Type MV-105 cables & terminations	$32,000
7	Disconnect and remove cables between north and south aeration buildings.	$5,000
8	Electrical Subcontractor Field and Project Management	$10,000
	TOTAL DIRECT COST	**$222,000**
	Contingency 25%	$56,000
	Subtotal	**$278,000**
	General Conditions (1) (±10%)	$28,000
	Subtotal	**$306,000**
	Contractor Overhead, Profit & Risk (±15%)	$46,000
	Subtotal	**$352,000**
	Sales Tax (2) (±6%)	$7,000
	SUBTOTAL PROJECT COST	**$359,000**
	Owner's Reserve for Change Orders 5%	$18,000
	TOTAL PROJECT COST	**$377,000**

Notes:
(1) Includes bonds, mobilization, insurance
(2) Based on 50% of Total Direct Cost

6.4 Remove Substation Nos. 5 and. 6 and Replace MCCs B1-B4 in Electrical Rooms for Aeration Blowers and DAFT System

The existing indoor 5 kV substation transformers No. 5 and No. 6 and related MCCs B1 through B4 contain very few electrical loads since much of the load was eliminated when the aeration blowers (AB-1 through AB-5) were constructed in the 1998 expansion. Therefore, the subject equipment and their large electrical capacity are not justifiable for the remaining connected load.

The indoor 5 kV substation transformers No. 5 and No. 6 could be removed and the source power obtained from the anticipated new outdoor transformers that will be installed as part of the SWWRF Nitrogen Removal project, for the 480 V supply power to new MCCs B1 and B2.

The schedule for the subject improvements could be flexible, perhaps within 5 years or by 2019 and the planning level cost estimate is $522, 000, as shown in Table 6.

Table 6	Probable Construction Cost - Remove Substations Nos. 5 & 6 and Replace MCC's B1 - B4 Southwest Water Reclamation Facility Electrical Master Plan Manatee County Utilities	
No.	**Description**	**Total**
1	Temporary power to keep existing compressors equipment in operation	$15,000
2	Remove substations No. 5. No. 6 and MCCs B1-B4	$10,000
3	Conduit work and supports	$55,000
4	480 Volt cable work	$30,000
5	New MCCs B1 and B2 (replace 4 MCCs B1-B4)	$80,000
6	New conductors from new MCCs to existing loads	$12,000
7	Installation and testing of electrical equipment	$20,000
8	Interconnection new MCCs to transformers (Part of Nitrogen Rem. Project)	$25,000
9	New insulated doors, insulate walls and ceiling	$15,000
10	Air conditioning in electrical rooms	$30.000
11	Electrical Subcontractor Field and Project Management	$15,000
	TOTAL DIRECT COST	**$307,000**
	Contingency (25%)	$77,000
	Subtotal	**$384,000**
	General Conditions (1) (±10%)	$39,000
	Subtotal	**$423,000**
	Contractor Overhead, Profit & Risk (±15%)	$64,000
	Subtotal	**$487,000**
	Sales Tax (2) (±6%)	$10,000
	SUBTOTAL PROJECT COST	**$497,000**
	Owner's Reserve for Change Orders (5%)	$25,000
	TOTAL PROJECT COST	**$522,000**

Notes:
(1) Includes bonds, mobilization, insurance
(2) Based on 50% of Total Direct Cost

6.5 Replace Substation Nos. 7 and 8 and MCCs DW1, DW2, D1 and D2 in Digesters and Dewatering Process Area

The existing indoor 5 kV substation transformers Nos. 7 and 8 and related MCCs DW1, DW2, D1, and D2 contain few remaining electrical loads and their transformer capacity is not justified for the remaining connected load, because the new transformers and MCCs included with the aerobic digesters project will supply most of the power in the solids treatment area. Therefore, the 5 kV substation transformers Nos. 7 and 8 could be replaced with new pad mounted outdoor transformers similar to units included with the anaerobic digester conversion project, for the supply of 480 V power to new MCCs DW-1 and DW2 in the dewatering area and new smaller MCCs D1 and D2 on the second floor of the digester control building.

The new MCCs DW-1 and DW-2 will maintain their current function, and will include additional capacity to supply power for the maintenance building and the new MCCs D1 and D2.

The schedule for the subject improvements could be flexible, perhaps within 5 years or by 2019 and the planning level cost estimate is $785,000, as shown in Table 7.

6.6 Remove Substation Nos.1 and 2 and Related 480 V Switchboards

The existing indoor 5 kV substation transformers Nos. 1 and 2 located in the engine-generator room supply power to critical loads for switchgear control power and loads in the administration building. The location of the substation transformers, the related switchboards, and Generator No. 1 could affect each other during a major electromechanical engine or substation fire incident.

Upon relocation of the existing effluent pumps to the new high service pumping station, substation transformers No. 1 and No. 2 could be removed. Their electrical loads could be connected to spare circuit breakers in existing switchboards No. 11 and No. 12, because these switchboards would have spare capacity upon construction completion of the high service pumping station, or the loads from removed substation No. 1 and No. 2 could be connected to a new switchgear No. 11 and No. 12 as proposed in paragraph 6.8

The schedule for the removal of substation No. 1 and No. 2 could be flexible, perhaps within 2 to 4 years or by 2018 and the planning level cost estimate is $548, 000, as shown in Table 8. This estimated cost includes replacement of MCCs E1 and E2 and miscellaneous lighting panelboards in the main electrical room. However, replacement of this equipment is not urgent and it could be done at a later date, if air conditioning is added within 1 or 2 years to the main electrical rooms.

6.7 Remove Substation Nos. 9 and 10 and Related 480 V Switchboards

Upon relocation of the existing effluent pumps to the new high service pumping station, there will be no remaining loads connected to substation transformers No. 9 and No. 10 therefore; they could be removed from their indoor location. Another option to reuse switchboards Nos. 9 and 10 could be for power to the 480 V MCCs Nos. E-1 and E-2 located in the main switchgear electrical room.

The schedule for these proposed modifications could be flexible, perhaps within 5 years or by 2019 and the planning level cost estimate is $61,000, as shown in Table 9.

Table 7	Probable Construction Cost - Replace Substations No. 7 & 8 and MCCs DW1, DW2, D1 & D2, Southwest Water Reclamation Facility Electrical Master Plan Manatee County Utilities	
No.	**Description**	**Total**
1	Temporary power to keep existing process equipment in operation	$15,000
2	Remove substations No. 7 and No. 8 and MCCs D1–D2 and DW1-DW2	$20,000
3	Underground and exposed conduit work and supports	$35,000
4	480 Volt cable work	$40,000
5	New MCCs DW1, DW2, D1 and D2 (replace 4 MCCs)	$110,000
6	Two new 5kV/480V Pad mounted transformers & switches	$100,000
7	New Conductors from new MCCs to existing loads	$18,000
8	Installation and testing of electrical equipment	$40,000
9	Interconnect new MCCs to outdoor transformers	$25,000
10	New insulated doors, insulate walls and ceiling	$15,000
11	Air conditioning in electrical rooms	$20,000
12	Electrical Subcontractor Field and Project Management	$25,000
	TOTAL DIRECT COST	**$463,000**
	Contingency (25%)	$116,000
	Subtotal	**$579,000**
	General Conditions (1) (±10%)	$58,000
	Subtotal	**$637,000**
	Contractor Overhead, Profit & Risk (±15%)	$96,000
	Subtotal	**$733,000**
	Sales Tax (2) (±6%)	$14,000
	SUBTOTAL PROJECT COST	**$747,000**
	Owner's Reserve for Change Orders (5%)	$38,000
	TOTAL PROJECT COST	**$785,000**

Notes:
(1) Includes bonds, mobilization, insurance
(2) Based on 50% of Total Direct Cost

Table 8	Probable Construction Cost - Remove Substations Nos. 1 & 2 and Replace MCCs E-1 & E-2 Southwest Water Reclamation Facility Electrical Master Plan Manatee County Utilities	
No.	**Description**	**Total**
1	Temporary power to keep existing process equipment in operation	$20,000
2	Remove substations No. 1 and No. 2 and MCCs E-1 and E-2	$10,000
3	Overhead conduit work and supports	$40,000
4	480 Volt power cable and control wiring	$35,000
5	New MCCs E-1 and E-2	$80,000
6	New Conductors from new MCCs to existing loads	$50,000
7	Installation and testing of electrical equipment	$40,000
8	Interconnection – New MCCs to new switchgear No. 11 & No. 12	$15,000
9	New panelboards for instruments and lighting	$18,000
10	Electrical Subcontractor Field and Project Management	$15,000
	TOTAL DIRECT COST	**$323,000**
	Contingency (25%)	$81,000
	Subtotal	**$404,000**
	General Conditions (1) (±10%)	$41,000
	Subtotal	**$445,000**
	Contractor Overhead, Profit & Risk (±15%)	$67,000
	Subtotal	**$512,000**
	Sales Tax (2) (±6%)	$10,000
	SUBTOTAL PROJECT COST	**$522,000**
	Owner's Reserve for Change Orders (5%)	$26,000
	TOTAL PROJECT COST	**$548,000**

Notes:
(1) Includes bonds, mobilization, insurance
(2) Based on 50% of Total Direct Cost

Table 9	Probable Construction Cost - Remove Substations Nos. 9 & 10 Southwest Water Reclamation Facility Electrical Master Plan Manatee County Utilities	
No.	**Description**	**Total**
1	Remove substations No. 9, No. 10 and associated conduit & wiring	$20,000
2	Patch floor's finish	$10,000
3	Electrical Subcontractor Field and Project Management	$5,000
	TOTAL DIRECT COST	**$35,000**
	Contingency (25%)	$9,000
	Subtotal	**$44,000**
	General Conditions (1) (±10%)	$5,000
	Subtotal	**$49,000**
	Contractor Overhead, Profit & Risk (±15%)	$8,000
	Subtotal	**$57,000**
	Sales Tax (2) (±6%)	$1,000
	SUBTOTAL PROJECT COST	**$58,000**
	Owner's Reserve for Change Orders (5%)	$3,000
	TOTAL PROJECT COST	**$61,000**

Notes:
(1) Includes bonds, mobilization, insurance
(2) Based on 50% of Total Direct Cost

6.8 New 480 V Switchgear for Replacement of Switchboards No 1, 2, 9,10,11 and 12.

The existing switchboards No. 9 - No. 10, and No. 11 - No. 12 and two 5 kV breakers for the generators occupy a large portion of the floor space in the existing 480 volts main room., but the individual equipment does not have ample spare capacity for future loads.

The replacement of the existing NEMA type switchboards is recommended using a higher grade equipment such as ANSI switchgear.

The schedule for the replacement of existing switchboards could be flexible, perhaps within 4 to 5 years or by 2019 and the planning level cost estimate is $906,000, as shown in Table 10.

6.9 Replace Existing Main 5 kV Switchgear and Improve Main Electrical Room Adjacent to FPL Vault

The main 5 kV switchgear is the most important electrical asset in the SWWRF because it receives input power from the electric utility (FPL) and/or from the standby power generators, and supplies output power to the remote substations-transformers. This switchgear has been in service for 26 years and is reaching the end of practical, reliable condition; therefore, judicious planning for its replacement is recommended.

Table 10 Probable Construction Cost – Replace Switchboards Nos. 11 & 12 Southwest Water Reclamation Facility Electrical Master Plan Manatee County Utilities

No.	Description	Total
1	Temporary power to keep existing process equipment in operation	$20,000
2	Remove switchboards No. 11 and No.12	$20,000
3	Overhead conduit work and supports	$45,000
4	480 Volt power cable and control wiring	$45,000
5	New 480V (ANSI) Switchgears No. 11 & No. 12	$300,000
6	New Conductors from new Switchgear to existing loads	$45,000
7	Installation and testing of electrical equipment	$45,000
8	Electrical Subcontractor Field and Project Management	$15,000
	TOTAL DIRECT COST	**$535,000**
	Contingency (25%)	$134,000
	Subtotal	**$669,000**
	General Conditions (1) (±10%)	$67,000
	Subtotal	**$736,000**
	Contractor Overhead, Profit & Risk (±15%)	$111,000
	Subtotal	**$847,000**
	Sales Tax (2) (±6%)	$16,000
	SUBTOTAL PROJECT COST	**$863,000**
	Owner's Reserve for Change Orders (5%)	$43,000
	TOTAL PROJECT COST	**$906,000**

Notes:
(1) Includes bonds, mobilization, insurance
(2) Based on 50% of Total Direct Cost

If air conditioning is added to the electrical room and electrical tests performed for assurance to improve any component, then the switchgear might be reliable to continue on duty for another 5 to 10 years, while capital budget is allocated for its replacement.

The existing main electrical room has limited space for installation of new 5 kV switchgear, while the existing 5 kV equipment is in service. The assembly of joining together multiple cabinet sections of the entire switchgear must be done in the field, because there is no ample room access for transporting heavy equipment in the room. Consequently, detailed design including work sequencing and careful planning would require for assurance of minimal errors during construction. Additionally, the installation of new 5 kV switchgear and new control panels will require provisions for temporary power equipment and rental of standby power generators during the transitions of removing old switchgear equipment and connecting new equipment.

The schedule for these proposed improvements could be flexible, perhaps within 5 to 10 years or ideally by 2019 and the planning level cost estimate is $3,013,000, as shown in Table 11.

6.10 Replace Existing 5 kV Switchgear for Synchronizing Standby Power Generators and Provisions of Separate Control Panels

The 5 kV switchgear, which includes the breakers for synchronizing of the two generators, supplies generator output power to the main 5 kV switchgear during failures of FPL utility power. This equipment appeared to be in fair condition however, the characteristics of the equipment should be improved and replaced at the same time as the main 5 kV switchgear; therefore, judicious planning for its replacement is in order. If air conditioning is added to the electrical room and electrical tests performed for assurance to improve any component, then this switchgear could be reliable for another 5 years. This would allow additional time for capital budget to be allocated for its replacement with the main 5 kV switchgear.

Additionally, the installation of generator's 5 kV switchgear and new control panels may require provisions for temporary rental of standby power generators during the transitions of removing old switchgear equipment and connecting new equipment.

The schedule for these proposed improvements could be flexible, perhaps within 5 to 10 years or ideally by 2019 and the planning level cost Estimate is $813,000, as shown in Table 12.

Table 11	Probable Construction Cost - Replace Main 5 kV Switchgear Southwest Water Reclamation Facility Electrical Master Plan Manatee County Utilities	
No.	**Description**	**Total**
1	Temporary power to keep existing process equipment in operation	$100,000
2	Remove half of existing 5kV switchgear in two phases	$30,000
3	Overhead conduit work and supports	$75,000
4	5kV - #350 KCM & #500 KCM Type MV-105 cables & terminations	$125,000
5	5kV switchgear	$950,000
6	Installation and testing of electrical equipment	$150,000
7	Provisions for construction sequencing and constraints	$50,000
8	Interconnection – new switchgear to existing loads(1)	$250,000
9	Electrical Subcontractor Field and Project Management	$50,000
	TOTAL DIRECT COST	**$1,780,000**
	Contingency (25%)	$445,000
	Subtotal	**$2225,000**
	General Conditions (2) (±10%)	$223,000
	Subtotal	**$2,448,000**
	Contractor Overhead, Profit & Risk (±15%)	$367,000
	Subtotal	**$2,815,000**
	Sales Tax (3) (±6%)	$54,000
	SUBTOTAL PROJECT COST	**$2,869,000**
	Owner's Reserve for Change Orders (5%)	$144,000
	TOTAL PROJECT COST	**$3,013,000**

Notes:
(1) Cost for replacement of generator's breakers & controls in separate table.
(2) Includes bonds, mobilization, insurance
(3) Based on 50% of Total Direct Cost

Table 12 Probable Construction Cost - Replace 5 kV Generator Breakers/Controls Southwest Water Reclamation Facility Electrical Master Plan Manatee County Utilities		
No.	**Description**	**Total**
1	Rent temporary generator for standby power	$50,000
2	Remove existing 5kV switchgear for generators	$10,000
3	Overhead conduit work and supports	$20,000
4	5kV - #500 KCM Type MV-105 cables & terminations	$30,000
5	5kV switchgear for synchronizing generators	$200,000
6	Separate low voltage control panels	$100,000
7	Installation and testing of electrical equipment	$20,000
8	Interconnection – New generator switchgear to new 5kV main switchgear	$25,000
9	Electrical Subcontractor Field and Project Management	$25,000
	TOTAL DIRECT COST	**$480,000**
	Contingency (25%)	$120,000
	Subtotal	**$600,000**
	General Conditions (1) (±10%)	$60,000
	Subtotal	**$660,000**
	Contractor Overhead, Profit & Risk (±15%)	$99,000
	Subtotal	**$759,000**
	Sales Tax (2) (±6%)	$15,000
	SUBTOTAL PROJECT COST	**$774,000**
	Owner's Reserve for Change Orders (5%)	$39,000
	TOTAL PROJECT COST	**$813,000**

Notes:
(1) Includes bonds, mobilization, insurance
(2) Based on 50% of Total Direct Cost

6.11 Other Improvements: Existing 480/208 V Miscellaneous Panels

In depth analysis and assessment of the existing miscellaneous equipment, such as 480 V transformers that step the voltage down to 120 V and miscellaneous panelboards that supply control power to instruments and lighting, was not included in the scope of the electrical master plan. However, suggestions are offered as an opinion of cost for the future replacement of panels in the maintenance building and the operations/control building and for allocation of capital budget.

The schedule for the above proposed improvements could be flexible, perhaps within 10 years or by 2024 and the planning level cost estimate is $200,000.

Note: a partial cost for replacement of low voltage control panels in the main electrical room has been included in Table 8.

6.12 Replacement of Standby Diesel-Engine Generator No. 2

The standby power generator No. 2 is the older generator at SWWRF. It was installed during the last major upgrade and expansion of the facility in 1988, which means it has been on duty for over 25 years, although the total run hours is very low and from a mechanical perspective the engine could last many more years. The change in federal regulations for engine exhaust gas emissions will eventually require the replacement of this unit and changes in engine technology will decrease the availability of future spare parts.

The schedule for replacing the generator could be flexible, perhaps within 5 to 8 years or ideally by 2019 and the planning level cost estimate is $1,300,000.

6.13 Periodic Maintenance Improvements

The electrical equipment requires periodic inspections and testing for verification of adequate insulation condition and assurance that conductive parts and bolted connections have not decayed due to possible overheating or corrosion. This periodic maintenance requires the momentary shutdown of energized equipment and use of sophisticated testing equipment.

The professional service of specialty testing companies is required and represents a periodic operating expense, as part of the plant budget for operation and maintenance. Therefore, a respective allowance in operating budget is recommended for periodic testing of electrical equipment.

6.14 Approach for Opinions of Probable Construction Cost

The generation of the construction cost opinions is based primarily upon Carollo's experience and judgment as a professional consultant. Since Carollo has no control over such factors as weather, cost and availability of labor, material and equipment, labor productivity, contractor's procedures and methods, competitive bidding, market conditions or other factors affecting such opinions or projections, Carollo does not guarantee that the actual rates, costs, etc. will not vary for the opinions and projections developed herein.

The conceptual cost estimates were developed to fulfill the need for a quick method of determining an approximate probable cost of a project without the benefit of detailed scope definition or any engineering design. These types of estimates fit the AACEI description of "Order-of-Magnitude" (Class 5) estimates. Since conceptual estimates are based on limited information, they are subject to considerable variation. Their accuracy depends on the amount and quality of the information available at the time of the estimate.

The approach for estimating the opinion of probable cost for future construction is based on the following criteria:

1. The cost estimating process did not include quantity take-off of materials, site plans or account for project constraints.
2. Equipment cost is a budget amount of typical list prices published by manufacturers.

3. Labor for installation cost is based on a multiplier comparable to the equipment cost.
4. Add-on costs for general conditions such as construction management, mobilization, temporary storage, and incidental work is included as a percentage of the basic construction.
5. A contingency of 25 percent was included based on the planning level nature of the estimates.

Tables 3 - 12 include the major elements of the construction cost associated with the proposed master planning for the replacement of the 5 kV equipment and 480 V equipment.

7.0 SUPPLEMENTAL CRITERIA FOR ELECTRICAL UPGRADES

The provisions of electrical standards and guidelines, for design and major upgrades or replacement of the key power distribution equipment to the water reclamation facilities is beyond the scope of the subject electrical master plan.

Nevertheless, the basic approach and criteria for upgrading the existing power distribution system should be based upon the experience of plant personnel from all water reclamation facilities in the County Water Utilities Department, a requirement for safety by design, simple maintenance procedures and minimum inventory of spare parts. The minimum criteria for upgrades might be based on the following guidelines:

Use state of the art features in technology for power distribution in the wastewater treatment industry, as a guideline for consistency of standards to follow during future designs, to provide safe and reliable functionality, and also to increase safety, operability, redundancy, and ultimately, increase value and minimize capital for construction and future maintenance.

Flexibility and electrical rooms space for future additions to the SWWRF should be considered from a process perspective, as an allowance for load growth within the electrical power system.

- All electrical rooms shall have ample dedicated space for required equipment; adequate clearances required by code; large doors for access of machinery and transporting heavy parts or equipment sections; air conditioning equipment for the electrical room shall not interfere with clearances for electrical equipment; room space shall not be used for storage of non-electrical items.
- Rooms for electrical equipment shall not be located adjacent to buildings or structures with presence of hydrogen sulfites and other corrosive gases, such as no electrical room at headworks structure, biosolids dewatering or drying process. If the electrical rooms are near or adjacent to such structures, then there shall not be access doors or ventilation openings that allow entry of corrosive gases or humidity.
- Follow the EPA Class 1 reliability criteria for design, including the distribution of process equipment loads in separate power sources, that facilitate maintenance with de-energize equipment.

- Follow the NFPA-820 guideline, Standard for Fire Protection in Wastewater Treatment and Collection Facilities

- Include Safety by Design for 5 kV switchgear and 480 V equipment, to facilitate maintenance with de-energize equipment. Provide control features considering minimum arc flash risk for personnel during operations and/or maintenance.

- Include separate low voltage controls for medium voltage equipment, to minimize the risk of arc flash for operating personnel

- Specify circuit breakers with manual selector switch for setting instantaneous trip of the breaker during momentary system maintenance and reducing incident energy levels, thus allowing reduced levels of PPE to be used, offering an improvement to worker comfort and mobility.

- Preferable specify 480 volt switchgear with power breakers, manufactured per ANSI C37 standard and UL 1558 standard, because it withstand a 30 cycle short circuit, in lieu of switchboards that only include a 3 cycle withstand rating, for the supply of power to downstream MCCs.

- Specify outdoor type pad mounted transformers with less flammable insulating fluid, with capacity rating for 55 degrees Celsius, and enclosures made of 316 stainless steel with a powder coated green finish. Also, specify primary selector switches for transformers that would allow redundant source of input power to the transformer.

- Do not install large power transformers indoors, to avoid their heat exhaust into electrical rooms and for reducing energy cost of air conditioning.

- Specify MCCs with separate cabinet for the MCC main circuit breaker, not with common open bus to adjacent MCC sections, to avoid propagation of arc flash into entire MCC lineup. Also, main circuit breaker should include RELT controls switch on the trip unit, for reducing incident let through energy during maintenance, in order to assure very low level of arc flash category at the MCC equipment.

- Specify transient voltage surge suppression for all power distribution equipment, including switchgear, switchboards, MCCs, and panelboards.

- Underground manholes need ample space for working clearances. The minimum dimensions for electrical manholes for conductors up to 480 V should be 6 ft x 6 ft x 6.5 ft or larger depending on the size and quantity of power cables. All cables shall be supported on cable racks with ample clearance for cable pulling or replacement.

- The minimum dimensions for electrical manholes with 5 kV conductors should be 6 ft x 7 ft x 6.5 ft or larger depending on the size and quantity of power cables. All cables shall be supported on cable racks with ample clearance for cable pulling or replacement.

- Medium voltage cables for 5 kV applications need a higher voltage rating of at least 8 kV at 133% insulation.
- All indoor electrical equipment needs to be placed in air-conditioned space to prevent corrosion due to humidity in Florida and the corrosive environment at the water reclamation facility.
- Enclosures for outdoor and exposed electrical equipment that contains power and/or controls shall be made with 304 stainless steel or aluminum material and white powder coated finish to resist corrosion and reflect sunlight heat.

APPENDIX A – ADDITIONAL FIGURES WITH EQUIPMENT ASSESSMENT (ISSUES) AND RECOMMENDATIONS

The condition assessment of each electrical equipment item and the pertinent recommendations are shown on the following pages:

Issues with Existing 5kV Main Switchgear

- Near the End of its Useful Life after 26 years on Duty.
- Manufacturer May Discontinue Spare Parts for Protective Relays.
- High Incident Energy and Arc Flash Risk for Personnel, If Necessary to Troubleshoot with Open Front Panels.

Engineer Recommendation:

- Add A/C to Electrical Room to Extend Equipment Life
- Add Operating Procedures & De-energize Half Section if Front Covers are Opened
- Replace in 5 to 10 years
- Future Separate Low Voltage Controls for Personnel Safety
- Frequent Periodic Testing for Assurance of Reliability

Issues: Interconnection w/ 5 kV Breaker for Generators 1 and 2:

- Generator Connection Limited to Left Half Section = Partial Reliability
- Existing Configuration Not Flexible for Replacements. Would Require Careful Planning

Engineer Recommendation:

- Future Replacement Should Include Second Tie Breaker in Mid- Section.
- Interconnect with Generators at Mid-Section Between Tie Breakers.
- Add Metering for SCADA Power Management.

Figure A1
5 kV Switchgear Assessment

Issues with Breaker from Generators 1 and 2 Power and 5kV Switchgear

- 5 KV Breaker for Gen. Power Supplied / Built by ASCO
- 5 kV Switchgear is Square D.
- Controls are interconnected between both products
- Who Provides Maintenance ?

Engineer Recommendation:

- Future New Switchgear shall be from a One Manufacturer for Warranty and Repairs
- Specify Separate Low Voltage Controls from 5 kV Cabinet for Better Personnel Safety

Assessment of 5 kV Breakers and Controls for Generators 1 and 2:

- Overall Condition is Acceptable but Controls Are Limited for Doing Easy Manual Operation During Emergency
- Fire Incident in One Breaker Cell Could Affect or Spread to Adjacent Breaker For Other Generator.
- Failure of Common Controls Would Inhibit Running Both Generators.

Engineer Recommendation:

- Replace at Same Time with 5 kV Main Switchgear.
- Add Third Circuit Breaker to interconnect with Main 5 KV Switchgear (photo above)
- Add A/C to Room to Extend Life Until Capital Budget is Available

Figure A2
Generator's 5 kV Breakers And Controls

Issues with Existing Substations No. 1 & No. 2:

- Near the end of its useful life after 26 years on duty.
- Progressive Corrosion Due to Room Humidity.
- A Major Mechanical or Fire Incident Could Cause Damage Between Substation & Generator No. 1.

Engineer Recommendation:

- Remove Substations No 1 & No 2 and Do Not Replace.
- Use Spare Power Capacity in Substation's No. 9, 10 or No. 11,12 to Supply Power to Loads in MCCs E1 and E2.

Comment About Low Voltage Transformer adjacent to Substation No. 2 (Left Side of photo)

- Condition Appears Fine for its Age.

Engineer Recommendation:

- Transformer and Switch Location May Remain In Generator Room, But Replace Upon Upgrades to Other Low Voltage Equipment.

Figure A3
Substations No. 1 & No. 2 Assessment

Issues with Existing 480V MCC E-1:

- Near the end of its useful life after 26 years on duty.
- May Have High Magnitude of Incident Energy for Arc Flash Due to Non Adjustable Tripping Feature From the Switchboards on Substation No. 1 & No. 2.
- Function Should be for Critical Loads In the Main Electrical Room.
- Less Critical Loads for Outside the room Should be In Separate MCC

Engineer Recommendation:

- Future Replacement Should Include a Separate MCC for Non-Critical Loads.
- Consider Adding Separate MCC in Electrical Room With Switchboards No. 11 & No. 12

Issues with Existing 480V MCC E-2:

- Same Comments Above for MCC E-1

Engineer Recommendation:

- Same Comments Above for MCC E-1

Figure A4
MCC E-1 & MCC E-2 Assessment

Issues with Existing 480V Substations No. 3 & No. 4:

- Near the end of its useful life after 26 years on duty.
- Severe Corrosion Due to Humidity and Headworks H^2S Gases.
- Connected Load is a Small Fraction of Electrical Capacity.

Engineer Recommendation:

- Demolish in its Entirety and Do Not Replace
- Relocate the Input 5 kV Feeders to New Manhole Outside and Extend 5 KV Feeders to Anoxic Basins.

Issues with MCC HW1 & MCC HW2:

- Severe Corrosion Due to Humidity and Headworks H^2S Gases.
- Connected Load is a Small Fraction of Electrical Capacity.
- Most Motor Starters are not being used.

Engineer Recommendation:

- Demolish in its Entirety and Do Not Replace.
- Supply Power to Headworks Equipment and to Secondary Clarifiers No. 3 and No. 4 from Newer MCC at Anoxic Basins Electrical Room.

Figure A5
Substations No. 3 & No. 4 and MCCs HW1 & HW2

Issues with Existing Substations No. 5 & No. 6:

- Near the end of its useful life after 26 years on duty.
- Severe Corrosion Due to Humidity and No A/C in the Room.
- Branch Breakers Do Not Have Adjustable Tripping to Reduce High Incident Energy to MCCs.
- Connected Load is a Small Fraction of Electrical Capacity.

Engineer Recommendation:

- Remove 5 kV Switch & Transformer.
- Replace Switchboards Only and Add Air Conditioning to electrical room space.
- Specify Branch Circuit Breakers With Adjustable Trip Settings.

Issues with MCCs B1 – B4:

- Progressive Corrosion Due to Humidity in the Room.
- Connected Load is a Small Fraction of Electrical Capacity.
- Most Motor Starters are not being used.

Engineer Recommendation:

- Replace 4 MCCs With Only Two MCCs
- Future New MCCs Shall Have Main Circuit Breaker in Separate Cabinet.
- Main Input Breaker Shall Have Adjustable Trip Settings and Instantaneous Tripping Feature

Figure A6
SubstationS No. 5 & No. 6 and MCCs B1 – B4

Comments About Existing 5 kV MCC for Blowers:

- Apparent Condition is Acceptable
- Lack of Arc Flash Labels to Inform Personnel about Category of Incident Energy.
- 5 KV Input Power Cables from other Substations May Be Overloaded

Engineer Recommendation:

- Add Separate 5 KV Input Power Feeders from the Main 5 KV Switchgear, for Assurance of Reliability to Aeration System

Comments About MCC-1 to Power Blower's Valves:

- Power to All Blower's Valves In One Power Source.

Engineer Recommendation:

- Add Second MCC and Distribute Power for Blower's Valves on Separate MCCs

Figure A7
Blowers 5kV MCC & 480V MCC-1 Assessment

Issues with Existing 480V Substations No. 7 & No. 8:

- Near the end of its useful life after 26 years on duty.
- Progressive Corrosion Due to Humidity and H^2S Gases from Dewatering Process.
- Branch Breakers Do Not Have Adjustable Tripping to Reduce High Incident Energy to MCCs.
- Connected Load is a Small Fraction of Electrical Capacity.

Engineer Recommendation:

- Remove 5 kV Switch & Transformer.
- Add Air Conditioning to electrical room space.
- Do Not Have Doors or Openings between the Electrical Room and GBT Dewatering Process.
- Specify Branch Circuit Breakers With Adjustable Trip Settings.

Issues with MCC DW1 & MCC DW2:

- Progressive Corrosion Due to Humidity in the Room.
- Near the end of its useful life after 26 years on duty.

Engineer Recommendation:

- Replace With Larger Capacity MCCs and Get Input Power From New Outdoor Transformers.
- Use New MCCs DW1 & DW2 to Supply Power to Remote MCCs D1 & D2.

Figure A8
SubstationS No. 7 & No. 8 and MCCs DW1 & DW2

Issues with Existing MCC D1 & D2:

- Near the end of its useful life after 26 years on duty.
- Progressive Corrosion Due to Humidity in the Room.
- Connected Load is a Small Fraction of Electrical Capacity.

Engineer Recommendation:

- Replace With Smaller New MCC
- MCC Main Breaker Shall Be in Separate Cabinet with Adjustable Trip Settings
- Add Air Conditioning to Electrical Room Space.

Issues with Existing LRC Drives adjacent to MCCs D1 & D2 :

- Equipment is Disconnected and Not Being Used.

Engineer Recommendation:

- Remove Non-used Equipment.

Figure A9
MCC D1 & MCC D2 Assessment

Issues with Existing 480V Substations No. 9 & No. 10:

- Apparent Condition Looks Fine.
- There will be no Connected Load After Completion of Water Reuse High Service Pumping Project.

Engineer Recommendation:

- Maybe Use to Supply Power to Loads of Substation No. 1 & No. 2, or,
- Remove in its Entirety.

Issues with Deep Well Pumps VFDs:

- High Temperature in the Room due to non A/C.
- VFD Functioning With Open Doors for Ventilation. It Might Be An Arc Flash Hazard to Operating Staff.
- Life of VFD Equipment is Decreasing Due to High Room Temperature.
- VFD Doors Shall Be Closed to Minimize Risk of Arc Flash Hazard to Personnel.

Engineer Recommendation:

- Add A/C to the Room.

Figure A10
Substations No. 9 & No. 10 and D. W. Pumps VFDs

Comments About 5 kV Switches and Substations No. 11 & No. 12:

- Age and Condition of Equipment Is Like New Due to Few Years On Duty
- Progressive Corrosion May Become Apparent Due to Humidity and No A/C in Room

Engineer Recommendation:

- Add Air Conditioning to electrical room space

Comments About 480V Switchboards No. 11 & No. 12:

- Connected Load Would Be a Small Fraction of Electrical Capacity, Upon Completion of Water Reuse High Service Pumping Station Project.
- Progressive Corrosion May Become Apparent Due to Humidity and No A/C in Room

Engineer Recommendation:

- Consider Adding Circuit Breakers to Supply Power to MCCs E1 and E2, in Lieu of Using Substation No. 1 & No.2, or…
- Consider Future Replacement with 480 Volts Switchgear Using Power Breakers in Lieu of Molded Case Breakers

Figure A11
5kV SWs, Substations & 480V SWBRDs
No. 11 & No. 12 Assessment

Comments About 480V Switchgear No. 13 & No. 14:

- New Condition at the Time of This Assessment
- The Electrical Configuration And Characteristics May be a Model of Criteria for Future 480 Volts Switchgear at SWWRF.
- Separate Cabinet With Low Voltage Controls Would Have Been A Great Feature…. Oh Well, May Be in Future Equipment.

Engineer Recommendation:

- Implement Maintenance Program for Periodic Testing Every 5 Years, to Assure Long Term Reliability

Figure A12
Substations No. 13 & No. 14 Assessment

APPENDIX B – TECHNICAL DATA OF STATE OF THE ART ELECTRICAL EQUIPMENT

Basic technical data, features and characteristics of present technology for electrical products are shown on the following pages, for convenience of understandings available equipment for replacement of existing.

Additional figures with other products and respective data will be included in the final Technical Memorandum, including review comments and product preference from County staff.

5 kV Non- Arc Flash Resistant Switchgear State of the Art Features:

- The switchgear assembly contains insulating materials, protective and control devices, electrical contacts, and operating mechanisms, which must be protected against dirt, moisture, cement dust, foreign materials, corrosive atmospheres, and extreme temperature change.
- The most important element of the 5 kV switchgear is the vacuum interrupter, in combination with state of the art electronic relays, which delivers fast, quiet switching and precise arc extinction with adequate protection for equipment and the loads.
- Front accessible circuit breaker operating mechanism for ease of maintenance
- Closed door racking
- Floor rollout circuit breaker in lower cell without a dolly
- Visible secondary disconnect
- Circuit breaker ships inside of cell, thus reducing installation cost and transit damage
- Electronic Protective Relays for Protection of Equipment and Loads
- Uses the latest developments in vacuum interrupter technology
- Highly reliable vacuum interrupters - MTTF over 57,000 years
- Common type 3AH3 operator platform for all ratings
- Generator circuit breakers (to IEEE C37.013 optionally available)
- 10,000 operations to overhaul
- Three-cycle interrupting time (optional)
- Meets or exceeds the latest ANSI, IEEE and NEMA standards
- UL or C-UL Listing available
- Available as factory insulated for internal buss.

Engineer Recommendations / Comments:

- Future Replacement Should Include Two Tie Breakers with Generator Power Connection in Mid- Section.

Figure B1
Non-Arc Flash Resistant 5 KV Switchgear

5 kV Arc Flash Resistant Switchgear
State of the Art Features:

- The switchgear includes the same features and basic benefits of non-arc flash resistant switchgear.
- Additionally, Arc Resistant Switchgear provides addi¬tional protection in the event of an internal arcing fault. Aarc resistant switchgear meets or exceeds ANSI/IEEE C37.20.2 as they apply to metal-clad switchgear and IEEE Guide C37.20.7 for arc resis¬tant rating type 2B.The assemblies also conform to CSA C22.2 No.31.Type VCP-W vacuum circuit breakers meet or exceed all ANSI and IEEE standards applicable to AC high voltage circuit breakers rated on a symmetrical current basis.
- A switchgear assembly contains insulating materials, protective and control devices, electrical contacts, and operating mechanisms, which must be protected against dirt, moisture, cement dust, foreign materials, corrosive atmospheres, and extreme temperature change.

Engineer Recommendations / Comments:

- Future Replacement Should Include Two Main Circuit Breakers and Two Tie Breakers with Generator Power Connection in in Mid- Section.

Figure B2
Optional Arc Flash Resistant 5 kV Switchgear

Generator Master Control Panel, State of the Art Features

- Includes Manual and Automatic Control features.
- PLC for Automatic Control Logic
- Metering Interconnected with SCADA Power Management.

Engineer Recommendations / Comments:

- Specify PLC brand consistent with SCADA products at the plant.

Generator Low Voltage Control Panels, State of the Art Features:

- Each Generator has a Dedicated Control Panel.
- Low Voltage Controls are Separate from 5 KV Equipment.

Engineer Recommendation:

- Low Voltage Controls for Generators shall not be Combined with 5 kV Cabinet

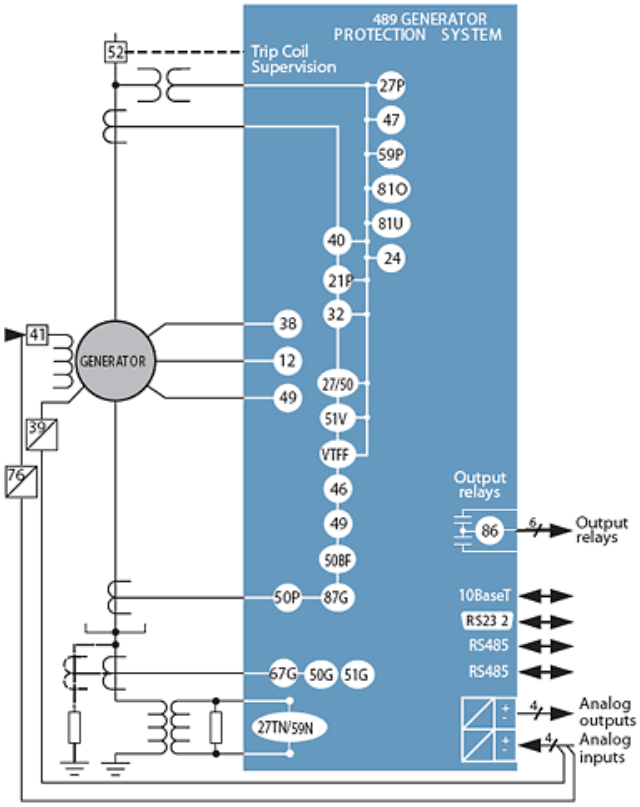
Figure B3
Generator Control Panels

State of the Art Features

- Generator stator differential
- 100% stator ground
- Loss of excitation
- Distance backup
- Reverse power (anti-motoring)
- Overexcitation
- Ground directional overcurrent
- Inadvertent energization
- Breaker failure
- Stator and bearing thermal monitoring
- Stator and bearing vibra. monitoring
- Negative sequence overcurrent

Engineer Recommendations / Comments:

- Specify Electronic Protective for Each Generators



12	Overspeed protection
21P	Phase distance
24	Volts/Hz
27P	Phase undervoltage
27/50	Accidental generator energization
27TN/59N	100% stator earth fault
32	Directional power
38	Bearing overtemperature (RTD)
39	Bearing vibration
40	Loss of excitation
46	Stator current unbalance
47	Phase reversal
49	Thermal overload
50BF	Breaker failure
50P	Phase instantaneous overcurrent
50G	Ground instantaneous overcurrent
51P	Phase time overcurrent
51G	Ground time overcurrent
51_2	Negative Sequence Time Overcurrent
51V	Voltage restrained time overcurrent
59P	Phase overvoltage
67G	Ground directional overcurrent
81O	Overfrequency
81U	Underfrequency
86	Lockout
87G	Generator differential
VTFF	VT fuse failure

Figure B4
Generator Protection System

480V Switchgear State of the Art Features:

- Manufactured per ANSI C.37.20 standard and UL 1558 Standard.
- Each Switchgear consist of Two Main Circuit Breakers and two Tie Circuit Breakers.
- Feeder Breakers Supply Power to Remote MCCs

Engineer Recommendations / Comments:

- Consider Specifying 480 Volts Switchgear and not Switchboards.

Figure B5
480V Switchgear

5 KV Switchgear State of the Art Features:

- Manufactured per ANSI C.37.20
- Optional Arc Flash Resistant with Arc Plenum
- Switchgear consist of Two Main 5 KV Breakers and two Tie Circuit Breakers.
- Breakers for Two Generators would be located in center section between Tie Breakers.
- Feeder Breakers Supply Power to Remote 5 KV/480V Transformers
- Consider locating low voltage controls in separate cabinet.

Engineer Recommendations / Comments:

- Consider Specifying 5 KV Switchgear Rated for Arc Resistant.
- Sample Switchgear layout may be used as guideline for lengthening existing electrical room into previous space of FPL vault
- Ample Front Gear Clearances for maneuvering heavy equipment parts.
- Room with Air Conditioning
- 5 KV Electrical room shall have no Low Voltage MCCs

Figure B6
Sample 5 KV Switchgear Layout