LIVERMORE
CALIFORNIA

Livermore Water Reclamation Plant

2012 MASTER PLAN UPDATE

FINAL REPORT

TETRA TECH

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November 2013

LIVERMORE
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Livermore Water Reclamation Plant
2012 Master Plan Update

November, 2013

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LIST OF ABBREVIATIONS

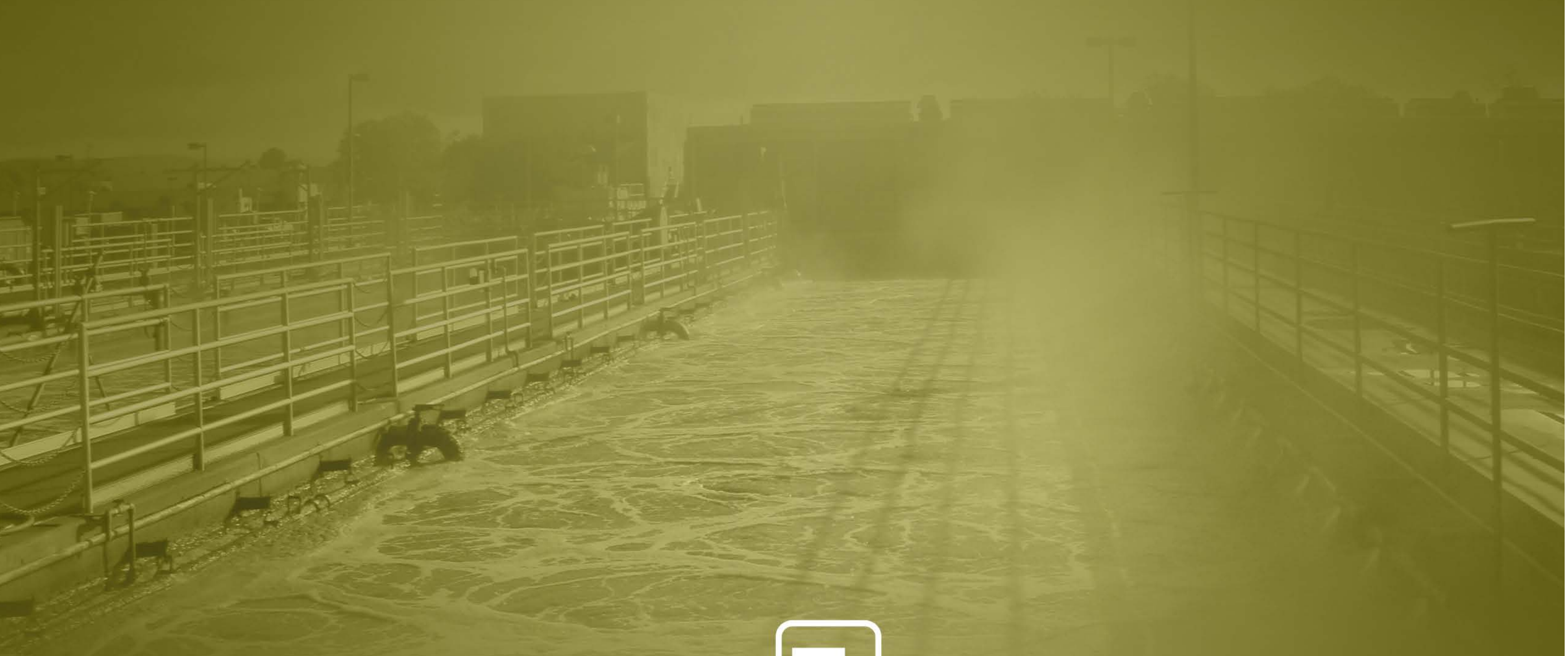
AACE	Association for Advancement of Cost Estimate
ADWF	Average Dry Weather Flow
AWWF	Average Wet Weather Flow
BFP	Belt Filter Press
BNR	Biological Nutrient Removal
BOD	Biological oxygen demand
BTU	British Thermal Unit
$CBOD_5$	Carbonaceous five-day biochemical oxygen demand
CEPT	Chemically enhanced primary treatment
CFD	Computational fluid dynamics
cf	Cubic feet
cfm	Cubic feet per minute
CPE	Comprehensive Performance Evaluation
DAF	Dissolved Air Flotation
DO	Dissolved Oxygen
DSL	Digested sludge
D/T	Dilution-to-threshold
EHB	Emergency Holding Basin
EOF	Emergency overflow
EPA	Environmental Protection Agency
FA	Foul air
FBO	Fluidized bed oxidizer
FBW	Filter backwash
FDB	Flow diversion box
FE	Filter effluent
FEB	Flow equalization basin
FET	Flow equalization tank
FI	Filter influent
F/M	Food to Microorganism ratio
FOG	Fats, oils, and grease
ft^2	Square feet
ft^3	Cubic feet
gpd	Gallons per day
gpm	Gallons per minute
GBT	Gravity Belt Thickener
GR	Grit
GTO	Gravity thickener overflow
HDPE	High-density polyethylene
HMI	Human-machine interface
hp	Horsepower
HRT	Hydraulic retention time
ILS	Influent lift station
HVAC	Heating, ventilation, and air conditioning
IFM	Influent force main
kV	Kilovolts

kW	Kilowatts
kWh	Kilowatt-hours
lb/d	Pounds per day
lb/hr	Pounds per hour
lb/dt	Pounds per day per dry ton
LAVWMA	Livermore-Amador Valley Water Management Agency
LWRP	Livermore Water Reclamation Plant
MCC	Motor control center
MCRT	Mean cell residence time
MF	Microfiltration
MG	Million gallons
mg/L	Milligrams per liter
mgd	Million gallons per day
MHF	Multiple hearth furnace
ML	Mixed liquor
mLs	Milliliters
MLR	Mixed liquor recycle
MLSS	Mixed liquor suspended solids
MLVSS	Mixed Liquor Volatile Suspended Solids
MT	Metric tons
NaOCl	Sodium hypochlorite
N/D	Nitrification and denitrification
No.	Number
NO_x	Nitrogen oxide
NRCS	Natural Resource Conservation Service
NTU	Nephelometric turbidity units
O&M	Operation and maintenance
ORP	Oxidation reduction potential
OSHA	Occupational Safety and Health Administration
PAR	Pathogen Reduction
PAC	Powdered activated carbon
PACL	Poly-aluminum chloride
PAO	Phosphorus accumulating organisms
PE	Primary effluent
PI	Primary influent
PG&E	Pacific Gas and Electric
PIN	Personal identification number
PLC	Programmable logic controller
Poly	Polymer
ppd	Pounds per day
ppm	Parts per million
ppmv	Parts per million by volume
psi	Pounds per square inch
psig	Pounds per square inch gauge
PSK	Primary skimmings
PSL	Primary sludge
PWWF	Peak Wet Weather Flow

RAS	Return activated sludge
RFP	Request for proposals
RO	Reverse osmosis
rpm	Revolutions per minute
RTU	Remote terminal unit
RW	Recycled water or return water
RWQCB	Regional Water Quality Control Board
SCADA	Supervisory control and data acquisition
SCF	Standard cubic feet
SCFH	Standard cubic feet per hour
SCFM	Standard cubic feet per minute
SCFY	Standard cubic feet per year
SE	Secondary effluent
SL	Organic space loading
SLR	Solids loading rate or sludge return
SOR	Surface overflow rate
SRT	Solids retention time
SSK	Secondary skimmings
SVI	Sludge volume index
t/d	Tons per day
TCLP	Toxic characteristics leaching procedure
TDH	Total dynamic head
TDS	Total dissolved solids or thickened digested sludge
TDW	Thickener dilution water
TE	Tertiary effluent
TN	Total nitrogen
TP	Total Phosphorous
TSL	Thickened sludge
TSS	Total suspended solids
TWAS	Thickened waste activated sludge
UV	Ultraviolet
USDA	United States Department of Agriculture
VAR	Vector Attraction Reduction
VFA	Volatile fatty acids
VFD	Variable Frequency Drive
VOCs	Volatile organic compounds
VS	Volatile solids
WAS	Waste activated sludge
wt/d	Wet tons per day
wt/y	Wet tons per year
yd^3	Cubic yards

LIVERMORE
CALIFORNIA

EXECUTIVE SUMMARY



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EXECUTIVE SUMMARY

In accordance with the Agreement for Engineering Services dated June 25, 2012, Tetra Tech prepared this 2012 Master Plan Update Report for the City of Livermore Water Reclamation Plant (LWRP). The purpose of the master plan is to deliver a roadmap for upgrading and expanding the plant facilities that incorporates the appropriate technology, optimizes operations, and minimizes cost. The following is a summary of the design values selected for the Master Plan Update. All of the projected flows and loads reflect build-out forecasts.

Table ES - 1. Projected Flows and Loads at Ultimate Buildout

Parameter	Units	Average Annual	Peak Month	Two Week	Peak Day	Peak Hour
Flow	mgd	9.47 (1)	10.93	12.4	15.29	26.1
$CBOD_5$	mg/L	247	309	N/A	427	N/A
$CBOD_5$	lb/d	19,500	28,200	N/A	54,500	N/A
TSS	mg/L	299	392	N/A	755	N/A
TSS	lb/d	23,600	35,700	N/A	96,300	N/A

(1) Flow is presented as ADWF instead of average annual. Average annual flow is 9.66 mgd at the ADWF of 9.47 mgd.

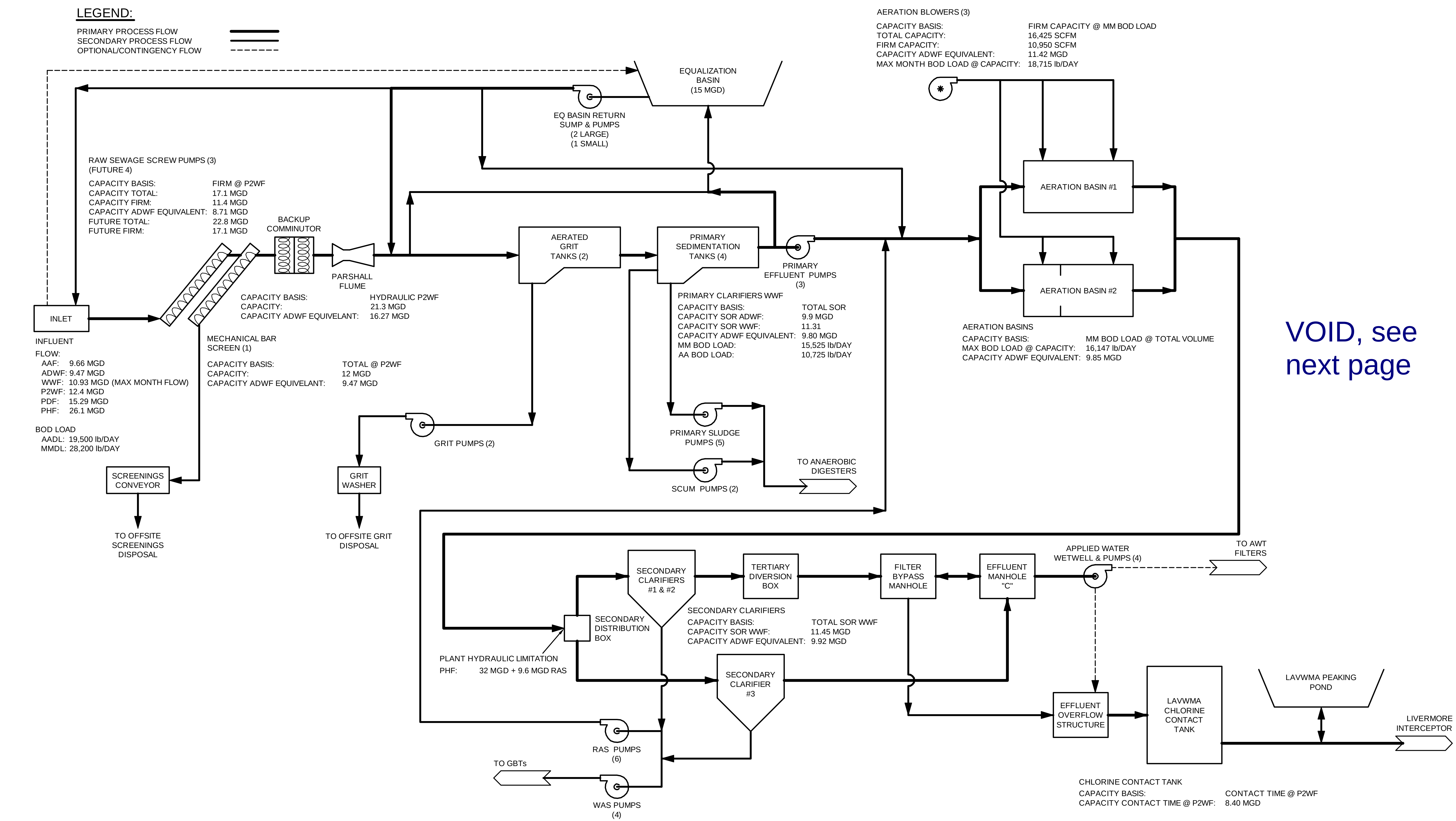
A detailed review of the recent performance of the LWRP is included in this Master Plan Update Report. The review includes data from the past three years (2009 to 2012). The comprehensive performance evaluation (CPE) of the LWRP estimated the capacity of the facilities under current organic loading and discharge conditions and was used to estimate treatment performance under projected future flow and loading conditions.

Recommended Plan

The evaluation of the liquid and solids treatment systems indicate that the LWRP will be able to serve the ultimate buildout population without a major expansion project. Figure ES-1 shows the calculated capacities for each major unit process as presented as ADWF without improvements. Note that not all of the capacities for unit processes are based on ADWF, some are based on wet weather flows and some are based on BOD loading; however for comparison purposes the capacity limiting criteria (as discussed in Section 3) was converted to an ADWF.

Figure ES-1 shows that the capacity for influent pumping, the chlorine contact, and anaerobic digestion are lower than the ultimate buildout ADWF of 9.47 mgd. The following rationale was used to comply with ultimate buildout demands without a major expansion project:

- The influent pumping capacity needs to be increased by installing a fourth influent screw pump. There is adequate space for a fourth pump without expanding the structure for the influent pump station.



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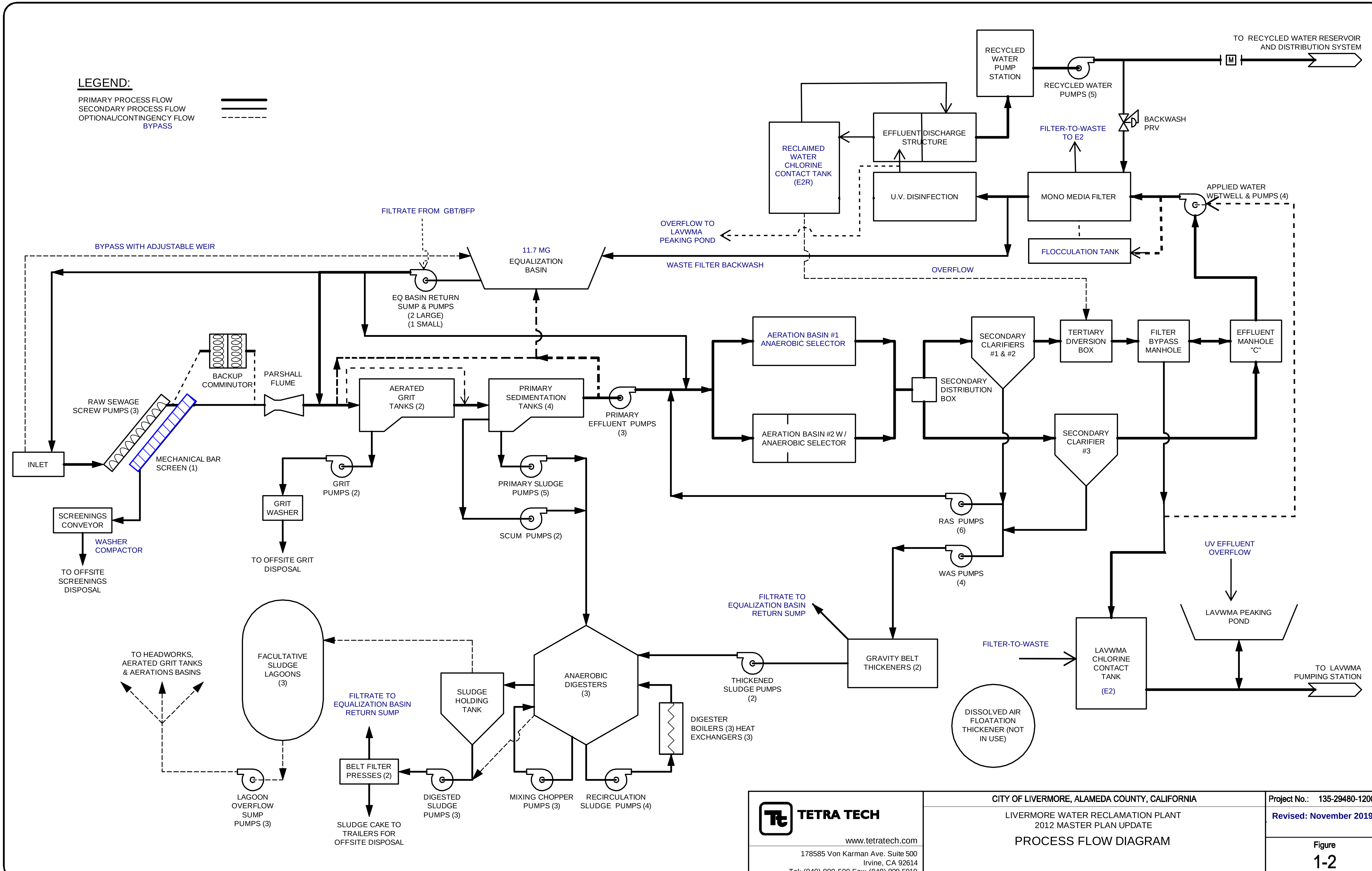
CITY OF LIVERMORE, ALAMEDA COUNTY, CALIFORNIA

LIVERMORE WATER RECLAMATION PLANT
2012 MASTER PLAN UPDATE

LIQUID STREAM CAPACITY FLOW DIAGRAM

Project No.:	135-29480-12001
Date:	MAY 2013
Designed By:	RL
Figure	ES-1

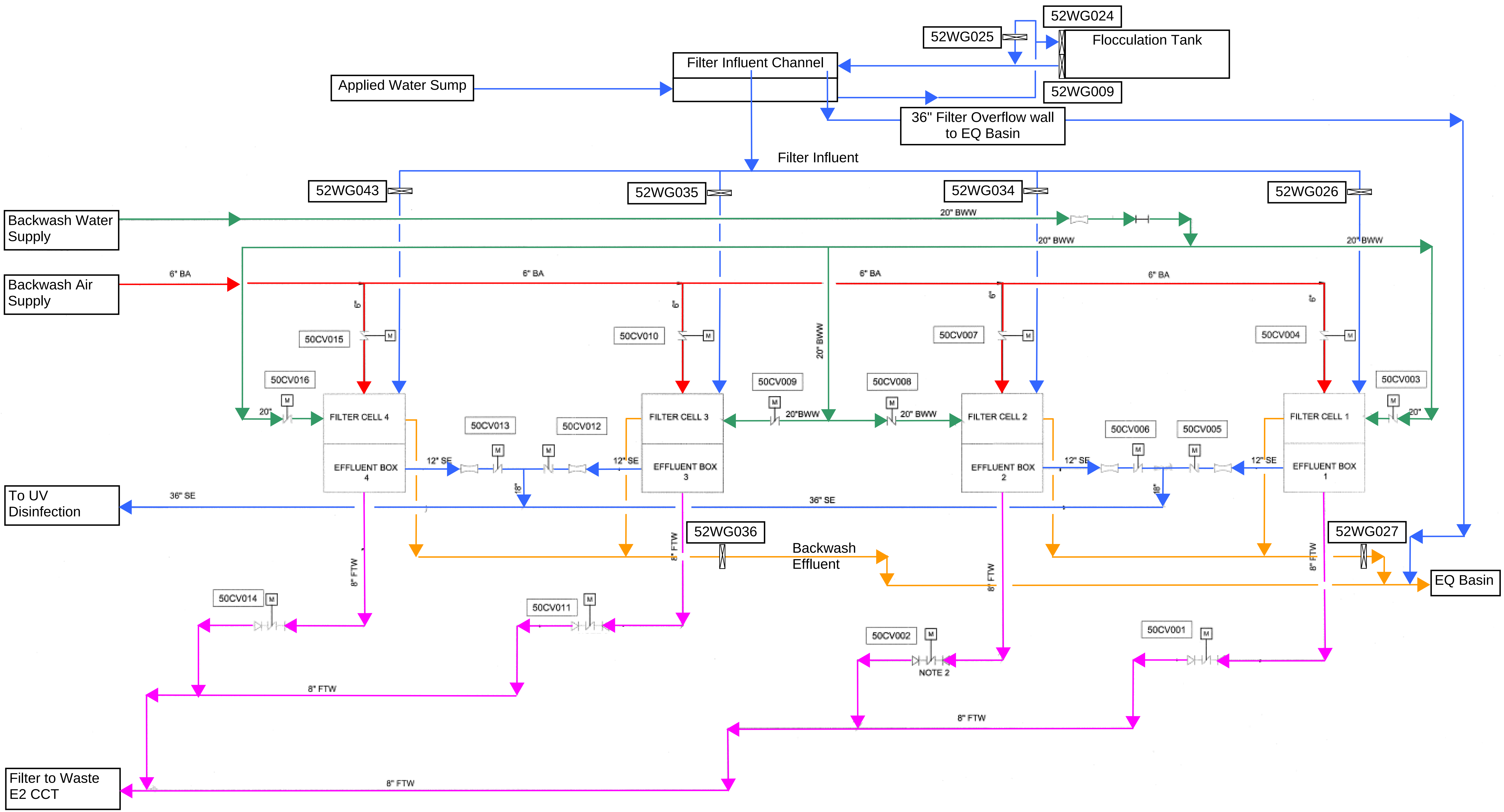
Bar Measures 1 inch

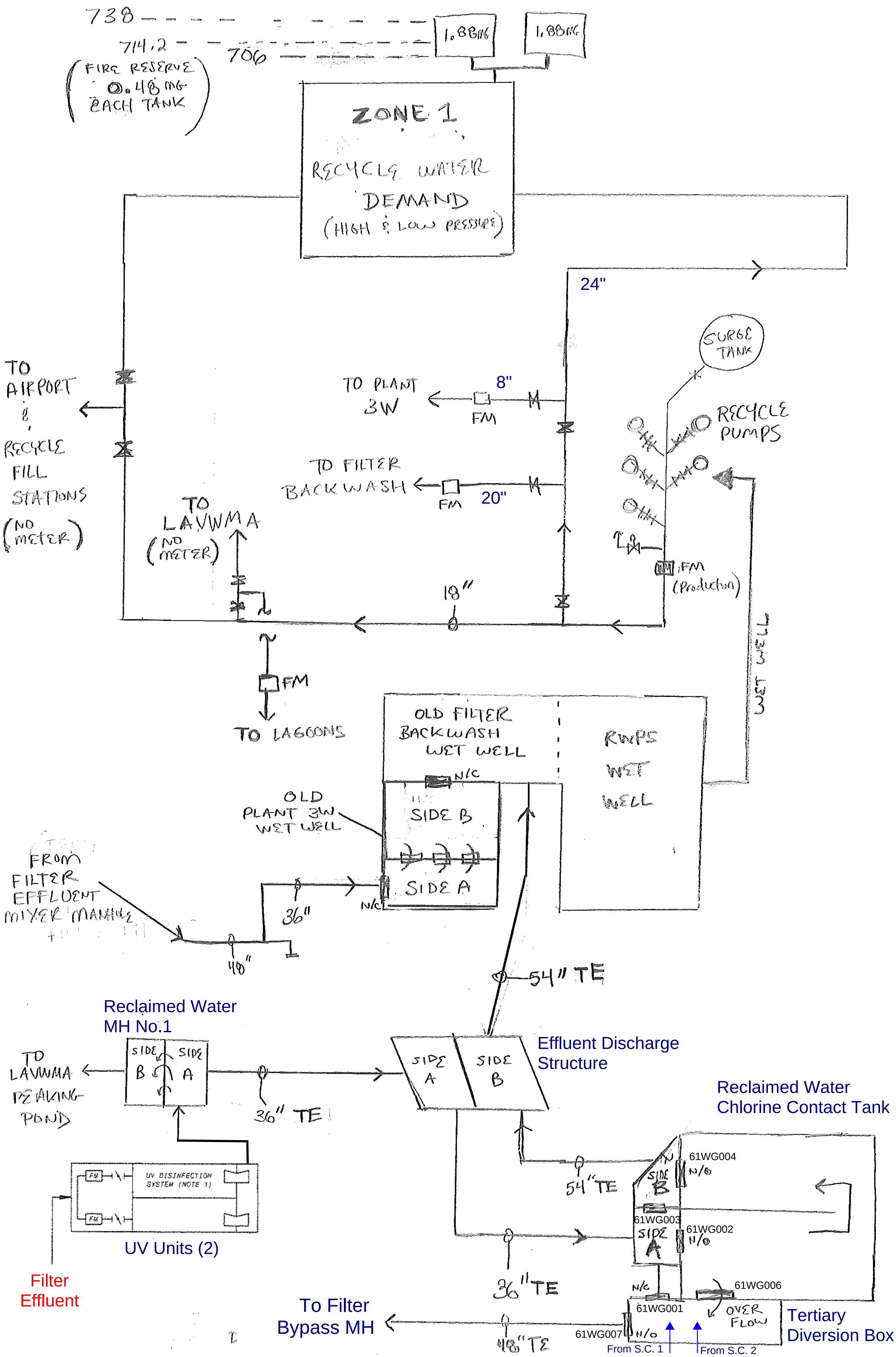


Bar Measures 1 inch

9/17/2013 9:03:27 AM - P:\01287\133-01287-12001\CAD\CONCEPTUAL\FIG-1-2.DWG - WITTENMEIER, CHUCK

Flocculation and Filtration Processes




738
714.2
706
1.8 BMG
1.8 BMG
FIRE RESERVE 0.48 MG EACH TANK
ZONE 1
RECYCLE WATER DEMAND
(HIGH & LOW PRESSURE)
24"
SURGE TANK
TO AIRPORT & RECYCLE FILL STATIONS (NO METER)
TO PLANT 3W
8"
FM
RECYCLE PUMPS
TO FILTER BACKWASH
FM
20"
TO LAVWMA (NO METER)
FM (Production)
18"
FM
TO LAGOONS
WET WELL
OLD FILTER BACKWASH WET WELL
RWPS WET WELL
N/C
OLD PLANT 3W WET WELL
SIDE B
SIDE A
FROM FILTER EFFLUENT MIXER MANHOLE
36"
N/C
48"
54" TE
Reclaimed Water
MH No.1
TO LAVWMA PEAKING POND
SIDE B
SIDE A
36" TE
SIDE A
SIDE B
Effluent Discharge
Structure
Reclaimed Water
Chlorine Contact Tank
UV DISINFECTION SYSTEM (NOTE 1)
UV Units (2)
54" TE
61WG004
N/O
SIDE B
61WG003
SIDE A
61WG002
N/O
Filter
Effluent
36" TE
N/C
61WG006
To Filter
Bypass MH
48" TE
61WG007
N/O
61WG001
OVER FLOW
Tertiary
Diversion Box
From S.C. 1
From S.C. 2

- While there is not adequate contact time in the chlorine contact basin to treat flows at ultimate buildout, there is adequate contact time in the Livermore Interceptor pipe to achieve adequate disinfection beyond ultimate buildout. The regulatory compliance point is at the end of the LAVWMA outfall; therefore, the contact time in the interceptor can be considered and there is no need to install additional chlorine contact basin volume for ultimate buildout.
- The capacity of the anaerobic digesters is limited by the minimum HRT required at maximum month loading. The HRT in the digester can be increased by adding digesters volume, which have a high capital cost and would be considered expansion; however, the HRT can also be increased by increasing the concentration of the sludge being fed to the digesters. The existing primary sludge concentration is 3.55% solids. Installing gravity thickeners can increase the primary sludge concentration to 4.5 to 6% solids. With gravity thickeners concentrating the primary sludge to a 4.5% concentration will increase the HRT in the digesters so they could handle and equivalent ADWF of 10.51 mgd. It is recommended to retrofit the currently abandoned DAFT to a gravity thickener and construct a new 25-ft diameter gravity thickener.

In addition to capacity issues, other projects were identified that improve efficiency, reliability, operations, or are needed as a result of projected future regulations. The following improvements are recommended to meet present and future conditions:

- Project #1: Replace the air piping and diffusers within Aeration Tank #1. Add an anaerobic selector similar to Aeration Tank #2. Rehabilitate the gates that control the step-feed for Aeration Tank #1. Rehabilitate or replace the gate actuators. Repair the frames and replace the seals around the gates.
- Project #2: Install standby generator to power critical processes and equipment. Perform overall electrical system coordination study to minimize tripping area in case of a fault.
- Project #3: Install a new fine screen downstream of the existing coarse screen. Configure channels so each screen can serve as the redundant unit to the other.
- Project #4: Provide the following improvements to aid process control and improve energy optimization:
  - Install additional dissolved oxygen (DO) probes and air flow control valves to create a two additional airflow control zones to each of the aeration basins.
  - Install TSS meters in each aeration basin
  - Install automatic gate actuators on the slide gates that control the flow entering aeration basins for step-feed mode.
  - Install a suspended solids probe in the waste activated sludge (WAS) line to the gravity belt thickeners so the operators can monitor the WAS concentration on a real-time basis.
- Project #5: For reuse treatment, install new ultra violet (UV) disinfection equipment for the reuse system with improved automatic cleaning system and the capability to control the target delivered UV dosage based on flow and UVT variations.
- Project #6: Install slide gates equipped with hand-wheel actuators at primary clarifiers, and install an additional grit classifier.
- Project #7: Provide additional odor control at several locations in the plant.
- Project #8: Replace the aerated grit removal system with either a vortex grit removal system or a headcell grit removal system.
- Project #9: Perform an economic evaluation study to determine whether it would be cost-effective to change dewatering technologies as the belt filter presses (BFPs) approach the end of their useful life.

- Project #10: Perform study to evaluate the costs and benefits for installation of a phosphorus recovery system. For CIP planning, assume construction of such a system.
- Project #11: Perform a study to determine the payback potential of power generation at the LWRP and construct cogeneration facility. For CIP planning, assume construction of cogeneration facility.
- Project #12: Convert abandoned Dissolved Air Flotation (DAF) Unit to a gravity thickener and construct a second 25-ft diameter gravity thickener to increase the solids concentration in the anaerobic digesters to increase the digester capacity and improve BNR operation
- Project #13: Upgrade the activated sludge system to at least a three-stage BNR process.
- Project #14: Update the 2008 Arc Flash study for each switchboard and MCC and apply the required signs that show the hazard category, safe operating distance and the proper personal protective equipment for personnel.
- Project #15: Implement miscellaneous structural improvements.
- Project #16: Install a fourth influent screw pump to increase influent pumping capacity.
- Project #17: Replace the mechanism in Secondary Clarifier #2, recoat launder and walls, RAS piping and valves and install automated gates in the Secondary Distribution Box
- Project #18: Upgrade the emergency holding basin return pumps. Install two 4.5 mgd chopper pumps for peak flow and one 1 mgd chopper pump for returning diurnal flow. Replace piping from emergency holding basin to the headworks with new 18 inch pipe.
- Project #19: Miscellaneous improvements that are required throughout the LWRP.
- Project # 20: Electrical Distribution System Upgrades (refer to Appendix D- Electrical Distribution System Analysis Technical Memorandum prepared by Carollo Engineers in 2013
  - Add new 21-kV fuses in existing 21-kV main switchgear to supply power to new double-ended unit substation transformers.
  - Replace existing transformers TC-1 and TC-2 with two liquid-filled 21-kV, 480-volt transformers (rated 1,500/1,680 kVA each).
  - Replace existing main switchboards MSBD-A and MSBD-B with new double-ended, draw-out type, NEMA 3R, walk-in switchgear.
  - Install new feeder cables between the new sections of 21-kV main switchgear and new liquid-filled transformers.
  - Install new feeder cables between the new liquid-filled transformers and the new double-ended switchgear.
  - Install new feeder cables between the new double-ended switchgear and the existing Motor Control Centers (MCCs).
  - Install new ductbank between the new double-ended switchgear and a new underground pullbox near the switchgear.
- Project # 21: MCC Replacement (refer to Appendix D- Electrical Distribution System Analysis Technical Memorandum prepared by Carollo Engineers in 2013
  - Replace the older MCCs (MCC-A, -B, -C, -CE, -D, -E, and -F) with new MCCs.
  - Replace feeders from the older vintage MCCs and field equipment with new feeders.

The estimated construction cost for all of the proposed improvements identified herein is $53,000,000. The project cost estimating was performed using the Association for the Advancement of Cost Engineering (AACE) Class 4 estimate. Construction costs consist of site work, mechanical equipment, concrete, pumps, chemical metering equipment, piping, valves, structural, electrical and instrumentation, etc. Bonds and insurance have been included at 2% and contractor's overhead and profit is assumed to be 10%. A 30% construction cost contingency is included for this planning level stage. The total capital cost includes a 20% cost allowance for preparing engineering plans, specifications, bidding and construction phase services, on-site inspection, incidental permits, survey, geotechnical, legal, and City administrative costs. The following table provides summary of the proposed Capital Improvement Program (CIP) costs.

Table ES- 2. Estimated Project Cost Summary

Project No.	Description	Total Cost	Capacity Cost Component	Existing User Costs
	Phase I Capital Improvement Program			
1	Aeration equipment replacement	$940,900	$665,000	$275,900
4	Process control improvements	$712,200	$0	$712,100
2	Electrical upgrades and standby power	$3,560,100	$712,000	$2,848,100
14	Update 2008 Arc Flash Study	$65,000	$0	$65,000
3	Finer mechanical screening equipment	$1,183,100	$856,500	$326,600
6	Primary clarifier gate actuation and redundant grit classifier	$668,500	$357,000	$311,500
11	Cogeneration	$5,171,700	$0	$5,171,700
15	Miscellaneous Structural Improvements	$410,500	$0	$410,500
19	Miscellaneous Improvements	$150,000	$0	$150,000
20	Electrical Distribution System Upgrades	$4,545,000	$1,340,000	$3,205,000
	Total Phase I	$17,406,900	$3,930,500	$13,476,400
	Phase II Capital Improvement Program			
5	UV system replacement	$3,709,400	$0	$3,709,400
8	Grit system improvements	$1,153,100	$900,000	$253,100
16	Additional Influent Screw Pump	$232,400	$232,400	$0
12	Gravity Thickener	$1,205,600	$1,205,600	$0
13	BNR Upgrades	$15,480,100	$12,650,000	$2,830,100
17	Secondary Clarifier #2 mechanism replacement	$270,000	$0	$270,000
	Total Phase II	$22,050,600	$14,988,000	$7,062,600
	Phase III Capital Improvement Program			
18	Basin Return Pumps Upgrades	$438,500	$438,500	$0
7	Additional odor control	$1,367,300	$0	$1,367,300
9	Dewatering improvements	$3,695,400	$1,800,000	$1,895,400
10	Phosphorus recovery	$3,910,300	$0	$3,910,300
21	MCC Replacement	$4,165,500	$0	$4,165,500
	Total Phase III	$13,577,000	$2,238,500	$11,338,500
	Total CIP (Phases I through III)	**$53,034,500**	**$21,157,000**	**$31,877,500**

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1.0 INTRODUCTION

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1.0 INTRODUCTION

In 2012, the City of Livermore retained Tetra Tech to perform a review of the Livermore Water Reclamation Plant (LWRP) and prepare an updated Master Plan. The purpose of the master plan is to develop a roadmap for upgrading and expanding the plant in a manner that incorporates the appropriate technology, optimizes operations, and minimizes cost.

1.1 Background

The original LWRP was constructed in 1958 and has been expanded and/or upgraded in five phases since then. Including the Phase V modifications, the LWRP is now designed to treat an average dry weather (ADWF) flow of 8.5 million gallons per day (mgd), and wet weather peak hour flow of 15.5 mgd, respectively, and to meet discharge permit limits for the following parameters.

Table 1-1. Current Discharge Permit Requirements

Parameter	Units	Monthly Average Permit Limit
$CBOD_5$	mg/L	25
TSS	mg/L	30
pH	Units	6.0-9.0

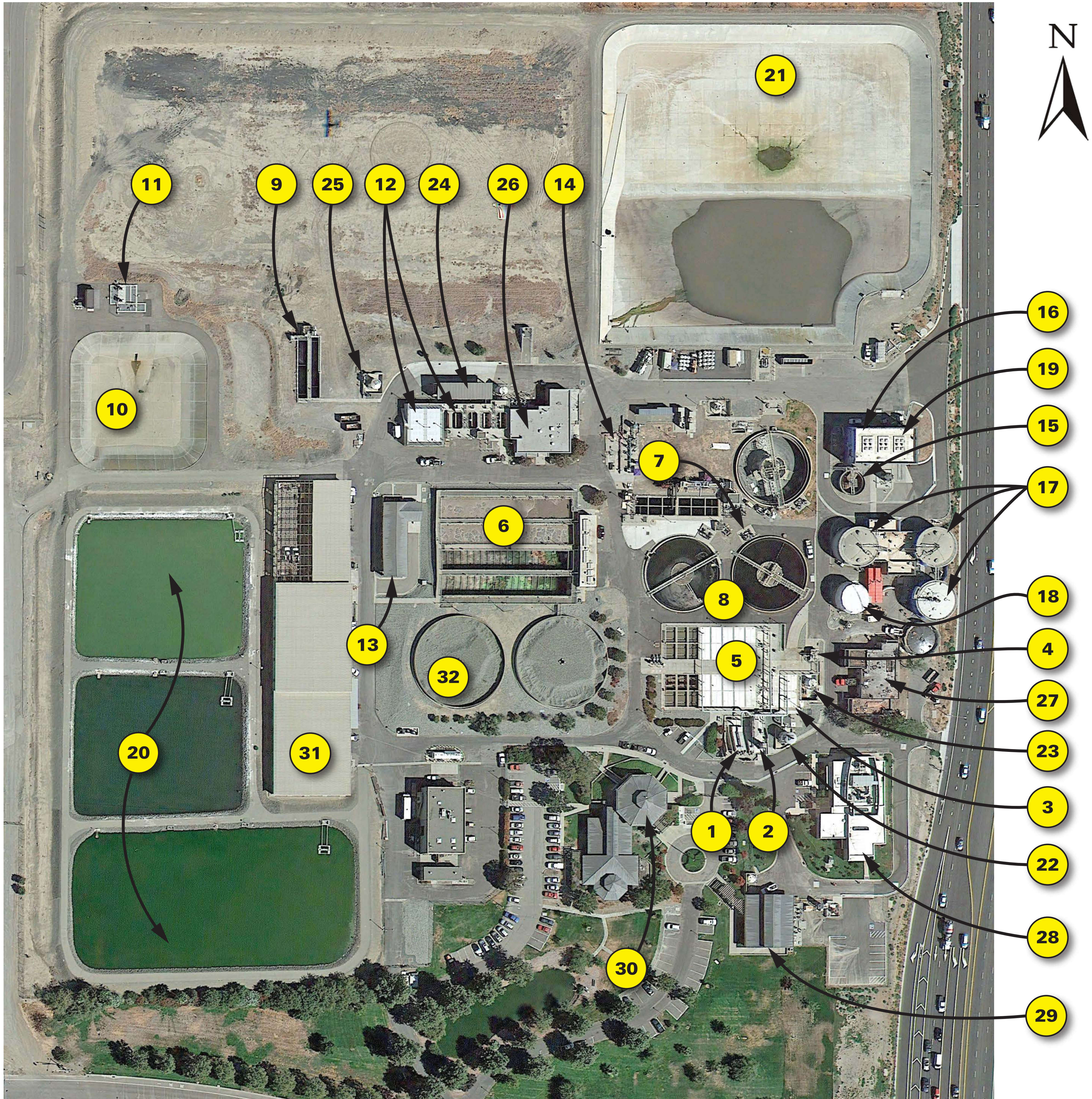
Figure 1-1, Site Plan, shows the existing facilities at the LWRP. Figure 1-2, shows the process flow diagram. The plant includes the following treatment processes:

Liquid Treatment Processes:

- Raw Sewage Pump Station
- Bar Screen
- Aerated Grit Removal
- Primary Sedimentation
- Aeration Basins
- Secondary Clarification
- Chlorine Contact Tank
- LAVWMA Pump Station

Solids Treatment Processes:

- Gravity Thickening
- Anaerobic Digestion
- Belt Filter Press Solids Dewatering



LEGEND

1. Raw Sewage Pump Station
2. Bar Screen
3. Aerated Grit Tanks
4. Grit Washer
5. Primary Clarifiers
6. Aeration Basins
7. Secondary Distribution Box
8. Secondary Clarifiers
9. Chlorine Contact Tank
10. LAVWMA Peaking Pond
11. LAVWMA Pumping Station
12. Tertiary Filters & Flocculation Tank
13. Ultraviolet Disinfection
14. Recycled Water Pumps
15. Dissolved Air Flotation Thickener (not in use)
16. Gravity Belt Thickners
17. Anaerobic Digesters
18. Sludge Holding Tank
19. Belt Filter Press
20. Faculative Sludge Lagoons
21. Emergency Holding Basin
22. Odor Control Facility
23. Ferric Chloride Facility
24. Sodium Hypochlorite Facility
25. Sodium Hydroxide Facility
26. Collection Offices
27. Water Offices
28. Lab Building
29. RO Building (not in use)
30. Administration Building
31. Vehicle/Material Storage
32. Trickling Filters (abandoned)

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Figure 1-1

Existing Site Plan

LIVERMORE WRP 2012 MASTER PLAN UPDATE

Scale: Not to Scale

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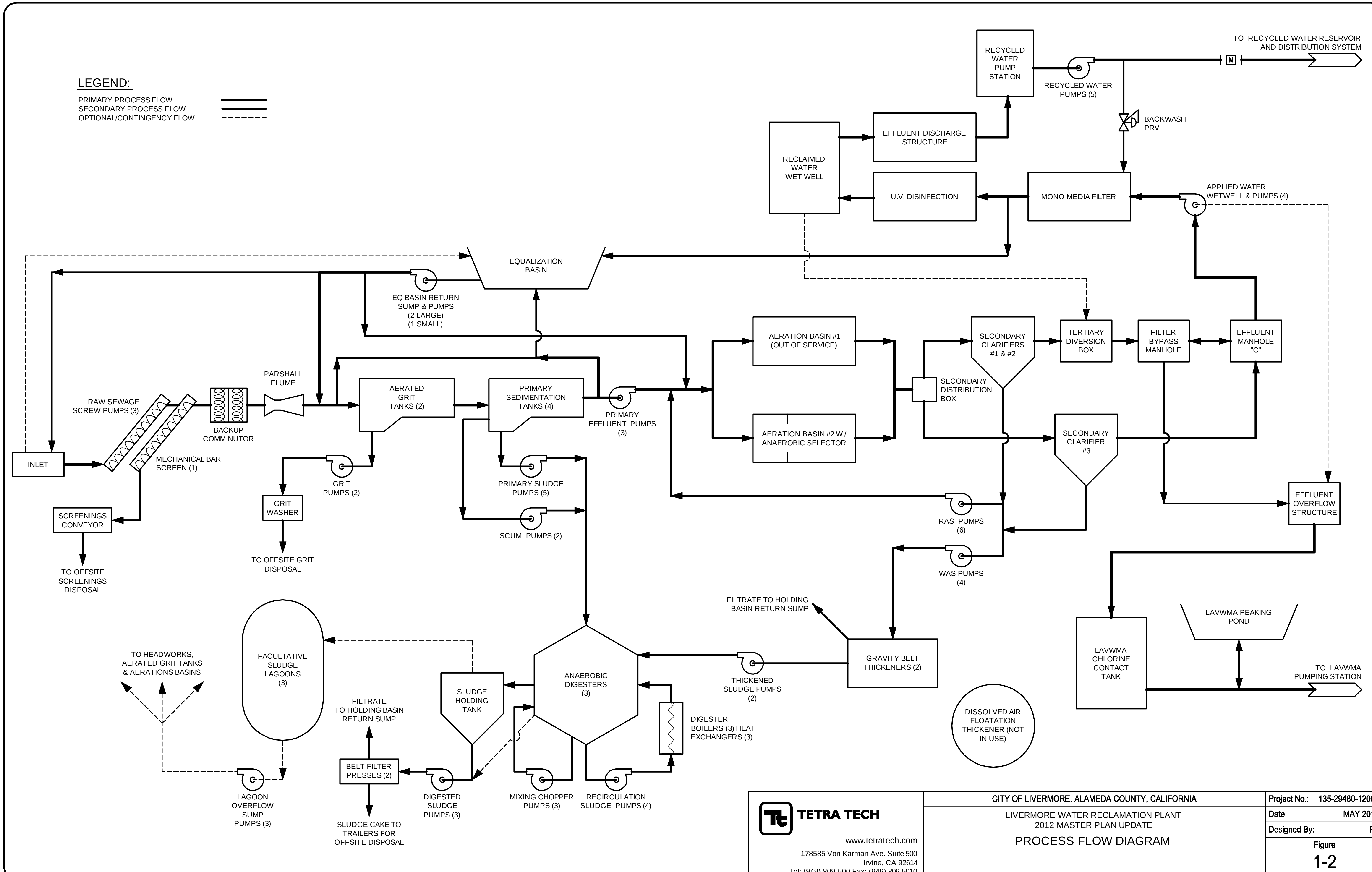

Bar Measures 1 inch

9/17/2013 9:03:27 AM - P:\01287\133-01287-12001\CAD\CONCEPTUAL\FIG-1-2.DWG - WITTENMEIER, CHUCK

The LWRP provides secondary treatment and disinfection for up to 8.5 mgd ADWF. Treatment consists of screening, grit removal, pre-aeration, primary clarification with ferric chloride addition for hydrogen sulfide control, activated sludge, secondary clarification and disinfection using sodium hypochlorite. Raw sewage is lifted by means of three 5.7 mgd screw pumps that are covered for odor control. The wastewater then travels through a single mechanical bar screen that removes rags, sticks, and other inorganic trash that might clog treatment processes further down the flow path. A 24-inch Parshall flume with a hydraulic capacity up to 21.3 mgd is used to measure the flow. The wastewater passes through two aerated basins where grit is removed and raw wastewater gets freshened.

The screened and degritted flow is discharged to four rectangular primary clarifiers. Primary effluent is conveyed to the aeration tanks by three pumps. The pumped primary effluent can be directed to either the aeration tanks or to the emergency holding basin, which has a storage capacity of 15 million gallons (MG). The aeration tanks provide a two pass, out and back, flow path. Aeration tank mixed liquor is discharged to a splitter structure for distribution to three circular secondary clarifiers. Settled sludge in secondary clarifiers is collected using “organ-pipe” differential-head type sludge collectors. Secondary clarifier underflow sludge is returned to the aeration basins via six centrifugal return activated sludge (RAS) pumps or wasted to thickening and anaerobic digestion.

The secondary effluent from the plant is either conveyed to Livermore-Amador Valley Water Management Agency (LAVWMA) for disposal to San Francisco Bay or further treated to meet recycled water regulations for landscape irrigation (i.e. non-potable reuse). For discharge to the Bay, disinfection is accomplished via hypochlorite addition followed by chlorine contact. For reuse, both granular media filtration and ultra violet (UV) disinfection are utilized.

Waste activated sludge (WAS) is thickened using gravity belt thickeners (GBTs), while primary is thickened within each clarifier to about 4.5% to 5.0% solids. The thickened WAS, or TWAS, is pumped to three anaerobic digesters using four centrifugal pumps. Primary sludge and secondary sludge are mixed in-pipe upstream of the digesters. Digested sludge overflows by gravity to a storage tank. Digested solids are dewatered using belt filter presses (BFPs). Filtrate flows by gravity to a wet well prior to being pumped to the head of the aerated grit basins.

The anaerobically digested biosolids meet Environmental Protection Agency (EPA) Part 503 criteria for vector attractor reduction (VAR) and Class B pathogen content. During the winter, dewatered biosolids is hauled to the landfill where it is either used for daily cover (primary use) or buried in active cells (if necessary). The remainder of the year, the dewatered biosolids is hauled to agricultural sites beneficially land applied as a soil amendment. Two boilers are fired using digester gas, and a third operates from natural gas.

A summary of design data for each unit treatment process is presented in Table 1-2.

Table 1-2. Existing Plant Design Summary

Item	Value
INFLUENT PUMP STATION	
Type	Screw Pumps
Number	3
Drive Type	VFD
Lift (feet)	14.5
Capacity, each (mgd)	5.7
INFLUENT SCREENING	
Type	Mechanically Cleaned Climber
Number	1
Bar spacing (inches)	5/8
Capacity (mgd)	12
SCREENINGS HANDLING EQUIPMENT	
Type	Spiral Wash Press/Compactor
Number	1
INFLUENT GRINDER (By Pass Channel)	
Type	Channel Mounted Grinder
Number	1
Capacity (mgd)	11
INFLUENT FLOW MEASUREMENT	
Parshall Flume size (inches)	24
Maximum flume depth (feet)	3
Capacity (mgd)	21.3
AERATED GRIT REMOVAL	
Number of Basins	2
Width (feet)	19
Length (feet)	34
Side Water Depth (feet)	10
Detention time at ADWF (minutes)	16
Detention time at PWWF (minutes)	9
Air rate (scfm/ft length)	13.2
GRIT HANDLING	
Grit Pumping	
Type	Torque Flow
Number	2
Capacity, each (gpm)	245
Grit Dewatering	
Type	Cyclone/Classifier
Number of Classifiers	1
Capacity, each (gpm)	100
Number of Cyclones	1
Capacity, each (gpm)	220

Item	Value
PRIMARY CLARIFIERS	
Type	Rectangular
Number	4
Width (feet)	19
Length (feet)	124
Depth (feet)	10
Surface area, each (sf)	2,356
Surface overflow rate at ADWF (gpf/sf)	1,005
Historical Removal Efficiency	
BOD_5 avg. removal, percent	45
TSS avg. removal, percent	66
Sludge concentration, percent	3.55
Primary Sludge Pumps	
Type	Progressive Cavity
Number	5
Capacity (gpm)	50
Primary Scum Pumps	
Type	Progressive Cavity
Number	2
Capacity (gpm)	50
Preaeration Grit Pumps	
Type	Recessed Impeller Centrifugal
Number	2
Capacity (gpm)	140
Primary Effluent Pumps	
Type	Propeller
Number	3
Capacity (gpm)	5000
Emergency Holding Basin	
Capacity (MG)	15
AERATION BASINS	
Type	Rectangular
Number	2
Basin Volume, total (MG)	2.08
Detention time (hours) @ design ADWF	5.3
SRT (days)	4.8
MLSS (mg/L)	3,000
Aeration Blowers	3
Type	Centrifugal
Number	3
Firm Blower Capacity (scfm)	10,950

Item	Value
SECONDARY CLARIFIERS	
Number	3
Diameter (ft)	90
Side Water Depth (ft)	15
Surface Area (ft^2)	6,362
RETURN ACTIVATED SLUDGE PUMPS	
Type	Non-Clog Centrifugal
Number	6
Capacity each (mgd)	2.83
WASTE ACTIVATED SLUDGE	
Type	Non-Clog Centrifugal
Number	4
Capacity each (gpm)	110
DISINFECTION	
Chlorine Contact Tank	Non-Clog Centrifugal
Volume (ft^3)	19,500
HRT (min)	25
Ultraviolet Disinfection System	
Type	Low Pressure High Efficiency
Number of Channels	2
Capacity (mgd)	6.5
TERTIARY TREATMENT	
Granular Media Filters	
Number	4
Area each (ft^2)	364
Firm Capacity (mgd at 5 gpm/ft^2)	7.86
SLUDGE THICKENING	
Gravity Belt Thickener	
Number	2
Capacity each (gpm/m)	150
Belt Width, each (m)	1.5
SLUDGE STABILIZATION	
Anaerobic Digester	
Number	3
Volume each (MG)	1.154
Solids Retention Time, Peak Month (days)	19.1
Solids Retention Time, Average (days)	22.2
Volatile Solids Loading Rate (lb/ft^3/day)	0.12
Sludge Holding Tank	
Number	1
Volume (gal)	202,000
Retention Time, Peak Month (days)	3.4

Item	Value
SLUDGE DEWATERING	
Belt Filter Press	
Number	2
Belt Width, each (m)	2

1.2 Plant Influent and Effluent Data

Operational data provided by the City were reviewed in preparing this Master Plan. The following tables provide summary of the plant influent and effluent data.

Table 1-3. Representative Influent 24-hour Composite Sample Data January 2009 – June 2012

Parameter	Units	30-Day Average	Maximum 30-Day	Minimum 30-Day Average
Flow	mgd	7.07	8.0	6.68
$CBOD_5$	mg/L	240	330	170
$CBOD_5$	lb/d	14,300	20,700	10,400
Primary Eff. $CBOD_5$	mg/L	130	170	100
Primary Eff. $CBOD_5$	lb/d	7960	11,276	5,683
TSS	mg/L	290	430	220
TSS	lb/d	17,200	26,200	12,500
Ammonia	mg/L	44	52	35
Ammonia	lb/d	2,660	3,240	2,140
Mixed Liquor Temp.	Degrees C	21.7	26.8	17.3

Table 1-4. Representative Effluent 24-hour Composite Sample Data January 2009 – June 2012

Parameter	Units	Permit Limit	30-Day Average	Maximum 30-Day Average	Minimum 30-Day Average
$CBOD_5$	mg/L	25	4.6	8.2	2.8
TSS	mg/L	30	10.6	20.9	4.8
Ammonia	mg/L	93	40	46	34
pH	S.U.	6.0-9.0	7.7	8.4	6.2
Temperature	Degrees C		20.6	25.4	16.7
Fecal coliform	#/100 mLs	500	2.7	5.0	2.0

1.3 Scope of Work

The Scope of Work included in this evaluation included the following tasks:

- Determining existing flows and loadings.
- Projecting ultimate build-out loadings.
- Conducting unit process audits to ensure overall process sustainability.
- Reviewing current plant biosolids processing and disposal practices.
- Determining future biosolids management trends and recommending options for disposal.
- Developing a plant hydraulic model and identify potential hydraulic limitations.
- Updating liquid treatment and solids process flow diagram.
- Reviewing historical plant process data and make recommendations that reduces cost and/or improves efficiency.
- Identifying and providing preliminary cost estimates for required water reclamation plant improvements for ultimate flows and loadings.

This LWRP 2012 Master Plan Update is premised on treating ADWF of 9.47 mgd and wet weather peak hour flow of 26.1 mgd, respectively, at ultimate build-out conditions.

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2.0 LWRP FLOWS & LOADINGS

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2.0 LIVERMORE WATER RECLAMATION PLANT (LWRP) FLOWS AND LOADINGS

Tetra Tech reviewed previous reports including the 2004 Final Report Sewer Master Plan, 2005 Wastewater Disposal Master Plan, the 2006 Water Reclamation Plant Master Plan Update, as well as recent operating data from the treatment plant.

2.1 Recent Wastewater Flows

The Tetra Tech team reviewed the methodology adopted in the 2006 Water Reclamation Plant Master Plan Update. The City provided 3 years of operating data in order to analyze plant performance and efficiency. Based on the historical flow data, an evaluation was conducted to determine the average flow, peak daily flow and peak hourly flow for the past three years.

Table 2-1. Livermore Plant Influent Flowrate

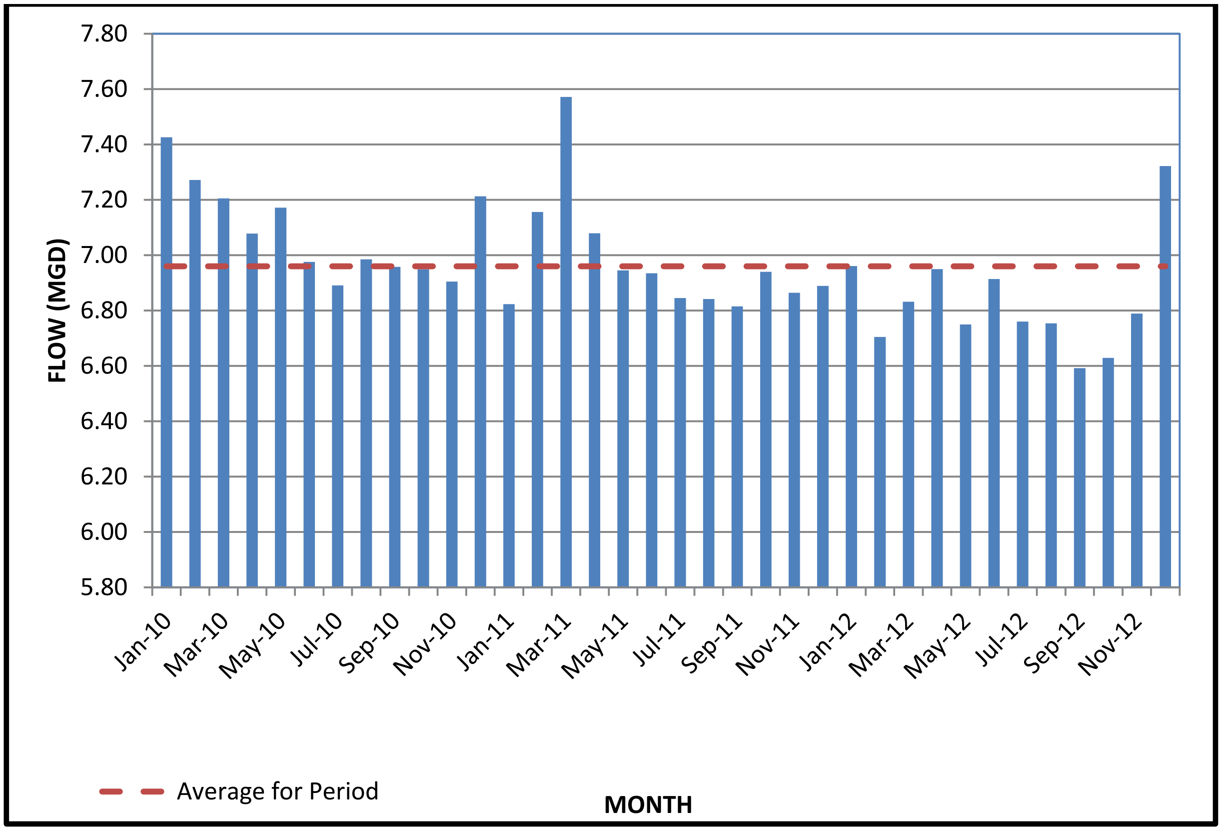
Year	Predicted Master Plan Plant Influent ADWF (mgd) (a)	Actual Plant Influent ADWF (mgd) (b)	Variation (% difference)
2003	6.52	-	-
2010	7.21	6.91	-4.2
2011	7.31	6.82	-6.7
2012	7.41	6.64	-10.4
2015	7.72	-	-
2020	8.08	-	-
2025	8.48	-	-
Build-out	9.47	-	-

(a) From 2005 Wastewater Disposal Master Plan
(b) From Plant operating data, ADWF based on lowest consecutive three months

2.1.1 Average Flow

Figure 2-1 shows the monthly average flow to LWRP during the three-year period from January 2010 through December 2012. The overall average flow for the period was 6.96 mgd. The highest monthly average flow was in March 2011 with a flow of 7.57 mgd. The lowest monthly average flow occurred in September 2012.

Figure 2-1. Monthly Average Flow



2.1.2 Peak Daily Flow

Figure 2-2 shows the trend of peak daily flows each month to the LWRP during the three-year period from January 2010 through December 2012. The highest daily flow occurred in March 2011 with a flow of 9.98 mgd. The lowest peak daily flow occurred in September 2012 at a flow of 6.88 mgd.

Figure 2-2. Peak Daily Flow

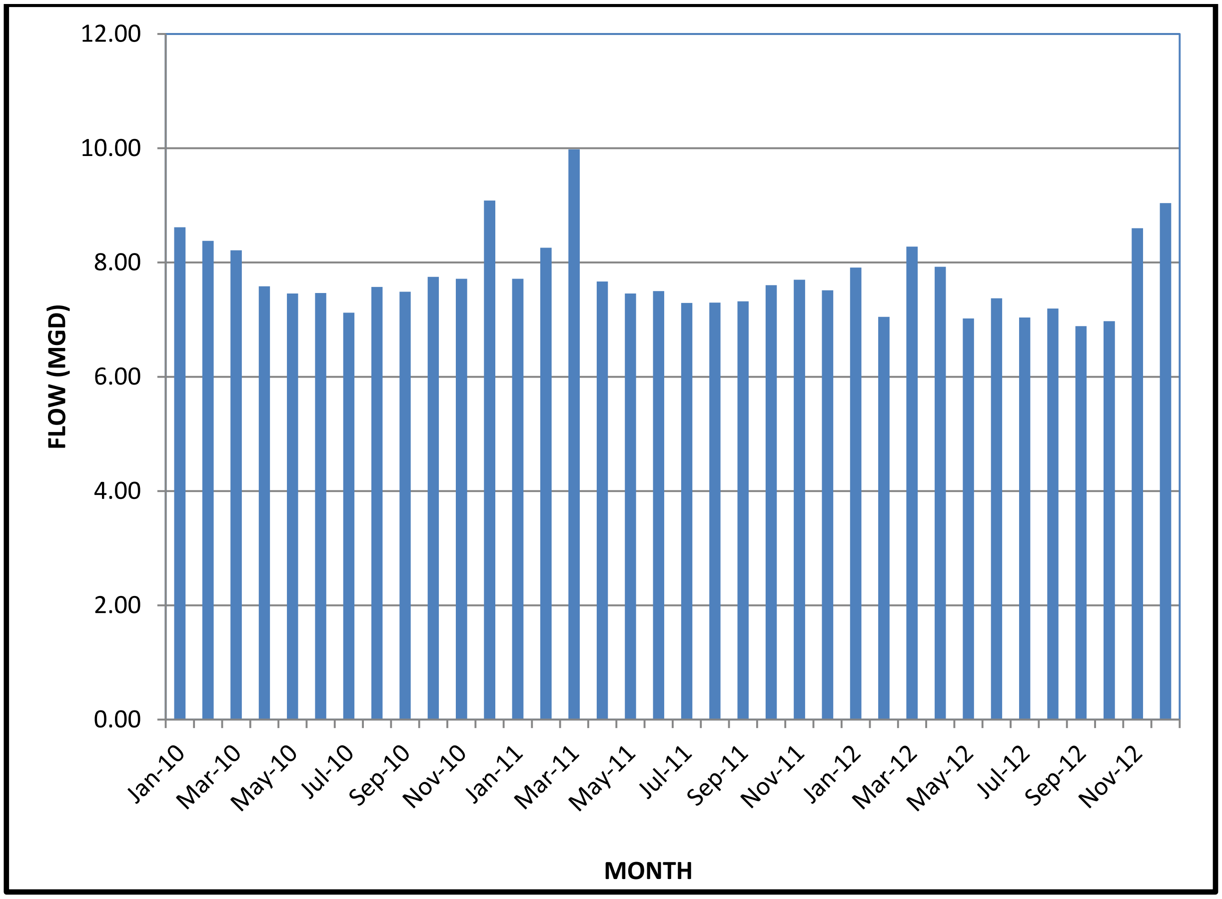
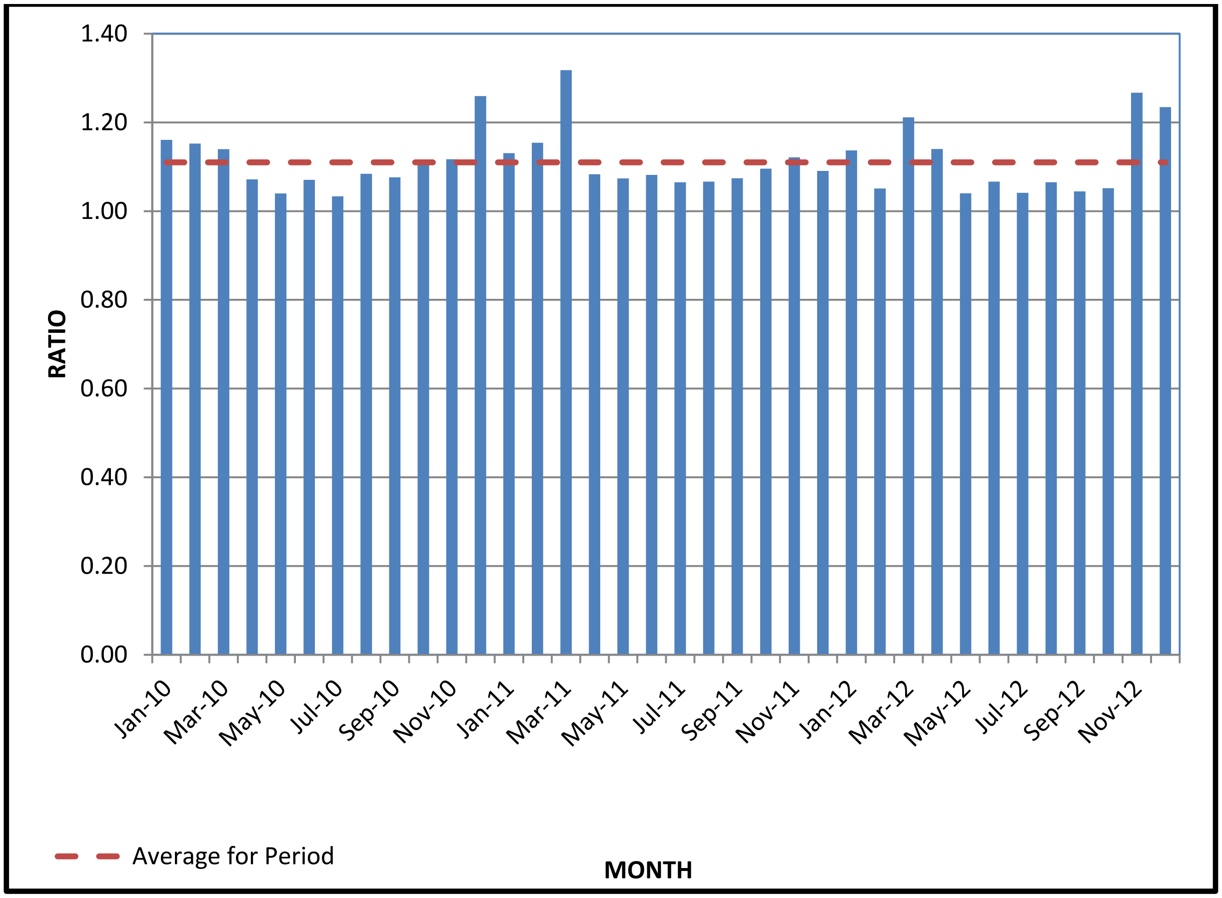


Figure 2-3 shows the ratio peak daily flow to monthly average flow by month. The ratio of peak daily flow to average daily flow averaged 1.11 during the period of review. The maximum ratio of 1.32 was observed in March 2011. The minimum ratio of 1.03 was observed in July 2010.

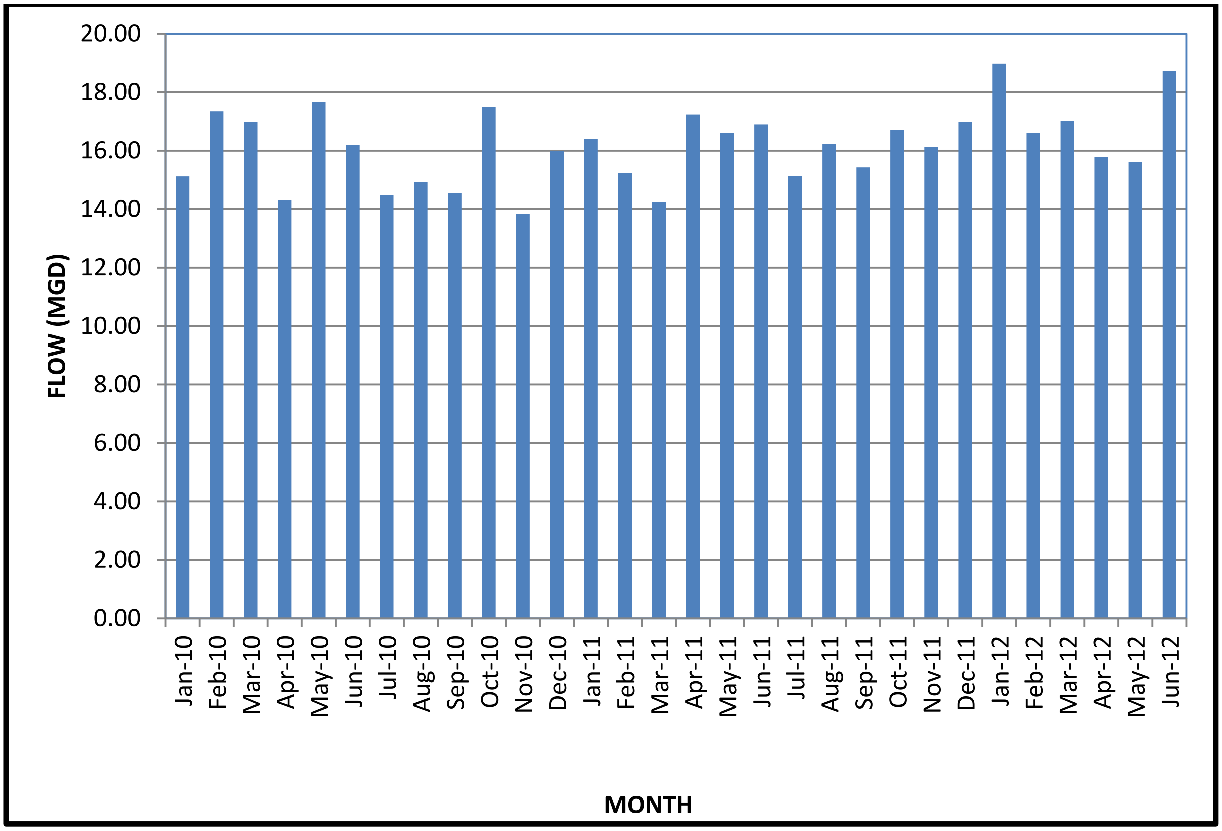
Figure 2-3. Flow Ratio – Peak Daily to Monthly Average



2.1.3 Peak Hour Flow

Figure 2-4 shows the trend of peak hourly flows from each month that were treated by the preliminary treatment factilies at the LWRP during the period from January 2010 through June 2012. The maximum peak hourly flow occurred in January 2012 with a flow of 18.9 mgd. Flows above 17 mgd are be diverted to Emergency Holding Basin, therefore peak hourly flows during big storms can be more than the flows shown in Figure 2-4.

Figure 2-4. Peak Hourly Flow Treated the Preliminary Treatment Facilities



2.2 Recent Process Loadings

The Tetra Tech team was on-site for the CPE during the week of September 17, 2012, and physically observed operational, influent, and effluent conditions. Data from the LWRP was analyzed and the results compared to the on-site physical observations and to standard norms for WWTP loadings. Data for 3.5 consecutive years from January 2009 through June 2012 were used to determine minimum and maximum month (i.e. 30-day average) loading conditions, as well as seasonal variations in wastewater characteristics.

Table 2-2. Representative Influent 24-hour Composite Sample Data January 2009 – June 2012

Parameter	Units	30-Day Average	Maximum 30-Day Average	Minimum 30-Day Average
Flow	mgd	7.07	8.0	6.68
$CBOD_5$	mg/L	240	330	170
$CBOD_5$	lb/d	14,300	20,700	10,400
Primary Eff. $CBOD_5$	mg/L	130	170	100
Primary Eff. $CBOD_5$	lb/d	7,960	11,276	6,683
TSS	mg/L	290	430	220
TSS	lb/d	17,200	26,200	12,500
Ammonia	mg/L	44	52	35
Ammonia	lb/d	2,660	3,240	2,140
Mixed Liquor Temp.	Degrees C	21.7	26.8	17.3

2.2.1 Biochemical Oxygen Demand

Influent data were taken from the monthly data summary provided by Livermore and are summarized in Table 2-2 above. The average $CBOD_5$ concentration of 240 milligrams per liter (mg/L) suggests typical municipal wastewater strength. In comparison, the previous master plan projections presented an average dry weather $CBOD_5$ value of 302 mg/L at a loading of 23,900 lb/d at ultimate conditions.

2.2.2 Total Suspended Solids

The current TSS value of 290 mg/L is slightly higher than normal. In comparison, the previous master plan projections presented an average dry weather TSS value of 262 mg/L, at a loading of 17,000 lb/d for Phase V conditions and 20,700 lb/d at ultimate conditions. The plant data between 2009 through 2012 indicates the current TSS loading is comparable to previous projections.

2.2.3 Ammonia Nitrogen

The ammonia concentration of 44 mg/L is quite high when compared to a typical value of 25-30 mg/L. However, ammonia data from around the United States can vary significantly, so no obvious conclusions can be made based on this data.

2.3 Projected Flows and Loadings

The City's 2003-2025 General Plan was used in previous studies to develop the base flow projections at buildout. The design flows for the LWRP Phase V expansion is summarized as follows:

- ADWF is 8.5 mgd
- Peak dry weather flow is 11.1 mgd
- Peak hour wet weather flow is 15.5 mgd

The 30-day ADWF at buildout was estimated at 9.47 mgd during the 2004 Sewer Master Plan.

2.3.1 Growth Projections

The previous planning studies were based upon single-family and multi-family residential flow factors of 60 gallons per capita per day. A density of 3.0 persons per dwelling unit was also used for single family units. An estimated 10,000 new residential units were assumed to be developed through buildout, based on the General Plan Land Use Map. Between 2001 and 2011, the population of the City of Livermore had increased from 75,728 to 82,039, or roughly averaging a growth rate of about 0.83% per year. If the current growth rate continued, the projected population in 2025 would be approximately 91,571. The 2003 General Plan estimated a build-out population beyond 2025 of approximately 101,000 persons.

2.3.2 Flow and Load Projections

Based upon a review of current conditions and discussions with the City, the previous flow projections planning data still appear to be valid, even though they may be conservative. Although the flow projections are likely a bit high due to water conservation measures and the general trend of decreasing wastewater generation per acre, the City has also added some more density in land use due to infill development and zoning revisions since the last land use update in 2003. As a result, the previous flow planning data assumptions appear to be valid for estimating future build-out conditions. The flow projection for the LWRP can be reviewed again along with plant operating data during a subsequent master plan update. The following table provides summary of the flows and loads considered for process evaluation.

Table 2-3. Projected Flows and Loads at Ultimate Buildout

Parameter	Units	Average Annual	Peak Month	Two Week Peak	Peak Day	Peak Hour
Flow	mgd	9.47 (1)	10.93	12.4	15.29	26.1
$CBOD_5$	mg/L	247	309	N/A	427	N/A
$CBOD_5$	lb/d	19,500	28,200	N/A	54,500	N/A
TSS	mg/L	299	392	N/A	755	N/A
TSS	lb/d	23,600	35,700	N/A	96,300	N/A

(1) Flow is presented as ADWF instead of average annual. Average annual flow is 9.66 mgd at the ADWF of 9.47 mgd.

2.4 LAVWMA Wet Weather Flow Storage Analysis

The LWRP connects to the Livermore-Amador Valley Wastewater Management Authority (LAVWMA), which has a regional effluent disposal system. The LWRP has an Emergency Storage Holding Basin which is used to store flows that are in excess of the capacity in the LAVWMA system. The Wastewater Disposal Master Plan prepared by Brown and Caldwell in 2005 projected that peak dry weather flows would exceed the 12.4 mgd allocated capacity in the LAVWMA pipeline necessitating daily use of the Basin. As part of the 2012 Master Plan Update, Brown and Caldwell was contracted to perform additional hydraulic analysis using MOUSE to determine the amount of storage required on an hourly basis by storing flow when the hourly flow exceeded the 12.4 mgd allocated capacity in LAVWMA pipeline. A probabilistic analysis was performed on the storage volumes to determine the amount of storage that would be exceeded once every 20 years. The amount of time required to empty the Basin after a wet weather event is specific to each individual storm. The analysis determined the typical time to empty the storage basins under large storm conditions. The storage requirements for each event are shown in the letter report. The emergency holding basin can accommodate the flows from the 20-year and 100-year storm events and will be emptied at the rate of 12.4 mgd for a period of 14 days. The analysis and storage times are summarized in the letter report included in Appendix A. Based on this analysis; Tetra Tech evaluated the impact of 12.4 mgd on each process area and on the plant hydraulics. The impacts to each process area are discussed in Section 3.1.7 of this report and plant hydraulics in Section 2.5 of this report.

2.5 Hydraulic Evaluation

A Hydraulic Model of the LWRP was developed using a Microsoft Excel spreadsheet. The model included only the primary and secondary treatment facilities at the plant and determined headlosses and water surface elevations. The model analyzed the existing conditions based on the design flowrate of the Phase V facilities, wet weather flows to LAVWMA system and future flow conditions.

2.5.1 Approach

The LWRP Hydraulic Model was developed based on the Process Flow and Hydraulic Profile Drawings from the Phase V plans (1991).). The model was developed for the following two scenarios:

- One Aeration Tank and one secondary clarifier is not in operation
- All preliminary, primary and secondary facilities are in operation

The model was evaluated for the following flows to determine the maximum water surface elevation and flows at which overflow occurs at each process area for both the scenarios listed above.

- ADWF of 8.5 mgd – Existing Rated Capacity
- Peak hourly wet weather flow of 15.5 mgd – Phase V Design Capacity
- Ultimate build-out flow of 9.47 mgd ADWF
- Projected Peak Hourly flow of 26.1 mgd
- Projected Peak Day flow of 15.29 mgd
- LAVWMA peak wet weather flow of 12.4 mgd

2.5.2 Assumptions

From discussion with the City of Livermore, the RAS flow is equal to about 30% of the influent flow and enters into the process upstream of the aeration tanks. These additional flows are included in the aeration basin portion of the model at 4.65 mgd for the peak hourly flow rate and 2.55 mgd for the average daily flow rate. Additionally, prior information on the operation of the plant indicates that two secondary clarifiers be used unless poor sludge settleability causes the need for the third clarifier.

In developing the model, the pipe friction losses were based on a factor for aging pipe using the Hazen-Williams equation. Additional considerations in developing the model included minor losses from pipe fittings, appurtenances, and entrance/exit losses into and out of structures; headlosses over weirs and other appurtenances such as bar screens where applicable; and elevations of treatment structures from record drawings. Further details on the assumptions made to develop the model are described in the calculation worksheet of the model included in Appendix B.

2.5.3 Limitations

The hydraulic model was developed based on the flow and conditions listed in the assumptions above. In addition, the information used to develop the model was based on record drawings and discussions with the City staff. The water surface elevation of some processes listed in the model is based on the water surface elevation given in the Phase V Hydraulic Profile or a calculated water surface elevation if no weir or other structure causing a change in the hydraulic grade was indicated in the plans.

2.5.4 Existing Facility Hydraulic Capacity

Hydraulic calculations show that under both the scenarios the existing primary and secondary facilities have sufficient hydraulic capacity to pass the current flows, ultimate build-out flow of 9.47 mgd, peak hourly flow of 26.1 mgd, peak day flow of 15.29 mgd and LAVWMA peak wet weather flow of 12.4 mgd. The water surface elevations calculated in the model are relatively close to the previous hydraulic flow calculations. The model output for each flow scenario is included in Appendix B. The model also evaluated to determine the flows at which the facilities overflow. Based on the evaluation the secondary effluent distribution box will overflow at an influent flow of 32 mgd. The total flow at the secondary effluent distribution box will be 32 mgd plus 9.6 mgd RAS flow. The bar screen chamber will overflow at an influent flow of 35 mgd.

2.5.5 LAVWMA Pump Station Hydraulic Analysis

Secondary effluent from the LWRP discharges to Livermore-Amador Valley Water Management Agency pipeline. The City's allocated capacity in the LAVWMA system is 12.4 mgd. Tetra Tech completed a hydraulic analysis of the LAVWMA pump station to determine whether the existing pumps can handle the allocated flow of 12.4 mgd. The system curve was developed to determine the flow conditions using the existing pump curves. The hydraulic calculations determined that the existing pump can pump the allocated flow of 12.4 mgd and maximum flow of 13.5 mgd to the LAVWMA pipeline. The pump station hydraulic calculations and the system curve are included in Appendix C.

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3.0 PERFORMANCE EVALUATION OF EXISTING PROCESSES

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3.0 Performance Evaluation of Existing Processes

3.0 PERFORMANCE EVALUATION OF EXISTING PROCESSES

Tetra Tech conducted a comprehensive performance evaluation (CPE) of the LWRP to estimate major unit process capacities, for both the liquid and solids treatment trains, under current organic loading and discharge conditions.

3.1 Liquid Treatment Processes

The CPE evaluated the condition and capacity of the influent pumps, preliminary treatment equipment, the primary clarifiers, aeration basins, secondary clarifiers, chlorine disinfection, and the outfall pipeline. Unit capacities are either based on hydraulic flow rates or BOD loading. The capacities that are based on BOD loading are converted to an equivalent ADWF but the limiting criteria is based on a BOD load that can occur at flows above ADWF. There is equal probability that high BOD load occurs during higher flow or low flows. High wet weather flows are a result of storm events that add flow but not BOD load; therefore, the BOD concentration is lower during high flow events resulting in a similar overall BOD load. For unit capacity limiting criteria that are based on BOD loading it does matter whether the high BOD load occurs during high or low flow because the criteria is not time sensitive.

The effect of wet weather flows on the unit processes is discussed in Section 3.1.7 of the report. The project scope did not provide for a thorough evaluation of the reuse filters and the UV disinfection system. However, operational issues with the UV system were discussed with LWRP staff. Historical process control and other operational data was used to evaluate each unit process based on the current loadings and peaking factors. For each evaluation, three and a half years of data from January 2009 through June 2012 was used.

3.1.1 Influent Pumping

Raw sewage is lifted into the preliminary treatment area using three covered screw pumps, each with a capacity of 5.7 mgd, for a firm and total pumping capacity of 11.4 and 17.1 mgd, respectively. The channel leading to the influent pump wetwell has an overflow weir gate that automatically diverts high flows to the 15 MG emergency holding basin. The height of the weir gate is adjustable so the operators can vary how much of the influent flow is diverted into temporary storage. The peak two-week wet weather event requires an average daily flow of 12.4 mgd. If one of the influent pumps were out of service during the peak two-week event, 14 MG of storage ((12.4 mgd – 11.4 mgd)*14 days) would be required in the 15 MG storage basin. While the emergency storage basin is large enough to hold this volume, there is not enough storage volume to also equalize diurnal flows which is a critical part of the operation of the secondary treatment process as discussed in Section 3.1.4.6.

3.1.2 Preliminary Treatment

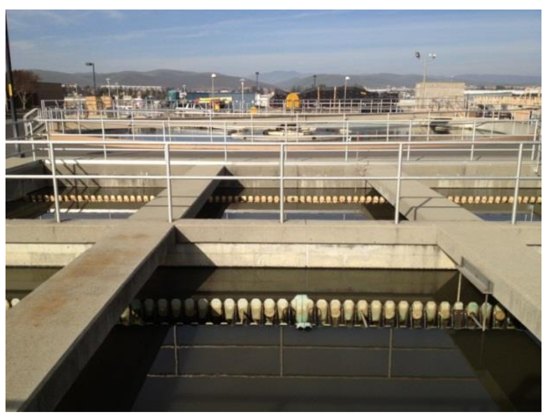
The lifted wastewater travels through a single mechanical climber-style bar screen with 5/8-inch clear openings that removes rags, plastic material and other inorganic debris that might clog treatment processes further down the flow path. The removed screenings are sent to a washer and compactor before being deposited in a dumpster that is periodically hauled to a landfill. The mechanical screen has a rated capacity of 12 mgd. There is a bypass channel around the mechanical screen that contains an in-channel grinder. In the event of peak flows that are greater than the capacity of the screen, the channel grinder or bypass channel can be used to pass the flow. Due to the presence of the grinder and bypass channels, there is no capacity limitation for preliminary treatment. If the mechanical screen is out-of-service, ground debris would flow into the primary clarifiers and perhaps the aeration tanks and secondary clarifiers as well. The bar screen is open to the atmosphere, and odors can exit from the wastewater to the atmosphere.

Immediately downstream of the screen is a 24-inch Parshall flume, which is the official influent flow measurement device for this plant. The flume has a hydraulic capacity of 21.3 mgd before becoming submerged. A refrigerated composite sampler and pH probe are located near the flume to collect samples for characterizing the quality of the influent flow. Downstream of the influent flume, recycle flows from the plant are introduced into the flow path. The recycle flows include return from emergency holding basin, filtrate from the Belt Filter Press (BFP) and Gravity Belt Thickener (GBT), and reuse filter backwash. Ferric chloride is typically added to influent downstream of the addition of the recycle flows at a concentration between 8 to 10 mg/L to control hydrogen sulfide production in the anaerobic digesters.

The influent wastewater is degritted using two aerated grit removal basins. These basins are 19 feet by 34 feet by 10 feet deep with a peak wet weather hydraulic detention time of approximately 9 minutes. The grit collected at the bottom of the basins is pumped by one of two 140 gpm recessed impeller grit pumps to a single grit classifier for washing and dewatering prior to temporary storage in a dumpster that is periodically hauled to a landfill for disposal.

3.1.3 Primary Treatment

The screened and degritted flow is recombined before being split among four rectangular primary clarifiers, each 10 feet deep with surface dimensions of 19 feet by 124 feet. Settled primary sludge, usually between 3.0% and 4.0% solids, is collected from the clarifiers and pumped via five 50 gpm progressing cavity pumps to the anaerobic digesters. The primary sludge pumps are controlled on adjustable timers that allow the operations staff to maintain an average sludge blanket of 2 feet. Scum is scraped from the top of the clarifiers and is collected at the influent side of the clarifier in dedicated scum boxes. The scum box is periodically pumped to the anaerobic digesters using one of two 50 gpm progressing cavity pumps.



Historical process control data was analyzed to determine performance of the primary clarifiers. The BOD and TSS removal efficiencies were determined and are summarized in Table 3-1. The removal efficiencies for both TSS and BOD are considered to be very high indicating excellent performance even though the primary clarifiers are already operating at a higher than typical surface overflow rates (SORs). A typical design SOR for primary clarifier design is 800 to 1,000 gal/ft^2/day based on average daily flow. Tetra Tech performed a sensitivity analysis to determine the SOR at which TSS or BOD removal efficiency began to decrease. The analysis showed that at a SOR of 1,100 gal/ft^2/day, there was a slight decrease in average removal efficiency (1.5% decline for BOD and 3% decline for TSS), while at 1,200 gal/ft^2/day there was a 6% and 3% decline in BOD and TSS respectively. The analysis showed that the LWRP can consistently provide high BOD and TSS removal efficiencies at SORs up to 1,000 gal/ft^2/day before experiencing a decrease in performance.

The capacity of the primary clarifiers is dependent on flow rate; therefore, it is important to distinguish between ADWF and AWWF capacity. Besides being able to hydraulically pass flow through the clarifiers, the capacity of the primary clarifiers is tied to BOD and TSS removal efficiency. For ADWF, the historical data showed that there was little decrease in removal efficiency between SORs of 1,000 to 1,100 gal/ft^2/day; therefore, using a design basis of 1,050 gal/ft^2/day should achieve current BOD and TSS removal efficiencies. The ultimate buildout BOD and TSS load (as shown in Table 2-3) is 28,200 and 35,700 lb/day respectively. The projected primary effluent load at ultimate buildout using the historical average BOD and TSS removal efficiencies of 45 and 66% (presented in Table 3-1) is 15,500 and 11,800 lb/day respectively. During wet weather flows; the removal efficiency will begin to decrease. The peak month wet weather flow rate at ultimate buildout is projected to be 10.93 mgd. At this flow rate, the primary clarifiers should be able to handle maximum month BOD load without much loss in removal efficiency. As shown in the sensitivity analysis, there was a slight decrease in removal efficiency (6% for BOD) at a SOR of 1,200 gal/ft^2/day which would correspond to a peak wet weather monthly flow of 11.31 mgd. For the peak two-week flow of 12.4 mgd at ultimate buildout, the SOR would be higher which will likely result in decreased removal efficiency. The primary clarifiers can hydraulically handle peak two-week flows, and the downstream aeration basins can handle a higher BOD concentration for a two-week period; therefore a peak two-week SOR does not limit the overall capacity of the primary clarifiers.

Table 3-1. Primary Clarifier Process Design and Operating Parameters for the period January 2009 through June 2012

Parameter	Units	30-Day Moving Average	Maximum 30-Day Moving Average	Minimum 30-Day Moving Average
Influent flow	mgd	7.07	8.0	6.68
Influent $CBOD_5$	mg/L	240	330	170
Influent $CBOD_5$	lb/day	14,300	20,700	10,400
Influent TSS	mg/L	290	430	220
Influent TSS	lb/day	17,200	26,200	12,500
Pri. Effluent CBOD	mg/L	130	170	100
Pri. Effluent CBOD	lb/day	7,960	11,276	5,683
Pri. Effluent TSS	mg/L	92	120	75
Pri. Effluent TSS	lb/day	5,500	7,000	4,300
BOD Removal	%	45%	68%	30%
TSS Removal	%	66%	82%	55%
SOR	gal/ft^2/day	900	1,100	700
Detention Time, hr	hr	2.4	2.56	2.13

The estimated 30-day average primary clarifier capacity is 9.90 mgd as summarized in Table 3-2. Firm capacity is not required for primary clarifiers, and capacity is considered to include all clarifiers in operation. Maintenance should be done on a clarifier during low flow periods. If a clarifier is unexpectedly out of service, additional ferric chloride can be fed to the system to increase removal efficiency at higher SOR.

Table 3-2. Primary Clarifier Process Capacity

Unit	Description	Design Evaluation Criteria (gal/ft2/day)	Estimated Present Capacity ADWF (mgd)
Primary Clarifiers	4 clarifiers @ 19' X 124' Total surface area: 9,424 ft^2	SOR_{ADWF} = 1,050	9.90
		SOR_{WWF} = 1,200	11.43
	3 clarifiers total surface area: 7,068 ft^2	SOR_{ADWF} = 1,050	7.34
		SOR_{WWF} = 1,200	8.48

3.1.4 Secondary Treatment

Primary effluent is pumped to the step feed aeration tanks by three, 5,000 gpm pumps which are equipped with VFDs. The flow rate to the aeration basins is set by the operations staff. Flows above the primary effluent pump setpoint flow by gravity to the emergency holding basin for equalization. The current operation diverts routine peak diurnal flows to the emergency holding basin, which are later returned to the aeration tanks during low flow periods. Equalization of daily diurnal peaks results in a relatively constant organic load being delivered to the aeration basins throughout the day.

There are two rectangular aeration tanks using two passes per tank; however, only one is operational at this time. Presently, Aeration Tank #1 is not functional and will require significant modifications to the aeration system before it is operable. Each tank is 30 feet wide by 320 feet long by 14.5 feet deep with a volume of 139,200 cubic feet or 1,041,216 gallons. Three high speed turbo (HST) blowers are installed, which can supply 9,100 SCFM on a firm capacity basis.

Aeration tank mixed liquor discharges to the clarifier splitting structure, which distributes the flow to the three secondary clarifiers. Each clarifier is 90 feet in diameter with a 15 foot sidewall depth. Therefore, each clarifier provides a surface area of 6,362 ft^2 and a volume of 95,430 ft^3 or 713,816 gallons. Typically, two or three clarifiers are currently used. If two clarifiers are on-line, the resulting surface area will be 12,723 ft^2 with 1,427,632 gallons in volume. If three clarifiers are on-line, the resulting surface area will total 19,085 ft^2 with 2,141,448 gallons in volume. Settled sludge is collected by "organ pipe" differential head sludge collectors located on each side of the center mechanism. Return sludge flow rate through each collector tube can be controlled slightly by adjusting individual tube discharge ports; however, often a slight modification can slow the flow rate to the point where the collector tube plugs. Thus, operators often tend to operate all tubes completely open, and the sludge concentration from each tube can vary significantly. Secondary sludge is collected and returned via six centrifugal RAS pumps rated at 2.83 mgd each, or wasted to the GBTs and then digestion using any of four 110 gpm centrifugal waste activated sludge (WAS) pumps. Typically, wasting occurs continuously 24 hours per day, 365 days per year.

Historical process control data was analyzed to evaluate the performance of the aeration basins. The average, maximum and minimum moving 30-day average was calculated for each parameter. Table 3-3 presents the results of the analysis and summarizes the following parameters:

- Mixed Liquor Suspended Solids concentration (MLSS)
- Mixed Liquor Volatile Suspended Solids concentration (MLVSS)
- Mean Cell Residence Time (MCRT)
- Hydraulic Retention Time (HRT)
- Solids Detention Time in the Aerator (SDT_A), which is defined as the time solids spend in a single pass through the aeration basin
- Organic Space Loading (SL)
- Food to Microorganism ratio (F/M)
- Sludge Volume Index (SVI)

Table 3-3. Step-Feed Activated Sludge Process Design and Operating Parameters for the period January 2009 through June 2012(1)

Parameter	Units	30-Day Moving Average	Maximum 30-Day Moving Average	Minimum 30-Day Moving Average
MLSS	mg/L	1,660	2,400	1,300
MLVSS	mg/L	1,400	2,000	1,100
MCRT	days	2.06	2.59	1.91
HRT, design(2)	hr	3.55	3.79	3.14
SDT_A(3)	hr	3.06	3.61	2.49
SL	lb CBOD /1,000 ft^3/day	58	70	42
Food to microorganism ratio (F/M)	lb/lb	0.69	0.85	0.45
SVI	mL/g	110	380	56

(1) One aeration basin was in operation during this period
(2) Based on influent flow rate only
(3) Based on influent flow rate plus return sludge flow rate

In general, the performance of the aeration basins is exceptional considering that the existing facility is already being operated at loadings above those considered maximum design values without exceeding permit limit or experiencing settleability problems. The operations staff coaxes this system to treat wastewater better than it should typically be able to treat. Exceptional operations, presence of an anaerobic selector, and flow/organic load equalization are thought to contribute to the exceptional performance. These factors are discussed later in the Master Plan.

Each of these parameters listed in Table 3-3 impact the activated sludge process in different ways and is described further in the following paragraphs. The capacity of the activated sludge process is determined by analyzing each of these parameters, evaluating how they interact, and determining which parameter(s) limits the capacity of the aeration basins.

3.1.4.1 Hydraulic Retention Time (HRT)

The HRT is dependent upon influent flow rate (Q) and is a measure of the average amount of time wastewater spends in the system. The SDT_A is dependent upon influent Q and return sludge flow rates and represents the time available for various microorganisms to attack, consume and metabolize organic wastewater constituents. Organisms can consume the organic BOD (i.e. CBOD) and store it. If the consumed BOD is not completely metabolized, the organisms can process it the next time through the aeration tank. However, if the organisms go to the clarifier with too much organic material still not metabolized, they will continue to process the material under anaerobic conditions in the clarifier. This can reduce settleability and thus jeopardize effluent quality. It can also be the source of organic acids that can spur the growth of certain filamentous organisms. Therefore, the objective is to completely metabolize the BOD before the wastewater discharges to the clarifiers. For most domestic wastewater that is aerated with adequate biomass, 3 to 4 hours of HRT gives the microorganisms enough time to completely metabolize the BOD.

Two lines in Table 3-3 relate to HRT. The first line represents a typical design value based solely on the volume of the aeration tanks and the influent flow. The second line entitled SDT_A, defines the actual time in the aeration tank that an organism stays in contact with the materials to be metabolized and includes all flows into the aeration tank. Therefore, the RAS flow rate is added to the influent flow rate to obtain the actual clarifier influent flow rate. By adding these flows, it can be seen that the "actual" time is less than the "design" time. However, the "actual" time gives a much truer representation of aeration tank metabolic conditions. Therefore, the actual time is more important.

3.1.4.2 Sludge Settleability

In most municipal activated sludge systems without significant industrial contribution, such as at the LWRP, the microorganisms are capable of metabolizing the organic materials contained in the influent wastewater. The hydraulic retention time calculation previously discussed addresses the issue of available time for the microorganisms to metabolize the materials. However, that time does not necessarily relate to the amount of food available per organism and the resulting growth rate expected. Too high growth rates tend to produce activated sludges that do not settle well. Sludge settleability is usually addressed during design by looking at two parameters, SL and F/M. High SL and F/M conditions tend to produce poor settling sludges that make it very difficult to meet TSS and BOD limits since 1 mg/L of effluent TSS will typically contain approximately 0.5 mg/L of BOD. Another parameter, MLSS, is often given a design value; however, SL and F/M both depend on MLSS. Therefore, even though MLSS is often listed as a design parameter, it has little to do with actual operations except as related to SL and F/M. The F/M ratio is also related indirectly to MCRT; but MCRT is more difficult to use as a design parameter; therefore, F/M will be used along with SL. The actual sludge settleability is often characterized by SVI. This parameter indicates the volume occupied by a unit weight of MLSS. Thus, systems operating within typical design ranges would have SVI typically in the 100-150 range. Higher values indicate poor (too slow) settling while very low values also indicate settleability problems (too fast). The following discusses each of these parameters in more detail.

3.1.4.3 Sludge Volume Index (SVI)

The 30-day average of 110 mL/g is very good, especially for a plant as highly loaded as the LWRP. Tetra Tech identified several potential reasons for the extremely good performance and feel that the following are among the most important: anaerobic selector, flow/organic load equalization, and good process control. Good process control alone cannot be used as a reason to allow high design loadings because effluent quality may change as staff changes. However, continued use of the anaerobic selector and primary effluent flow/load equalization justifies the use of loading values at the high end of the design and operating spectrum.

Microscopic observation of the activated sludge indicated a high population of phosphorus accumulating organisms (PAOs). The PAOs are physically much denser and tend to settle faster than typical activated sludge organisms. The anaerobic selector provides the growth environment that promotes the growth of the PAOs; therefore continued use of an anaerobic selector is critical to maintaining a low SVI. Diurnal flow equalization balances the loads throughout the day so that the microorganisms can grow at a slower and constant pace. Without load equalization, the bacterial growth rate increases when high diurnal loads enter the system, which can cause excessively fast growth and poor settling. Continuation of these two processes will allow higher standard loadings to be used.

3.1.4.4 Space Loading (SL)

In most systems, SL is a very important parameter that relates closely to the settleability of the sludge. If the sludge cannot settle well, there will be clarifier and effluent quality issues. The allowable SL for a step-feed activated sludge plant may range from about 40-60 lb BOD/10^3 ft^3. For the LWRP, the allowable space load was established at the upper limit of 50 lb BOD/10^3 ft^3 to provide some conservatism in aeration tank capacity. The actual average SL at Livermore is approximately 58 lb BOD/10^3 ft^3, resulting in an SVI of 110 mL/g. This shows that this SL value is suitable for design.

3.1.4.5 F/M Ratio/MCRT

The F/M ratio is basically the reciprocal of the MCRT. Thus, high MCRT provides low F/M ratio and vice versa. The F/M represents the amount of BOD consumed by a unit weight of microorganisms, typically a pound of MLVSS. Too much food per unit of organisms means that the organisms will grow too fast and develop a sludge that will not settle well in the clarifiers. On the other hand, too little food causes a starvation condition where it is theorized that the organisms begin to feed upon sticky waste products that have accumulated on the outside of the cell, and the cells cannot stick together. This produces a sludge that settles very rapidly, leaving a turbid effluent. The objective is to use an F/M that does not make the organisms grow too fast but does not starve them either.

The F/M is an empirical parameter for evaluating the capacity of a system. Past experience has shown that for a conventional activated sludge system, poor settleability can occur when the F/M is greater than 0.5 lb/lb and optimal settleability occurs when the F/M is between 0.3 and 0.5 lb/lb. The LWRP is currently operating with an average F/M of 0.69 lb/lb which is greater than the optimal settleability range. It is likely that the anaerobic selector and the diurnal flow equalization are preventing filamentous bacteria from growing abundantly and the F/M ratio can be higher than “typical” systems. To be conservative, a F/M of 0.4 lb/lb will be used as capacity criteria in the master plan.

3.1.4.6 Capacity Analysis for HRT, SL, and F/M

The capacity of the aeration basins was evaluated using HRT, SL, F/M, and aeration system capacity. All capacities are based on both aeration basins in operation, continued operation of the anaerobic zone, and diurnal flow equalization. If the operation changes, then sludge settleability could change and capacities listed in the table would be lower. The results of the analysis are presented in Table 3-4 and are summarized below.

Table 3-4. Total Aeration Basin Capacity

Unit	Design Evaluation Criteria	Organic Capacity (Primary Effluent) lb $CBOD_5$/d	Estimated Present Capacity – ADWF - mgd
Aeration Tanks 2@30'X320'X14.5'	HRT –4 hours	N/A	12.5
	Space Load – 58 lb $CBOD_5$/1,000 ft^3/day	16,147	9.85
	F/M – 0.4 lb/lb	16,395	10.00
Blowers	Peak Day Loadings	30,600	15.28
	Max Month Loading	18,715	11.42

As shown in Table 3-4 and using a conservative value of 4 hours of HRT for a step-feed process, the allowable influent flow rate using two aeration tanks is 12.5 mgd. Design HRT analysis is based upon the following equation:

$$HRT = \frac{V * 24}{Q}$$

Where:

V is the volume of the aeration tanks in MG
24 is the number of hours in a day
Q is the ADWF in mgd

Space loading is based upon the organic loading in lb CBOD/d per 10^3 ft^3 of the aeration tank. The recommended space loading rate of 58 lb CBOD/d/1,000 ft^3 for the LWRP is in the typical range for step-feed systems and is the current average organic loading. An additional 10 lb CBOD/d/1,000 ft^3 could have been added to account for the anaerobic selector, which has been shown to be very effective in improving sludge settleability, but to be conservative, it was not included at this time. Based upon the 58 lb $CBOD_5$/d/1,000 ft^3 and the volume of 278,000 ft^3, the allowable ADWF is 9.85 mgd, using maximum month BOD loading.

F/M ratio is usually limited to 0.4 lb $CBOD_5$/lb MLVSS even in a step feed system. Data analysis indicated that the average amount of sludge contained in the secondary clarifiers is about 18% of the total sludge mass, and the average maximum 30-day MLVSS is approximately 2,000 mg/L. Based upon these values and the maximum month BOD loading, the allowable influent ADWF based upon F/M for two aeration tanks is 10.00 mgd as shown in Table 3-4.

Both the anaerobic selector and the diurnal flow equalization improve settleability by limiting the growth of filamentous bacteria. Many filamentous bacteria that tend to grow in activated sludge systems are obligate aerobes that require DO to survive. The anaerobic conditions in the selector create an environment where obligate aerobes (i.e. many filamentous bacteria) cannot proliferate. The equalization of the diurnal load creates a relatively constant BOD going to aeration basins. This creates a constant supply of organic matter for the bacteria to consume and limits an environment where filamentous bacteria can obtain a competitive advantage to reach from the bacterial floc to consume spikes of organic matter. While both these improve operational conditions at the plant, their benefits cannot be quantified in terms of capacity; however, it is critical that current operation continue to maintain the currently settleability.

Based upon the limiting aeration tank factor of SL, the ADWF for the two aeration basins combined is 9.85 mgd which corresponds to a primary effluent BOD load of 16,100 lb/day. Based on this evaluation there is adequate aeration basin capacity to treat the ultimate buildout ADWF of 9.47 mgd.

3.1.4.7 Aeration Capacity

Air is supplied by three, 250 hp HST blowers. Firm aeration capacity is based on operations with one blower out of service and operating the step feed activated sludge system at a minimum DO of 2.0 mg/L at the maximum month loading. The capacity of the blowers at peak day loading is also calculated to ensure the blower system can supply at least 1.0 mg/L DO with all blowers operating. The blower capacity is lower of the peak day and maximum month conditions as described above.

The standard oxygen transfer efficiency (SOTE) of the fine bubble diffusers is calculated based on the following:

$$AOTE = SOTE[\frac{\alpha(\beta C_{SW} - C_L)}{C_S}]\theta^{T-20}$$

Where:

AOTE = field oxygen transfer efficiency, lb O_2/hr
SOTE = standard oxygen transfer efficiency, 1.8 lb O_2/ft (submergence)/hr for typical fine bubble diffuser
α = oxygen transfer rate constant, 0.5
β = oxygen saturation constant, 0.95
C_{SW} = oxygen saturation at site conditions, 8.32 mg/L
C_L = mixed liquor dissolved oxygen concentration, 1.0 mg/L (actually used)
C_S = oxygen saturation of clean water at std. conditions, 9.17 mg/L
θ = temperature correction constant, 1.024
T = maximum temperature of mixed liquor, 29°C

The above input values are used to calculate the mass of oxygen that must be provided by the blowers, which is compared to the blower's operating curve to estimate blower horsepower requirements. Based on maximum month conditions, two of the existing blowers can supply 10,950 SCFM which can treat up to 11.42 mgd of ADWF with 18,715 lb/day of BOD and an assumed 550 lb/day of ammonia (nitrifying approximately 5 mg-N/L). Based on peak day conditions, the three existing blowers can supply 16,425 SCFM, which can treat up to 30,600 lb/day of BOD and 1,493 lb/day of ammonia (nitrifying approximately 10 mg-N/L). Based on historical data at the LWRP, the peak day primary effluent to average primary effluent load is 1.74 which corresponds to an ultimate primary effluent BOD peak day load of 18,700 lb/day. The peak day load of 30,600 lb/day would not occur until the ADWF corresponds to 15.28 mgd.

3.1.4.8 Secondary Clarifiers

Historical process control data was analyzed to evaluate the performance of the secondary clarifiers. The average, maximum, and minimum moving 30-day average was calculated for each parameter. Table 3-5 presents the results of the analysis and summarizes the following parameters:

- Surface Overflow Rate (SOR)
- Solids Loading Rate (SLR)
- Return sludge pumping capacity

Table 3-5. Secondary Clarifier Design and Operating Parameters for the Period January 2009 through June 2012

Parameter	Units	30-Day Moving Average	Maximum 30-Day Moving Average	Minimum 30-day Moving Average
Surface area, total online	ft^2	12,723	19,085	12,723
Volume	MG	1.43	2.14	1.43
SOR	$gal/ft^2/day$	504	614	355
SLR	lb $TSS/ft^2/day$	9.12	15.03	6.23
Return sludge flow	mgd	2.44	3.89	1.72
RAS Flow	% of Inf Q	35	56	23

3.1.4.9 Surface Overflow Rate

The SOR is a measure of unit flow through a clarifier per square foot of surface area. This is a typical design parameter to determine the *hydraulic* capacity of a clarifier. Design of the secondary clarifiers is typically for a surface overflow rate between 600 to 800 gallons per square foot per day ($gal/ft^2/day$) on a maximum month basis. Higher SORs can adequately be supported by the clarifiers for shorter periods of time. As presented in Table 3-5 the maximum 30-day SOR from the data set was 614 $gal/ft^2/day$.

Assuming typical design criteria of 600 $gal/ft^2/day$ (which is conservative for a conventional activated sludge system) and based on maximum month wet weather flow under the current operation of all three clarifiers combined the secondary clarifiers have a hydraulic capacity of 11.45 mgd. Based upon SOR, the secondary clarifiers have plenty of hydraulic capacity to meet future flow needs and are not the capacity-limiting factor. This assumes plant staff performs planned preventative maintenance in the winter and all three units are available for the winter wet weather flow season.

3.1.4.10 Clarifier Solids Loading Rate

The SOR is easy to calculate and is the most commonly used design parameter for secondary clarifiers; however, it does not take into account the mixed liquor concentration. Thus, another useful design parameter for secondary clarifiers is the SLR which accounts for the mass of solids applied to the clarifiers. This parameter measures the mass of suspended solids entering the clarifier (and hence includes RAS and filter backwash flows) per square foot of clarifier surface area. Typical solids loading rate values for activated sludge facilities are between 25 and 30 pounds of TSS per square foot per day (lb $TSS/ft^2/day$). As shown in Table 3-5, the current maximum month SLR is 15.03 lb $TSS/ft^2/day$. The current SLR is low because the operations at LWRP tend to use a low RAS flow rate that averages to be 56% of the influent flow. This operation should be continued to minimize SLR. The capacity of the clarifiers was assessed on a maximum RAS of 100% of the influent flow rate which is required by many state criteria; although not recommended for operation. Assuming a maximum design criterion of 25 lb TSS/ft^2/day and a 100% return sludge flow rate, the secondary clarifiers have a 30-day wet weather 30-day flow capacity of 11.92 mgd and a 15.3 mgd capacity at the current average RAS flow of 56% influent flow rate.

3.1.4.11 Secondary Clarifier Capacity Summary

Similar to aeration tanks, the design parameters for the secondary clarifiers were used to determine a maximum hydraulic capacity, both in terms of hydraulic loading and solids loading. The capacity of the secondary clarifiers is based on all three clarifiers in service. With one clarifier out of service, the SOR at maximum month ultimate buildout flow conditions of 10.9 mgd would be 860 gal/ft^2/day which is lower than peak clarifier design capacity. The SLR would be 27 lb/ft^2/day at average RAS flow rates which is within the typical range for a clarifier. The size of the secondary clarifiers is adequate for ultimate buildout flows and loadings. Table 3-6 summarizes the capacity of the secondary clarifiers.

Table 3-6. Secondary Clarifier Process Capacity

Unit	Description	Design Evaluation Criteria	Estimated Present Capacity (1)
Secondary Clarifiers	3 clarifiers @ 90 ft dia. Total area: 19,085 ft^2	SOR = 600 gal/ft^2/d	11.45 mgd
		SLR = 25 lb TSS/ft^2/d @ Qr = 1.00 Q and MLSS = 2,400 mg/L	11.92 mgd
	2 clarifiers @ 90 ft dia. Total area: 12,723	SOR = 860 gal/ft^2/d	10.90 mgd
		SLR = 27 lb TSS/ft^2/d @ Qr = 0.56 Q and MLSS = 2,400 mg/L	10.90 mgd

(1) Flow capacities are considered to be maximum month wet weather flow rates.

3.1.5 Effluent Disposal

The effluent from the secondary clarifiers receives further treatment prior to reuse or discharge to the LAVWMA pipeline. The effluent discharged from the LWRP flows by gravity in the 27-inch diameter Livermore Interceptor for approximately 6 miles before it combines with treated wastewater effluent from the Dublin-San Ramon Services District (DSRSD) at the LAVWMA pump station. The combined treated wastewater flows are pumped and transported via the LAVWMA pipeline, which connects to the East Bay Dischargers Authority (EBDA) pipeline that then discharges to the San Francisco Bay. The City of Livermore has an allocated wet weather capacity of 12.4 mgd in the LAVWMA pipeline.

The official compliance points in the City's NPDES permit are as summarized in Table 3-7.

Table 3-7. Point of Compliance for NPDES Permit

Permit Parameter	Point of Compliance(1)(2)
$CBOD_5$	M-002E
TSS	M-002E
pH	M-002E
$CBOD_5$ % Removal	M-002E
TSS % Removal	M-002E
Oil and Grease	M-001
Chlorine Residual	M-001
Fecal Coliform	M-001
Enterococcus Bacteria	M-001
Cu (total)	M-001
CN (total)	M-001
Dioxin-TEQ	M-001
Total Ammonia	M-001
WET (acute and chronic)	M-001

(1) Monitoring point M-002E is defined as any point in the treatment plant at which adequate disinfection has taken place and just prior to where Livermore transfers control of its effluent to LAVWMA facilities.
(2) Monitoring point M-001 is defined as any point in the EBDA Common Outfall at which all waste tributary to that outfall is present after final dechlorination at the Marina Dechlorination Facility.

Effluent not discharged through the LAVWMA pipeline receives tertiary treatment at the LWRP before being reused locally in the City. Prior to reuse, secondary effluent is passed through granular media filters and then disinfected via UV light. The reuse treatment system has mono-media filters with a firm capacity of 7.86 mgd and a UV system with a permitted capacity of 6.0 mgd. The reuse water meets California Department of Health Services requirements for disinfected tertiary effluent, which allows for unrestricted use. From January 2009 through June 2012, an average of 22.8% of the wastewater entering the LWRP was treated for reuse. Currently the amount of reuse water is limited by customer demand, and not the capacity of either the main plant or the reuse treatment system.

3.1.6 Disinfection

The portion of the secondary effluent that is discharged to the LAVWMA pipeline is disinfected using liquid sodium hypochlorite prior to leaving the LWRP site. The chlorine contact basin has a volume of 19,500 ft^3. At the prior capacity allocation of the LAVWMA pipeline of 8.4 mgd, the chlorine contact tank can provide 25 minutes of contact time. However, at the expanded capacity allocation of 12.4 mgd, there is only 17 minutes of contact time. These contact times do not include time in the Livermore Interceptor or time in the LAVWMA pipeline. When detention time in these pipelines is considered, there is adequate contact time to achieve disinfection at wet weather flows of 12.4 mgd. The Livermore Interceptor adds approximately 1,000,000 gal of volume in ideal plug flow conditions. Based on volume this means that there is adequate disinfection volume to provide 25 minutes of contact time at flows up to 66.65 mgd. The pipeline is hydraulically limited before this flow is reached. Considering the interceptor is not full, actual contact time can be estimated based on an assumed velocity in the pipeline. Assuming a velocity of 5 ft/s (which is a fast velocity in an interceptor) there is over 115 minutes of contact time in the interceptor which is adequate contact time for disinfection.

As shown in Table 3-7, the City's official point of compliance for disinfection is immediately prior to discharge to the San Francisco Bay; however, member agencies of the LAVWMA require compliance with disinfection prior to treated effluent being mixed with other discharges. This effectively means that the City must comply with disinfection limits prior to the discharge to the LAVWMA Pump Station. Accordingly, the Livermore Interceptor can be included in chlorine contact time calculations. The pipeline provides nearly perfect plug flow conditions, which is highly desirable for chlorine disinfection. When considering the pipeline volume, Livermore has more than adequate contact time for disinfection at 12.4 mgd. Consequently, Tetra Tech does not recommend expanding the chlorine contact basin at the LWRP to deal with the increased wet weather flow conveyance capacity allocation of 12.4 mgd.

3.1.7 Wet Weather Flows

The emergency holding basin is used to shave peak wet weather flows that exceed capacity for preliminary treatment equipment. Peak storm events for the City have been evaluated in previous studies, which have concluded that the emergency holding basin can accommodate the flows from the 20-year and 100-year storm events and will be emptied at the rate of 12.4 mgd over a period of 14 days. Some, but not all of the unit capacities listed in this section are affected by wet weather flows. Wet weather events primarily increase flow (sometimes TSS from flushing deposited solids from the collection system) and not BOD. The only unit capacities that are limited by hydraulics are primary clarifier SOR, aeration basin HRT, secondary clarifier SOR and chlorine contact time. The HRT unit capacity for the aeration basins is adequate to handle the wet weather flows. The contact time for the disinfection system is not a concern when the use of the Livermore Interceptor is taken into account, as described in Section 3.1.6.

While the primary clarifier SOR will increase when flows increase, the principal impact is a gradual decrease in BOD and TSS removal efficiency, which adds additional load on the aeration basins. The primary clarifier SOR would be 1,315 gal/day/ft^2 at the peak flow of 12.4 mgd. Historical data indicates that the removal efficiency at high SOR decreases to approximately 35% for BOD and 55% for TSS. This would add 10% (45% average – 35% high SOR = 10%) to the average load to the aeration basins, which is less than the maximum month conditions. The aeration basins can handle this slight increase in organic loading for the short term two week basis. Accordingly, wet weather flows do not limit primary clarifier capacity.

The SOR that controls the capacity of the secondary clarifiers can also be exceeded for a two week period. The SOR associated with a peak two week wet weather flow of 12.4 mgd is 650 gal/day/ft^2, which is slightly higher than the recommended 30-day SOR of 600 gal/day/ft^2 for maximum month flow conditions. The recommended SOR in literature (Wastewater Engineering and Treatment, Metcalf and Eddy, 2004 and WEF MOP 8) for a peak condition is 900 gal/day/ft^2. While there is not any standard literature values for a peak two week condition, considering the 650 gal/ft^2/day value is only slightly higher than the maximum month and considerably lower than the peak condition, the peak two week SOR of 650 gal/ft^2/day at 12.4 mgd should not limit the capacity of the clarifier. The low SVIs experienced at the City also indicate that the City's secondary clarifiers can handle brief periods of higher SORs than that for the ADWF conditions.

3.2 Solids Treatment Processes

The CPE evaluated the condition and capacity of the GBTs, anaerobic digesters, and the BFPs. Historical process control and other operational data were used to evaluate each unit process based on the current loadings and peaking factors. For each evaluation, three and a half years of data from January 2009 through June 2012 was used.

3.2.1 Sludge Thickening

Secondary WAS is thickened using two, 1.5 -meter (m) GBTs. Typically, each unit processes approximately 120 gpm. Per the manufacturer, each unit has a maximum hydraulic throughput capacity of 300 gpm; however, as the hydraulic throughput increases beyond 150 gpm, the thickened sludge solids content and the solids capture decreases. The average WAS and TWAS solids concentrations are 0.59% and 6.8%, respectively. Polymer, Clarifloc VE200, is injected upstream of the GBTs at a rate of 0.5 gph to achieve enhanced thickening. The activity of Clarifloc VE200 is 30%. At a GBT thickening rate of 120 gpm, the 0.5 gph polymer feed rate results in a dose of 6.7 active pounds of polymer per dry ton of solids, which is a very reasonable and economical sludge conditioning dosage.

Secondary WAS is thickened to increase the solids concentration as much as possible prior to entering the anaerobic digesters. The thicker sludge concentration going to the anaerobic digesters will increase the solid retention time in the digesters, which will maximize the digester capacities. Primary and secondary waste sludges are combined in-pipe downstream of the GBTs. To maintain a consistent feed to the digesters and for ease of operation, the GBTs are run continuously 24 hours per day, 7 days per week. The system is designed with complete redundancy (one duty and one standby unit).

Depending on the solids concentration entering GBTs, the units are either solids limited or hydraulically limited. In the case of the LWRP, the feed solids concentration is low; therefore, the GBTs are hydraulically limited. Industry standard evaluation criteria for GBT throughput is 150 to 175 gpm/meter. For the purposes of this evaluation, Tetra Tech has conservatively assumed a maximum hydraulic throughput of 150 gpm/meter, which results in a maximum capacity of 225 gpm for each GBT. Operating the GBTs above this loading may result in lower solids concentrations or a decreased solids capture rate.

The design parameters for the GBTs were used to determine a maximum hydraulic capacity with one unit operating. The results presented in Table 3-8 show that the GBTs are limited to an influent plant flow rate of 12.38 mgd on an ADWF basis. The current maximum day WAS flow rate was 126 gpm based on historical. Assuming the influent loading will be similar to the previous 3 years, the maximum day WAS flow rate will need to be 172 gpm which will occur at an ADWF of 12.38 mgd with only 1 GBT in continuous operation.

Table 3-8. Gravity Belt Thickener Process Capacity

Unit	Description	Design Evaluation Criteria	Estimated Present Capacity based on ADWF
Gravity Belt Thickeners	2 Gravity Belt Thickeners @ 1.5 m width	Maximum Hydraulic Throughput	12.38 mgd

3.2.2 Anaerobic Digesters

The thickened sludge is pumped to three anaerobic digesters using two centrifugal TWAS pumps. Primary and secondary sludges are mixed in-pipe upstream of the digesters. Two of the digesters are of the same size and have a liquid volume of approximately 330,000 gallons each. The liquid volume of the larger unit is 500,000 gallons. The smaller digesters are equipped with concrete covers, while the larger digester is equipped with a steel cover.

Digested biosolids is conveyed to an overflow tank. The detention time in the digesters is typically 21 to 22 days. The digestion process is performing well based on the volatile solids destruction of 63 to 65%. In the past, gas mixing systems were used; however, the digesters are now equipped with Vaughn Rotamix mixers. The facility does not currently accept grease or any other high-strength organics in the digesters.

Struvite formation has historically resulted in significant pipe clogging in the solids handling areas. To minimize struvite fouling, the City replaced most of the digested sludge piping with glass-lined pipe about two years ago. Because the digesters have not been emptied and cleaned for approximately eight years (prior to conversion to glass-lined piping), the rate of struvite accumulation in the digester sand its implications is unknown. When necessary, operations staff uses a 2.5-inch fire hose to flush any struvite in the pipelines.

The TWAS pumps convey thickened residuals from the discharge end of the GBTs to the anaerobic digesters. Primary sludge is mixed with the TWAS upstream of the digesters. Currently, the three digesters are operated in parallel under conventional mesophilic conditions (95 to 98°F). The digestion process is performing well based on the volatile solids destruction of 63 to 65%.

Historical data was analyzed to evaluate the anaerobic digesters. The results of the analysis are summarized in Table 3-9. The current capacity of the anaerobic digesters is based on the following two metrics which are discussed further later in this section:

- Maximum month volatile solids loading rate = 0.18 lb VS / (ft^3*day)
- Minimum hydraulic retention time (HRT) at maximum month loading = 15 days

Table 3-9. Digester Design and Operating Parameters for the Period January 2009 through June 2012

Parameter	Units	30-Day Moving Average	Maximum 30-Day Moving Average	Minimum 30-Day Moving Average
Volatile Solids Loading Rate	lb/ft^3/day	0.10	0.11	0.08
HRT	day	22.8	25.7	20.3

It is important to consider the end use/disposal site for the biosolids when determining the capacity of the solids handling system. Biosolids are stabilized to meet VAR and Class B pathogen criteria during digestion and then hauled to the landfill for daily cover or burial. Beneficial reuse for landfill cover is much less expensive than burial in active cells as the landfill tipping fee is currently $42 per ton. Even though it is more expensive to bury raw dewatered sludge in the landfill, it still provides a viable temporary disposal option in case a digester has to be taken out of service. Based on this rationale, Tetra Tech's capacity calculations are based on total available digester volume, not firm capacity (with the largest digester out of service). Therefore, the digesters are not the limiting process in determining the overall plant capacity.

The design parameters for the digesters were used to determine the maximum 30-day throughput capacity, both in terms of hydraulic loading and solids loading. Laboratory experiments with ideal mixing have shown it takes approximately 7 days of HRT to anaerobically digest typical domestic sludge to produce a stabilized biosolids product. At full scale, experience has shown that it takes closer to 15 days of HRT to produce a stabilized biosolids product which is why 15 days has become the default EPA criteria. Less than 15 days of HRT can be provided in the digesters to still meet VAR and Class B pathogens in systems with good mixing. To be conservative, Tetra Tech used the EPA default criteria of 15 days at maximum month loading conditions to determine the capacity of the digesters. In addition to HRT, empirical experience has shown that volatile solids loading above 0.18 lb VS/ft^3/day results in increased foaming issues and a decrease in VS destruction. Tetra Tech recommends evaluating the capacity of the anaerobic digester on both HRT and VS loading. The results presented in Table 3-10 show that the digesters are adequately designed relative to VSLR for ultimate buildout. HRT limits the digester capacity to an equivalent ADWF of 8.79 mgd which is less than the ultimate buildout. Improvements will be required to increase the HRT of the existing digesters to increase the capacity to achieve the ultimate buildout of 9.47 mgd ADWF.

Table 3-10. Digester Process Capacity

Unit	Description	Design Evaluation Criteria	Estimated Present Capacity ADWF Basis
Anaerobic Digesters	2 digesters @ 0.327 MG and 1 digester @ 0.5 MG	Max Month VSLR = 0.18 lb VS/ft^3/d	10.92 mgd
	Total Volume = 154,250 ft^3	Minimum HRT at ADF = 15 d	8.79 mgd

3.2.3 Biosolids Storage, Dewatering, and Disposal

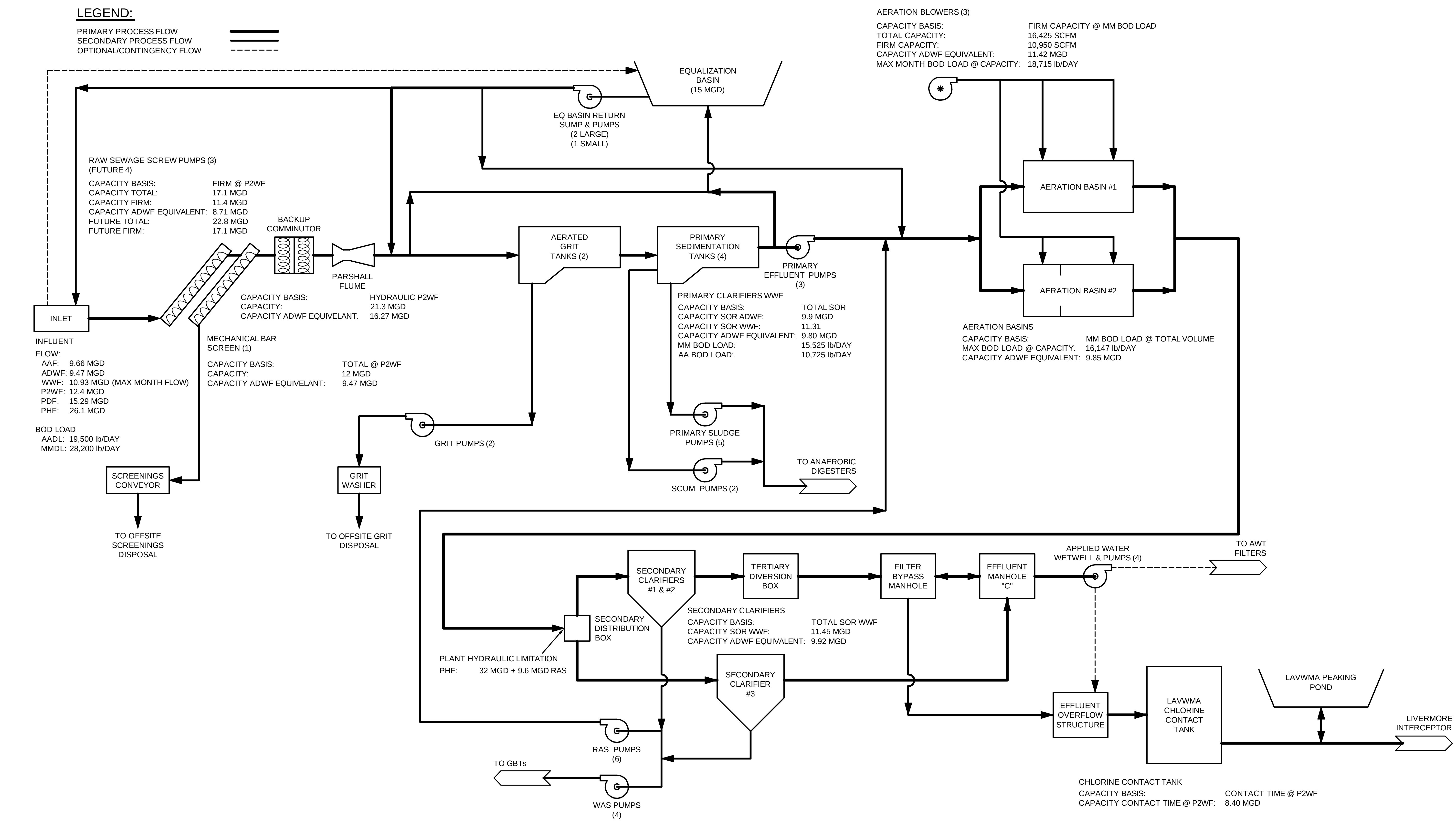
Digested solids are dewatered using two, 2-meter BFPs; one duty and one standby. The dewatered cake ranges from 16.5 to 17.0% solids. Filtrate is transferred to a wet well, prior to being returned to the head of the grit basins; however, the wet well is not large enough to provide equalization volume. No equalization of filtrate indicates that when biosolids dewatering is occurring, there is a substantial increase in ammonia load being recycled to the liquid treatment process. While this is not a large concern for the current operation, it is a concern if nutrient discharge limits are imposed in the future. Typically, the biosolids dewatering is performed during one shift each day, 7 days per week for approximately 8 hours per shift plus 2 hours for cleanup and shutdown. Recently during construction, dewatering was performed 7 days each week; 1) 6:30 a.m. to 11:30 a.m. and 2) 6:00 p.m. to 12:00 a.m.

Industry guidelines for BFP throughput of anaerobically digested primary and secondary sludge is approximately 600 dry lb/h/meter, which results in a maximum capacity of 1,200 dry lb/h for each BFP. The design parameters for the BFPs were used to determine a maximum throughput capacity with one unit operating. The results presented in Table 3-11 show that the BFPs have an equivalent ADWF of 11.82 mgd based on maximum month loading.

Table 3-11. Belt Filter Press Process Capacity

Unit	Description	Design Evaluation Criteria	Estimated Present Capacity ADWF Basis
Belt Filter Presses	2 Belt Filter Presses @ 2 m width	Maximum solids loading rate = 600 lb/h/m per unit	11.82 mgd

Figure 3-1 and 3-2 summarize the capacities and the respective maximum loading for each of the unit processes throughout the liquid and solids systems respectively.



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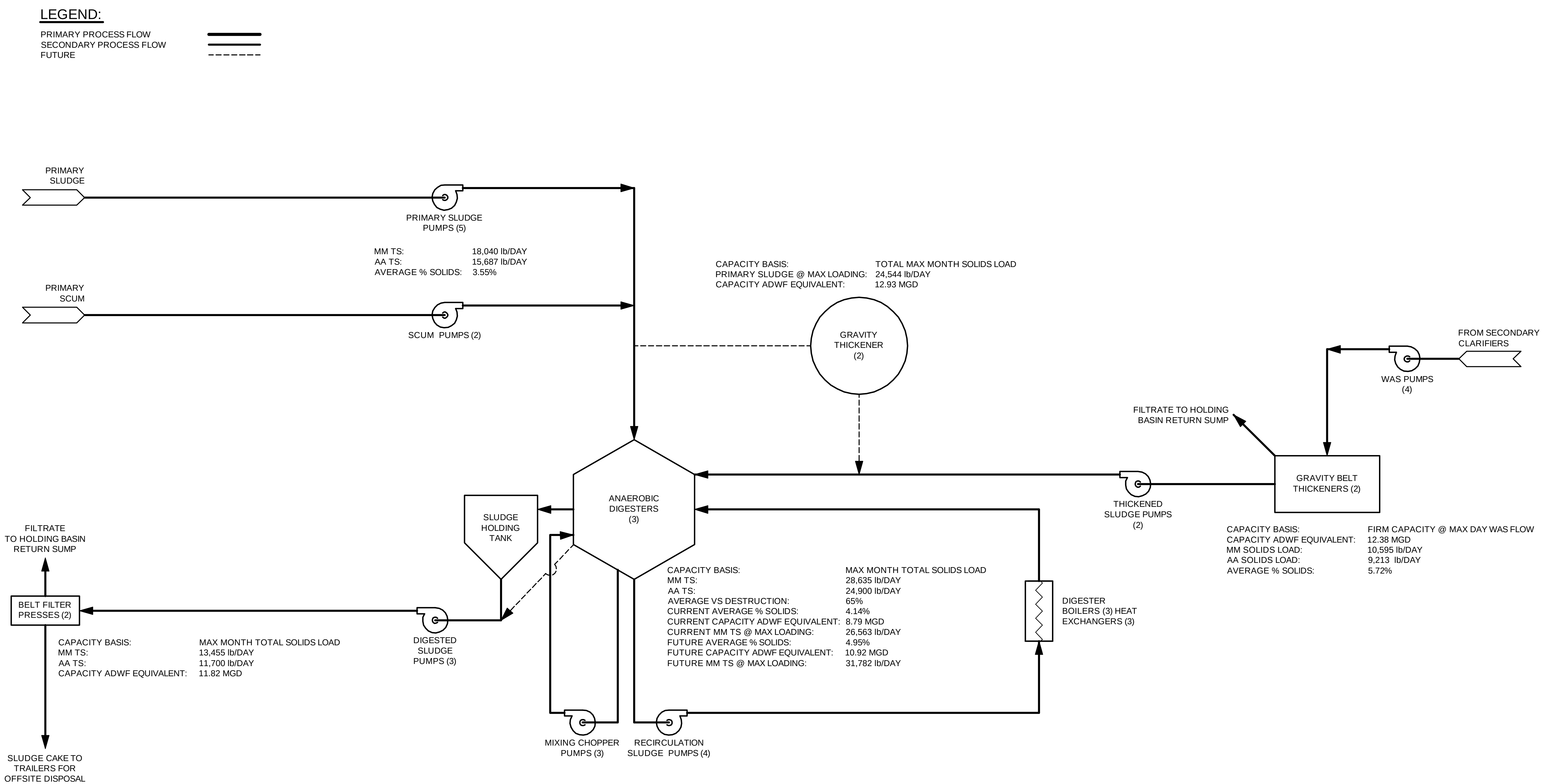
CITY OF LIVERMORE, ALAMEDA COUNTY, CALIFORNIA

LIVERMORE WATER RECLAMATION PLANT
2012 MASTER PLAN UPDATE

LIQUID STREAM CAPACITY
FLOW DIAGRAM

Project No.:	135-29480-12001
Date:	MAY 2013
Designed By:	RL
Figure	3-1

Bar Measures 1 inch



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CITY OF LIVERMORE, ALAMEDA COUNTY, CALIFORNIA
LIVERMORE WATER RECLAMATION PLANT
2012 MASTER PLAN UPDATE

SOLIDS STREAM CAPACITY FLOW DIAGRAM

Project No.: 135-29480-12001
Date: MAY 2013
Designed By: RL
Figure 3-2

Bar Measures 1 inch

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LIVERMORE
CALIFORNIA

4.0 LIQUID TREATMENT ALTERNATIVES

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4.0 LIQUID TREATMENT IMPROVEMENTS

The purpose of this section is to evaluate the liquid stream treatment process with respect to potential improvements that may be necessary to fix aging and damaged equipment, improve performance of the process, or to meet potential future regulatory requirements. This section focuses on the liquid treatment system including: influent pumping, preliminary treatment facilities, primary clarifiers, aeration basins, secondary clarifiers, and disinfection. Reuse facilities are not considered in this section except for UV disinfection.

4.1 Current System Performance Limiting Factors

The present LWRP meets permit limitations and runs quite well under self-imposed overloaded conditions as noted in Section 3. However, to continue to maintain that high level of performance and realize full plant capacity, there are a number of performance-limiting factors that have to be addressed as identified as part of the CPE. Several of these factors are critical and are limiting the performance and capacity of the liquid treatment process; therefore, they should be addressed as soon as possible. Other factors identified are operational and maintenance issues that should be rectified with future projects. The following is a prioritized list of improvements projects that should be completed to mitigate issues that are limiting the current performance or firm capacity of the LWRP.

- Project #1: Aeration equipment replacement
- Project #2: Electrical upgrades and standby power
- Project #3: Sequential mechanical screening equipment
- Project #4: Process control improvements
- Project #5: UV system replacement
- Project #6: Primary clarifier gate actuation and redundant grit classifier
- Project #7: Additional odor control
- Project #8: Grit system improvements
- Project #16: Install fourth influent screw pump

Descriptions of each recommended improvement project are provided within this Section. The capital cost and timing of each project are identified in Section 7.

4.1.1 Project #1: Aeration Tank #1 Rehabilitation and Aeration Equipment Replacement

Aeration Tank #1 is presently nonfunctional due to an aeration distribution and diffuser system that must be replaced, non-functioning step-feed gates, and potential structural issues. These items must be addressed before the aeration basin capacity stated in Section 3 can be realized. The aeration diffusers in the existing activated sludge system need to be replaced. With this aeration basin out of service all flow must be treated by Aeration Tank #2. If the diffusers in Aeration Tank #2 fail, the plant will not be capable of adequately treating the present wastewater. It is critical that the diffusers in Aeration Tank #1 be replaced as soon as possible so the plant has redundant aeration basins and so that full plant capacity can be realized.

The first part of the project requires the replacement of the diffuser, and air headers within Aeration Tank #1. The PVC piping has been damaged by UV rays from the sun and should not be reused. The existing stainless steel air drop pipes appear to be in good condition and do not need to be replaced. A diffuser evaluation should be conducted to determine which type of diffuser is best suited for the LWRP. Tetra Tech anticipates that the new diffuser system would be fine bubble membrane diffusers either in the shape of discs or tubes.

In addition to replacing the aeration diffusers, Tetra Tech recommends that an anaerobic selector be created similar to Aeration Tank #2. The anaerobic selector is critical to maintaining good settleability characteristics and the selector should continue to be used to support the same organic loading. Tetra Tech recommends that the dimensions of the anaerobic selector be the same as Aeration Tank #2. Mixers will be required in the anaerobic zone to maintain mixing without aeration. Partition walls for the dedicated anaerobic and swing zone should be constructed to prevent the backflow of oxygen from the aerobic zone. The swing zone is an aeration zone that is designed to either be aerated or non-aerated depending on the conditions of the plant. When the loading is relatively low, the swing zone is unaerated which decreases aeration demand; however, when loads increase and additional aeration volume is required, the swing zone can be aerated to add aeration capacity. Diffusers are not required to be installed in the anaerobic zone; however, diffusers should be installed in the swing zone. It is recommended that recirculation pumps not be installed because mixed liquor recycle to effect partial denitrification is not required at this time.

The gates that control step feed for Aeration Tank #1 also need to be rehabilitated in order for them to function. The capacity of the activated sludge system is based on the ability to use step-feed if needed during a poor settleability episode to reduce the solids loading on the secondary clarifiers. The gate actuators need to be rehabilitated or replaced, the frames need to be repaired, and the seals around the gates need to be replaced to keep them from leaking.

4.1.2 Project #2: Emergency and Standby Power

The LWRP does not have stand-by electrical power generation capability nor is there a second source if an outage of utility power occurs. In the event of a power outage, the emergency holding basin is currently used to store influent until power is restored; however, the basin can only hold about two days of average flow. Further, during the electrical "down" time, no oxygen is available for the microorganisms in the activated sludge system. Tremendous odor problems will occur as many of the activated sludge organisms convert the aeration tank into an anaerobic fermenter/digester. Once power is resupplied, many of the activated sludge organisms will have died, and the process will have to be started-up anew. This will cause the system to violate discharge standards until start-up is completed.

The City has indicated that they have evaluated several options regarding obtaining standby power. Along with the cost of purchasing a standby generator, the City reviewed options for obtaining a second service from the power utility and the possibility of contracting with a private company to provide mobile generators that could be brought to the site in the event of an extended power outage.

Tetra Tech recommends the City strongly considers supplying its own standby generator to power critical processes and equipment. Other standby power arrangements may not be sufficiently prompt or reliable to provide adequate standby service. The cost of a second service connection is costly and it is likely that when power is down in one service, it will also be unavailable from the second service. Contracting with a private company to supply standby power is also risky. In the event of a prolonged power outage, it is possible that the private company could not physically get the standby generator to the site within the two day window. The only option that allows the plant to control the process of standby power is the purchase and operation of the City's own generator.

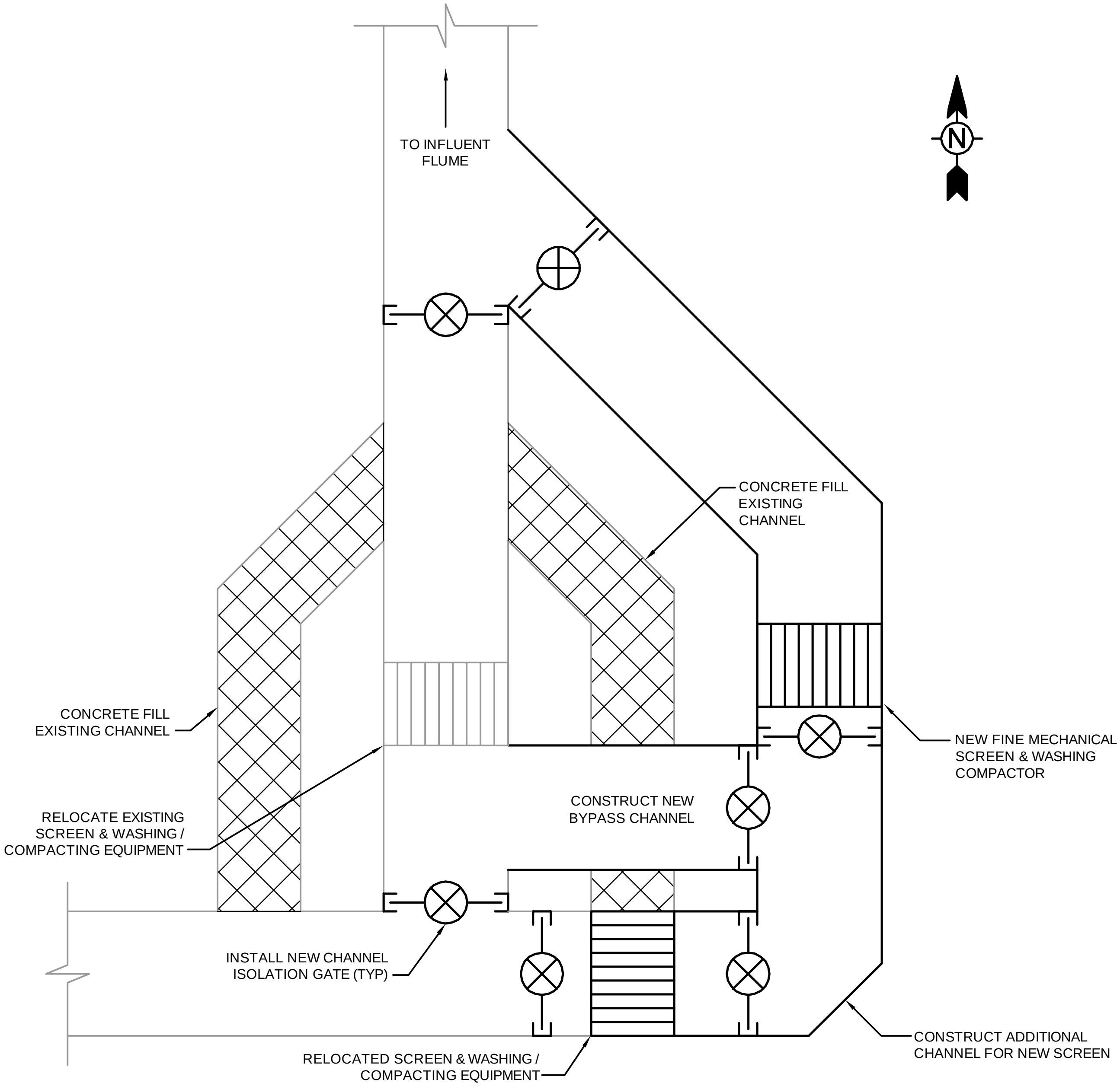
To install a functional standby generator, the electrical system throughout the plant would need to be improved. Two 480V transformers and a double-ended switch gear will be added to upgrade the electrical distribution system. Construction of these new systems is scheduled for the end of 2013. Based on the analysis performed as part of Electrical Distribution System Analysis Technical Memorandum prepared by Carollo Engineers in 2013 (included as Appendix D), a 1,500 kW standby generator is recommended to supply backup power to the LWRP.

4.1.3 Project #3: Sequential Influent Screening

The present single mechanical screen is a conventional bar rack with 5/8-inch clear openings that can allow rags and trash to pass through. In fact, studies have shown that this type of screen will only remove 30% to 50% of the inorganic material normally found in influent wastewater. The materials not removed can cause downstream plugging issues in pumps, piping, secondary clarifier suction tubes, etc. The 5/8-inch clear openings are relatively coarse and the long bars allow material to "line up" and pass through the rack even if they are larger than 5/8-inches in one dimension. Further, if the single screen mechanically malfunctions, unscreened wastewater will flow into the grit chambers and the primary clarifiers, causing significant debris problems. A second screen should be provided to eliminate that possibility.

Tetra Tech recommends that a sequential screening approach, using the existing equipment as a coarse screen, which would be followed by a fine screen in a series format. This approach will allow the existing screen to capture larger debris as it currently does. Then a fine screen (such as a perforated plate screen) can remove smaller debris that passes through the coarse screen. The coarse screen will protect the fine screen from large debris that can be prevalent during wet weather events that can damage the plates of the fine screen. Channel modifications will be required to the existing headworks in order to accomplish a sequential screening strategy. A schematic channel design is provided on Figure 4-1 that shows a potential layout for sequential screening. During the preliminary design phase, access to all equipment and maintenance should be evaluated. In the schematic, a new channel is constructed to hold the new screen, while the existing screen is relocated. The schematic layout provides a bypass channel that would allow the flow to bypass either screen in the event one unit was out of operation. This would act as redundant mechanical screening. During the detailed design for this project, this configuration should be evaluated further to determine whether there is adequate space at the existing screening location.

In addition to installing the new screen, replacing the submersible pumps in the emergency holding basin return pump station should be evaluated. During high flows, influent is automatically diverted to the emergency holding basin prior to influent screens. This condition allows trash and debris to bypass the screens, which winds up in downstream processes. To prevent debris from bypassing screening equipment, chopper pumps could be installed which would grind this debris and will limit



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LIVERMORE WATER RECLAMATION PLANT
2012 MASTER PLAN UPDATE

LAYOUT FOR SEQUENTIAL SCREENING

Project No.:	135-29480-12001
Date:	MAY 2013
Designed By:	ST
Figure	4-1

Bar Measures 1 inch

plugging and damage to downstream equipment. Another alternative is to return the flow to the influent manhole prior to the screen so that the flow will pass through the preliminary treatment equipment.

Another approach to the screening would be to relocate the existing screen to a new vault upstream of the emergency holding basin diversion then install a new fine screen in same location as the existing screen. This approach would remove debris upstream of the emergency holding basin and it will not require replacing the emergency holding basin return pumps. The construction cost for installing a vault that is large enough for the screen, plus the washer/compactor, would be higher than the first screening alternative. In addition, the lift required to remove the screenings into a roll-off dumpster is relatively high, which increases the power draw and potential for clogging. Tetra Tech used the first sequential screening alternative for the basis of the master plan. The second alternative can be evaluated in greater detail during the design phase of the project.

4.1.4 Project #4: Process Control

The existing aeration basins have limited process control equipment. The operations staff has done a good job to date of controlling the activated sludge performance through process control sampling. Additional on-line process control probes would aid process control and improve energy optimization. Additional DO monitoring, air control valves, step-feed gate control and WAS line suspended solids monitoring limit the plant's capabilities to function properly under full plant loading conditions. Adding two additional DO control points in each basin will improve efficiency of the aeration system. Lack of step-feed gate control limits overall aeration tank capacity. Operating without TSS monitoring for the WAS is typically the largest cause of activated sludge process malfunction due to the inability to truly determine the MCRT. A description of each improvement is discussed below:

- Additional DO probes and air flow control valves could be installed to add a second airflow control zone to each of the aeration basins. This will allow the plant to better match the air demand throughout the basin by delivering more air at the head of the aeration basins where the air demand is greater and less air at the end of the basins where the air demand lower.
- A suspended solids probe could be installed in each aeration basin to monitor MLSS concentration on a real time basis. This will improve the operators monitoring of MCRT and will reduce the time demand on the laboratory staff as fewer suspended solids tests would be required.
- Automatic gate actuators could be installed on the slide gates that control the flow entering aeration basins for step feed mode. By installing automatic actuators, the operators can easily convert to step-feed mode of operation when they need to.
- A suspended solids probe should be installed in the WAS line to the GBTs so the operators can monitor the WAS concentration on a real-time basis. The plant control system can be programed to waste a set amount of mass each day to more accurately control the MCRT within the plant.

4.1.5 Project #5: UV Disinfection

While the UV disinfection equipment is part of the reuse system and not the liquid treatment process, during the CPE it was noted that the system had operational issues that should be addressed. The existing UV system is prone to fouling and the automatic cleaning system does not work adequately.

The operators currently have to manually clean the bulbs on a regular basis. This level of cleaning is onerous for the operations staff and is taking time away from other areas of the plant. The existing UV system is also less energy efficient than new UV systems. The control systems for new UV systems monitor flow rate and UV transmittance (UVT) and pace the UV output to meet the target delivered dosage. In this way, electricity is saved during times when flows are lower and UVTs are higher. New systems also have higher output bulbs, which reduces the number of lamps and modules needed to achieve the same level of disinfection.

Tetra Tech recommends that a new UV system be installed with the capability to control the UV dose and with a proven and reliable automatic cleaning. Several systems are available with this type of control and should be evaluated further during the design phase of the project. An economic evaluation should be completed to determine the timing of the UV system replacement.

4.1.6 Project #6: Primary Clarifier Gates

The slide gates that control the flow into the primary clarifiers must be moved manually by pulling up or pushing down the gate by hand. This operation is difficult for the operators and could result in injury to the staff. When gates are not moved regularly, debris and solids can accumulate in the guides making it difficult to slide them up or down, especially when coupled with differential pressures on each side of the gates. Tetra Tech recommends that the slide gates be equipped with hand-wheel actuators to make it physically easier to control the gates. Making it easier to operate will give the operators more ability to make small changes in the gate position to balance flow distribution and to equalize the performance of each clarifier.

4.1.7 Project #6: Grit Classifier

There is only one grit classifier at the plant. If the present grit classifier does not function, grit is not properly collected, and it will flow into the primary clarifiers where it will be removed with the primary sludge. The grit will then deposit in the anaerobic digesters, taking up space and causing mixing problems. Grit will also cause excess wear on pumps and appurtenances. An additional grit classifier is recommended. The top of the grit shed is severely corroded and needs to be replaced as noted in Section 6.2.3. The grit shed should be replaced as part of this project.

4.1.8 Project #7: Additional Odor Control

While odor at the LWRP is not a current problem, there were several places throughout the plant where odor control could be improved. First, the mechanical screen at the headworks is not enclosed and odors were noticed around the screening equipment. The biotower that treats odor from the influent channels and the grit basins is located adjacent to the screening equipment. Only minor modifications would be required to enclose the bar screen in paneling and install a foul air fan and duct to the existing biotower.

Another area noted to have a noticeable odor was around the emergency holding basin when it was in use. This basin is large and is therefore not practical to cover and treat foul air. Instead of collecting and treating foul air, Tetra Tech recommends that the City install provisions to add chemicals to the flow entering the basin that suppresses odor. There are several chemicals available that suppress odor formation such as Bioxide®, liquid oxygen, ferric chloride, sodium hypochlorite, and others. The City already has ferric chloride on-site for addition to the anaerobic digesters and for the reuse filters. The ferric chloride feed system could be expanded to include additional chemical storage and chemical feed capabilities.

4.1.9 Project #8: Grit System

The aerated grit basins currently being used for degritting are not as efficient as other, newer grit removal technologies available. The grit that is not removed will settle in the primary clarifiers and then be pumped to the anaerobic digesters, where it will re-settle and reduce the active volume of these tanks. Inefficient liquid stream grit removal increases the frequency a digester needs to be taken out of service for cleaning. In addition to being deposited in the digesters, grit tends to gradually damage all of the downstream pumps, piping, and dewatering equipment. This includes the digester mixing pumps and nozzles.

Aerated grit also reduces the soluble BOD concentration in the influent. Currently this is not a concern as the BOD will be biologically removed in the aeration basins anyway; however, if regulations change and nitrogen and/or phosphorus removal is required, soluble BOD will be required to remove these nutrients biologically. Aerated grit becomes a larger concern if nutrients limits are imposed in future permits.

Excess grit in the process does not necessarily affect the performance of the plant; however, it increases maintenance requirements. This is the lowest priority improvement project and it will largely be driven by maintenance labor and equipment replacement requirements, plus future nutrient regulations. When the grit system is replaced, Tetra Tech recommends that the plant consider replacing the aerated grit removal system with either a vortex or headcell grit removal system.

4.1.10 Chemically Enhanced Primary Treatment (CEPT)

The BOD and TSS removal efficiency in primary clarifiers can be increased by adding a chemical coagulant such as ferric chloride to the influent wastewater. By increasing the removal efficiency in the primaries, the loading to the secondary treatment process is decreased, which would effectively increase the capacity of the secondary treatment process. The City already has ferric chloride chemical feed capabilities available at the primary clarifiers and CEPT could be implemented with only minor operational changes. Currently, about 9 mg/L of ferric is added upstream of the primary clarifiers to control odor in the anaerobic digesters. This dose is significantly lower than that typically required for

CEPT; therefore, the current ferric chloride dose is not likely to enhance the removal efficiencies of the primary clarifiers. The chemical doses required for CEPT varies from plant to plant with a typical range between 50 to 80 mg/L of ferric chloride. Pilot testing should be conducted to determine the correct dose for the LWRP. The expected dosing rate results in a high operational cost due to the cost of ferric chloride and is not recommended for long -term operation.

The benefits of CEPT at the LWRP are uncertain. The BOD and TSS removal performance of the primary clarifiers at the LWRP is currently excellent; better than for typical primary clarifiers. The high removal efficiencies indicate that the large portion of the particulate BOD and TSS are being removed already without the aid of coagulant. The BOD remaining in the primary effluent is largely soluble BOD that will not be removed in a primary clarifier even with the aid of coagulant. Tetra Tech does not anticipate a significant improvement in BOD or TSS removal efficiency with the addition of CEPT at LWRP. However, the facilities are currently in place to add ferric chloride upstream of the primary clarifiers, allowing for CEPT to be implemented during peak flow periods to maintain primary clarifier performance. The ferric dose could be increased to 50 to 80 mg/L when wet weather flows reach the peak flow rate of 12.4 mgd. The use of CEPT could maintain average primary clarifier removal efficiencies at higher SOR.

4.1.11 Project #16: Installation of Fourth Influent Screw Pump

During the CPE, it was determined that three screw influent pumps does not provide sufficient pumping capacity for ultimate buildout peak two week flow events. With three pumps, the firm capacity is 11.4 mgd while the peak two week flow is 12.4 mgd. If one of the influent pumps were out of service during the peak two week event, 14 mgd of the emergency holding basin would be needed to store excess influent that cannot be pumped through the preliminary treatment system. This is nearly the entire volume of the basin which would not leave any storage volume to equalize diurnal loads which is critical for maintaining the capacity of the aeration basins.

The existing influent pumping station includes space for a fourth screw pump without expanding the structure of the pump station. The firm capacity of the influent pump station should be able to handle the peak two week flow without sending any flow to the emergency holding basin. The ADWF associated with a peak two week flow of 11.4 mgd is 8.70 mgd. It is recommended that when the ADWF reaches 8.70 mgd a fourth pump be installed.

4.2 Potential Future Nutrient Regulations

In 1998, the EPA first established nutrient water quality criteria for TN and TP with the goal to reduce excessive algae growth and accelerated, cultural eutrophication that is caused by it. For example, excessive algae levels can cause low DO conditions (hypoxia), fish kills, high pH episodes, and reduced recreational use of the water. Algae also can create a wide variety of drinking water quality problems. These include taste and odor complaints and clogging of filters. In addition, hypoxia in the hypolimnion of a lake or reservoir can create reducing conditions and cause the release of soluble iron and manganese, which are difficult to remove to low concentrations. Elevated levels of iron and manganese will discolor potable water, typically resulting in numerous complaints and eroding customer confidence in the public water supply.

States have been relatively slow to either adopt EPA's eco-regional nutrient quality criteria or develop their own. A principal reason is that the linkage between nutrients and beneficial use impairments is imprecise at best, and utilities do not want to expend large amounts of capital and operational costs providing treatment that does not benefit the receiving stream. It is also clear, that nutrients can cause significant water quality impairments when in-stream or in-lake conditions are conducive to algae growth. The state of California has not adopted nutrient quality criteria to date; it is anticipated that criteria will be adopted in the future. Surrounding states have recently adopted state-wide nutrient control criteria. For planning purposes, it is anticipated that California will adopt state-wide nutrient criteria which could become effective as early as 10 years from now.

4.2.1 Project #13: BNR Alternatives Analysis

Nutrients can be removed biologically through the activated sludge process currently in place at the LWRP by making several physical and operational changes to the process. Nitrogen can be removed by the two-step nitrification and denitrification process. Phosphorus can also be removed biologically in the activated sludge process as previously discussed in Section 3. Through physical and operational changes, the conventional activated sludge process at LWRP can be converted to a biological nutrient removal (BNR) process for total phosphorous (TP) and total nitrogen (TN) reduction.

Nitrogen enters the plant as ammonia and as part of organic matter. The nitrification process uses a distinct class of bacteria that convert the ammonia and broken down organic nitrogen to nitrate. Under aerated conditions, the autotrophic bacteria responsible for nitrification oxidize ammonia to nitrate as a source of energy. The second step of the nitrogen removal process is denitrification, in which nitrate produced by the nitrification process is reduced to nitrogen gas, which is emitted to the atmosphere. Under non-aerated conditions, a different group of bacteria will use the nitrate as an electron acceptor in place of oxygen in the respiration process. This essentially allows the bacteria to consume organic matter without free dissolved oxygen.

Nitrogen removal is accomplished in an activated sludge process by controlling the environment for the microorganisms in the system. In order for nitrification to take place, the MCRT in the system must be long enough to grow a substantial mass of autotrophic nitrifying organisms. These bacteria grow slower than the other heterotrophic microorganisms responsible for BOD consumption. Currently, the LWRP is operated with a SRT that is low enough that it does not allow for the growth of nitrifying bacteria. By increasing the SRT at the LWRP the current process would start to nitrify. Currently, the LAVWMA permit and the reuse requirements do not require nitrification; therefore, in order to reduce operating costs, the SRT is normally kept low to prevent the growth of nitrifying bacteria. Once implemented, nitrification will increase the oxygen demand by 30 to 50%.

The denitrification process is accomplished by creating an anoxic zone and bringing together influent BOD, activated sludge mircrooganisms, and nitrate within it. To maximize the rate of denitrification and minimize the tank volume, the anoxic zone should be located at the head of the aeration tank where the concentration of soluble BOD is the highest. The required facultative heterotrophic bacteria are supplied via the RAS and the recycle of mixed liquor from the end of the oxic zone to the anoxic zone. This mixed liquor recycle (MLR) pumping also provides the nitrate that is to be reduced to nitrogen gas in the anoxic zone.

Bio-P can also be incorporated into the activated sludge process by controlling the environment to give a special type of bacteria, called a phosphorus accumulating organisms (PAOs), a competitive advantage over other microorganisms in the system. PAOs have the ability to absorb and store soluble organic matter (VFAs) under anaerobic conditions while other bacteria do not. By locating an anaerobic tank at the head of the aeration basin the PAOs will consume influent volatile fatty acids (VFAs) and will grow in higher numbers than other activated sludge organisms. Considering these bacteria store phosphorus, as more PAO cells grow more influent total phosphorus is taken up and stored within them.

In BNR systems, it is important to distinguish between anoxic and anaerobic conditions. Under anoxic conditions, there must be no oxygen present; however, nitrate is present unless/until all of what was contained in the MLR is reduced to nitrogen gas. Under anaerobic conditions, no oxygen or nitrate can be present. If nitrate is present, denitrification will occur which does not allow for preferential selection of PAOs.

While there are many different BNR process configurations, two basic BNR configurations were considered for the LWRP. The first configuration incorporates three stages. Figure 4-2 depicts a schematic of the three-stage BNR process. The first stage is anaerobic to promote the selection of PAOs. The second stage is anoxic and will provide for denitrification with the addition of MLR flow from the end of Stage 3. The third stage is aerobic to promote nitrification and oxidation of BOD.

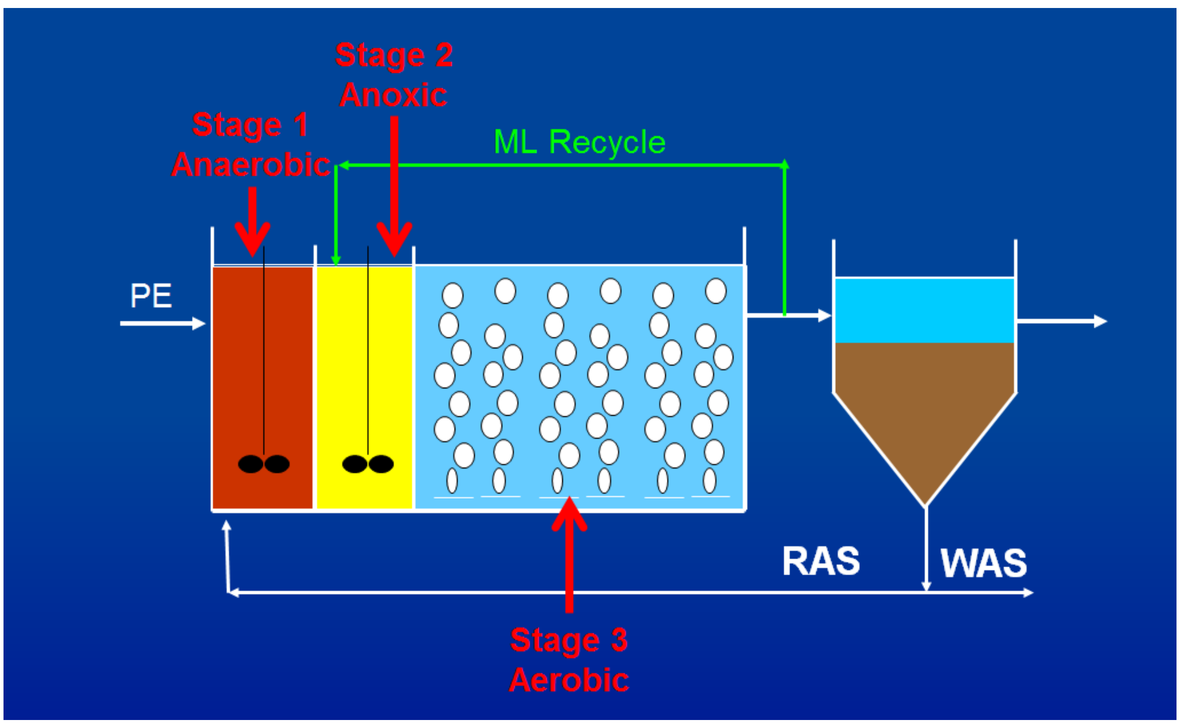

Figure 4-2. Three-Stage BNR Configuration Schematic

The second BNR configuration incorporates 5 stages and is depicted in Figure 4-3. The first 3 stages are the same as the first configuration. Stage 4 is a second anoxic stage to denitrify nitrate not recycled to Stage 2. Typically there is little BOD remaining at this stage; therefore, supplemental BOD could be added to increase the rate of denitrification and increase overall removal efficiency. The last stage is a small aerobic zone to oxidize any residual BOD added for denitrification in Stage 4 and to re-aerate the mixed liquor to prevent septic conditions in the clarifiers. The first configuration achieves a high level of TP removal (about 90%) and a moderate level of TN reduction (60% to 70%). The second configuration provides for supplemental nitrate reduction, increasing overall TN removal to about that achieved for phosphorous (i.e. 90%).

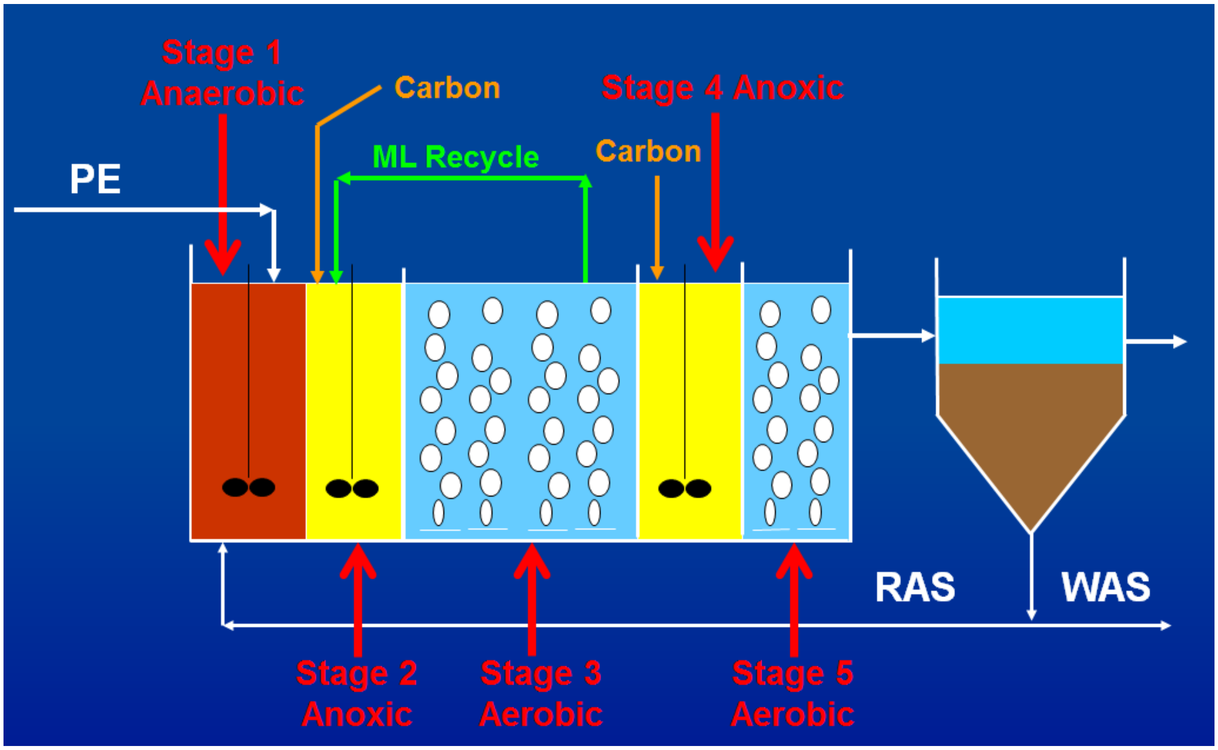

Figure 4-3. Five-Stage BNR Configuration Schematic

Table 4-1. Typical Effluent Nutrient Concentrations for BNR Configurations

Effluent Parameter (mg/L)	Nitrification Only	3-Stage BNR	5-Stage BNR
Ammonia	< 1	< 1	< 1
Nitrate + Nitrite	25 to 35	5 to 10	0 to 3
Total Kjeldahl Nitrogen	2 to 4	2 to 4	2 to 4
Total Nitrogen	27 to 40	7 to 12	3 to 5
Ortho-Phosphate	2 to 4	0.1 to 0.5	0.1 to 0.5
Total Phosphorus	4 to 8	0.2 to 1.0	0.2 to 1.0

The existing aeration basins are well configured for conversion to BNR when needed. The double pass configuration is ideal for installing simple and cost effective mixed liquor recycle pumping system. Figure 4-4 and Figure 4-5 show a recommended configuration for implementing a three and five-stage BNR process at LWRP.

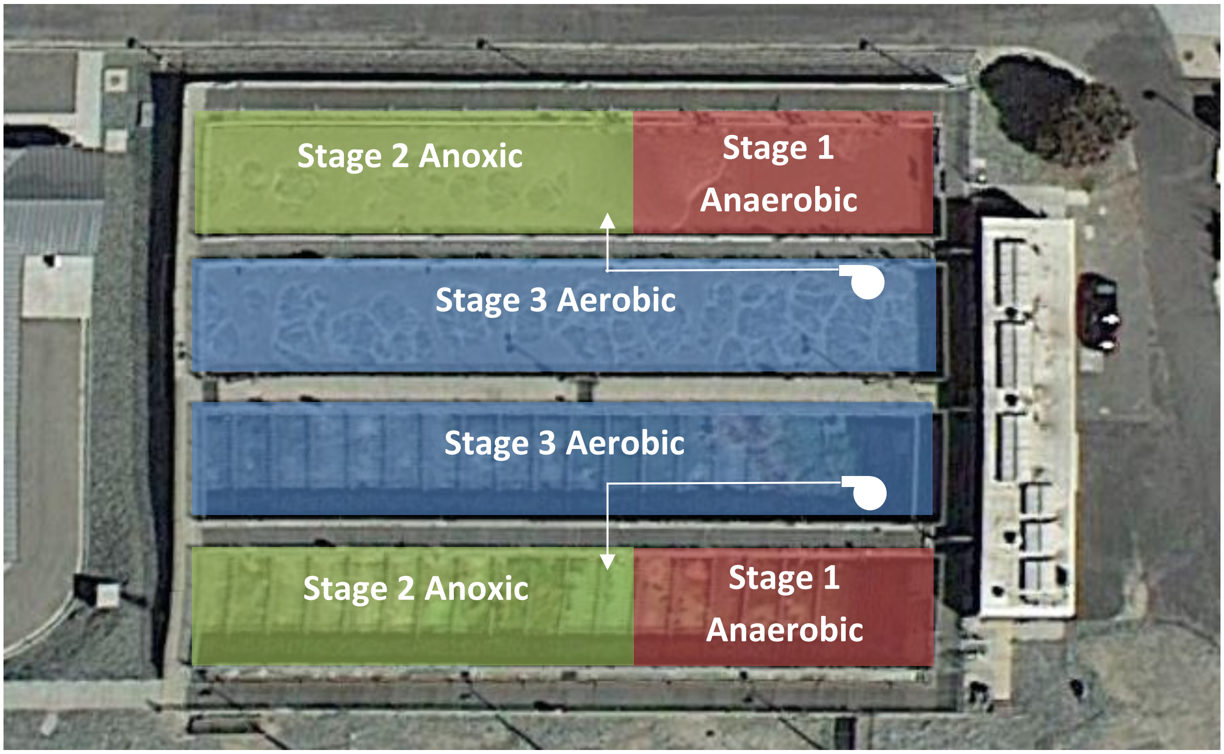

Figure 4-4. Three-Stage BNR Recommended Configuration

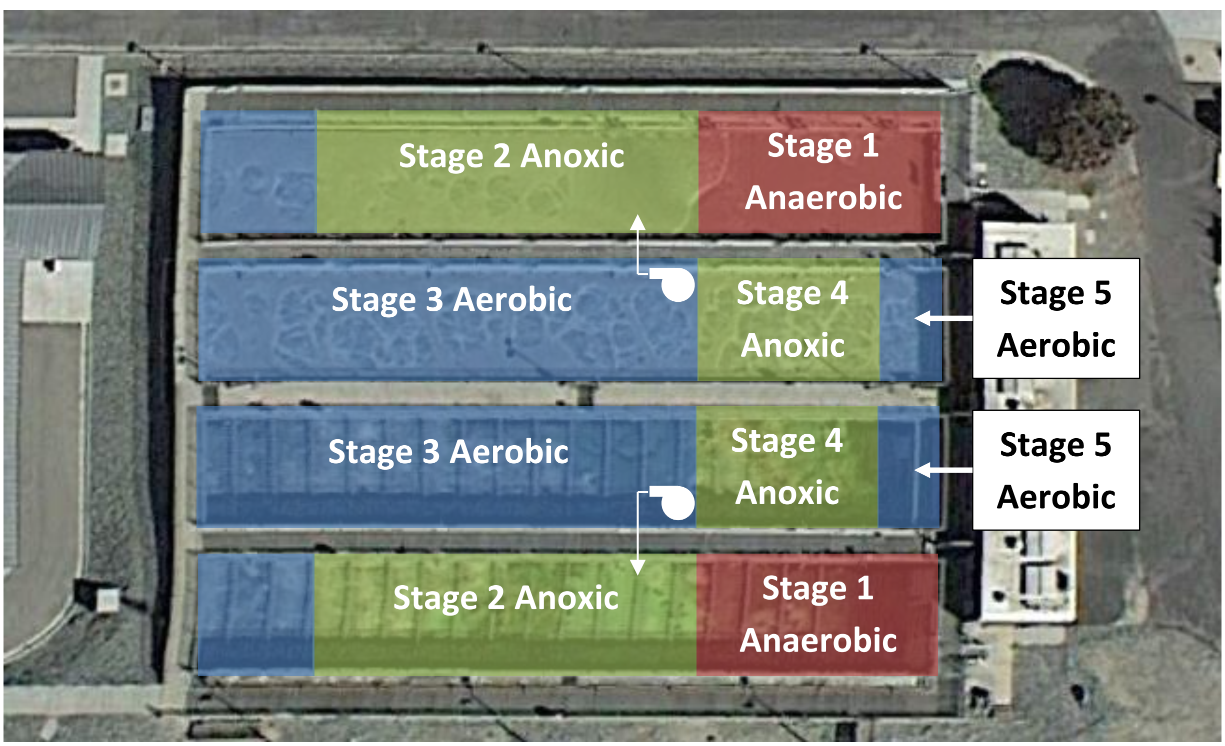

Figure 4-5. Five-Stage BNR Recommended Configuration

Converting the existing aeration basins to BNR will require operating at a higher SRT and will have less aerobic volume for organic removal and nitrification compared to the existing operation. As a result, once the aeration basins are converted to BNR, they will not be able to treat the same volume of wastewater. As discussed in Section 3, the current capacity of the aeration basins is 9.53 mgd on a ADWF basis. Implementing nitrification, the capacity would be reduced to 6.1 mgd on a ADWF basis which would require construction of additional aeration basins to maintain the same rated capacity of 9.53 mgd. A three-stage and five-stage BNR system would further reduce the capacity of the existing aeration basins, requiring construction of additional volume.

Preliminary aeration basin sizing calculations were performed to evaluate the total treatment volume using both a three-stage BNR system and a five-stage BNR system. The calculations showed that the BOD to ammonia ratio at LWRP is relatively low and there is not enough BOD to obtain the desired denitrification and biological phosphorous (Bio-P) removal performance without supplemental carbon addition with a three-stage or five-stage system. Supplemental carbon should be in a soluble form that is easily biodegradable such as acetate, Micro-C, or methanol (although methanol would require special handling conditions due to its flammability). For the three-stage system, if no supplemental carbon was added, the effluent nitrate concentration would be over 20 mg-N/L. With adding supplemental carbon to the anoxic zone, denitrification can be maximized to provide an effluent nitrate of less than 8 mg-N/L, which is more typical of this type of BNR system. For a five-stage system, supplemental carbon should be added both in the initial anoxic stage and in the second anoxic stage to achieve the desired effluent nitrate concentration. Table 4-2 summarizes the results of the preliminary calculations for each of the BNR systems considered. Calculations can be found in Appendix F. The aeration basin sizes represented in Table 4-2 are indicative of the total volume required to meet "typical" performance requirements for each respective BNR configuration at 9.53 mgd ADWF, as listed in Table 4-1.

Table 4-2. Preliminary Design Criteria

Parameter		Units	3-Stage w/o Supplemental Carbon	3-Stage with Supplemental Carbon	5-Stage with Supplemental Carbon
Aeration Basin Sizing					
	Number Basins		4	4	4
	Anaerobic Volume	MG	0.50	0.74	0.74
	Anoxic Volume	MG	2.60 (1)	1.12	1.12 / 0.52 (2)
	Aerobic Volume	MG	1.85	1.85	1.85 / 0.09 (3)
	Total Volume	MG	4.97	3.71	4.32
SRT					
	Anaerobic SRT	days	2.1	2.1	2.1
	Anoxic SRT	days	11	3.2	3.2 / 1.5 (2)
	Aerobic SRT	days	7.9	5.3	5.3 / 0.3 (3)
	Total SRT	days	18.4	10.6	12.6
Maximum MLSS Conc.		mg/L	3,500	3,500	3,500
Supplemental Carbon		ppd as BOD	0	7,100	8,200

(1) Anoxic Volume reported for three-stage without supplemental carbon includes theoretical retention time for endogenous respiration and may not be possible in actual conditions
(2) Anoxic volumes and SRTs reported as stage two/stage four
(3) Aerobic volumes and SRTs reported as stage three/stage five

The existing aeration basins contain 2.08 MG of volume which can be used as part of 3.71 or 4.32 MG required for a three-stage and five-stage system. For planning purposes, it was assumed that two additional aeration basins of equal volume as the existing basins would be constructed for BNR improvements. This volume could be configured as a three-stage or a five-stage system. There is adequate land available that is adjacent to the existing aeration basins for construction of the additional aeration basins by demolishing the decommissioned trickling filters. Figure 4-6 depicts the existing site with the expanded aeration basins.

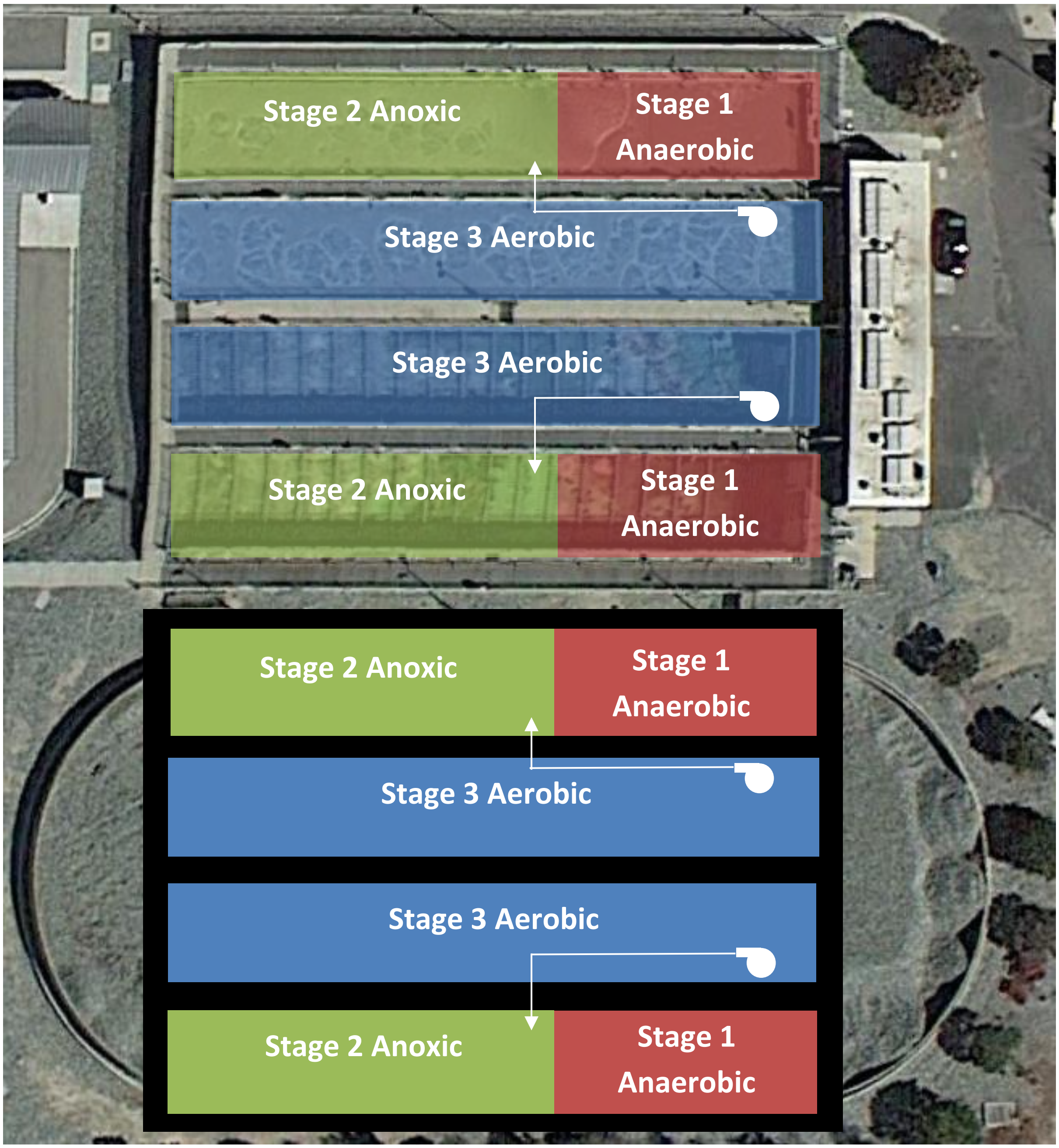

Figure 4-6. Expanded BNR Aeration Basin Layout

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5.0 BIOSOLIDS HANDLING, MANAGEMENT & IMPROVEMENTS

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5.0 Biosolids Handling, Management & Improvements

5.0 BIOSOLIDS HANDLING, MANAGEMENT, AND IMPROVEMENTS

The purpose of this section is to evaluate the status of the existing biosolids handling system and discuss some opportunities to enhance the performance and role that these facilities play in the overall operation of the LWRP.

5.1 Current System Performance Limiting Factors

Figure 5-1 is snapshot of the biosolids handling portion of the unit process capacity analysis presented in Section 3. As shown, the equivalent maximum month flow capacity of the secondary sludge thickening GBTs, anaerobic digesters, and dewatering BFPs are in excess of the overall rated plant's currently rated capacity of 8.5 mgd based on ADWF conditions. The capacity limiting parameter of the solids handling system is the digester HRT, with a capacity of 8.79 mgd on an ADWF. At ultimate buildout, the capacity of the solids handling system needs to handle 9.47 mgd of ADWF. In addition to increasing the HRT in the anaerobic digesters, some performance limiting factors were identified during the CPE. These factors include improving dewatering performance, minimizing struvite formation in the digesters and filtrate lines, improving odor control, expanding beneficial use of digester gas, and expanding the capacity of solids handling system when necessary. Considerations for each of these projects are summarized in the remainder of this section.

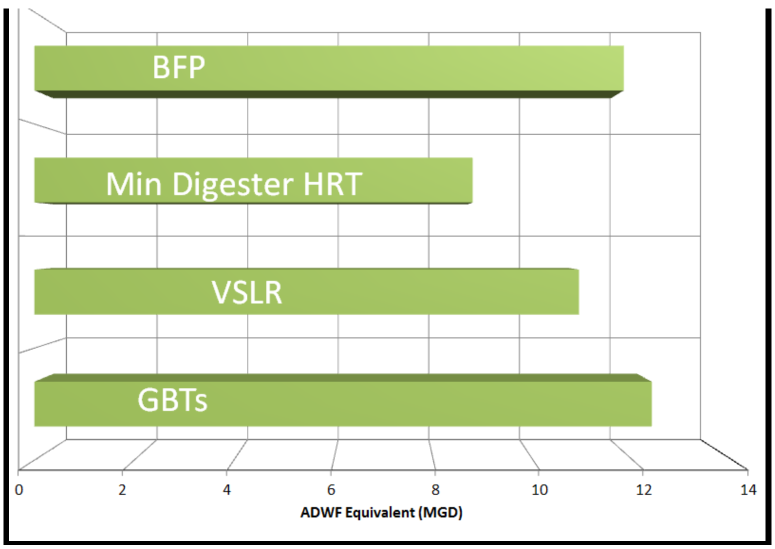

Figure 5-1. Solids Handling System Capacity Summary

5.1.1 Project #12: Conversion of Abandoned Dissolved Air Flotation (DAF) Unit to a Gravity Thickener and Construction of Second Gravity Thickener

To increase the capacity of the solids handling system to be able to handle ultimate buildout conditions, the HRT of the anaerobic digesters needs to be increased. Increasing the HRT can be accomplished by installing additional digester capacity or increasing the solids concentration in the digesters. The 8.79 mgd capacity of the digesters is based on the current average primary sludge feed concentration of 3.55% solids. With the use of a gravity thickener, the concentration of thickened primary sludge is typically between 4.5 to 6% solids. Using a conservative assumed thickened primary sludge concentration of 4.5% and the current average of 5.72% TWAS concentration, the combined average solids concentration going to the digesters is 4.95%. At this average concentration, there can be 31,800 lbs solids in the digesters. The equivalent ADWF to produce 31,800 lbs solids on a maximum month basis is 10.51 mgd of ADWF.

The existing DAF tank is no longer used for thickening since the GBTs were installed. Tetra Tech recommends that the existing DAF tank be converted to a gravity thickener. Gravity thickeners should be loaded between 20 to 30 lb/ft^2/day for thickening primary sludge. The existing 25 foot diameter DAF tank has enough capacity for 12,275 lb/day of primary sludge (using a 25 lb/ft^2/day loading rate) which is equivalent to an ADWF of 6.46 mgd. When the DAF is converted to a gravity thickener, a second 25 foot gravity thickener should be constructed for a total gravity thickening capacity of 12.92 mgd of ADWF or 24,550 lb/day of primary sludge.

Installation of gravity thickeners also has benefits for operation of a BNR system. Operating the primary clarifiers using a "thin-sludge pumping" and gravity thickening operating strategy is one way to increase the amount of soluble carbon available for improving BNR operation. For this mode of operation, the primary sludge from the primary clarifiers is quickly removed from the clarifiers to achieve a low primary solids concentration which is then thickened in a gravity thickener. The thickening process allows for controlled fermentation of the primary sludge. The gravity thickener overflow contains the soluble carbon produced in the fermentation process which can be piped directly to an anaerobic or anoxic zone to increase the efficiency of the biological phosphorus or denitrification process.

As a third benefit, if the City moves forward with conversion from aerated grit basins to vortex grit removal, it should also consider the implementation of thin sludge pumping of the primary clarifiers and gravity thickening of the primary solids. The concern is that pre-aeration may flocculate and improve the settleability of the influent solids. The exceptional BOD and TSS removal performance of the primary clarifiers is a key consideration in the capacity rating of the aeration basins. Some simple, bench-scale settling tests can be used to determine if the loss of pre-aeration will reduce the settleability of the influent solids. If so, then thin sludge pumping and gravity thickening of the primary solids should be integrated into any project that phases out the pre-aeration process. If not, then vortex grit removal can be implemented without (1) modification to the primary sludge pumping regime and (2) re-tasking and converting the DAF unit to a gravity thickener.

Retrofitting the DAF and installing a gravity thickener has a significantly lower capital cost than installing a fourth anaerobic digesters. Due to the lower capital cost and the BNR benefits of a gravity thickener, Tetra Tech recommends installing a gravity thickener to increase the capacity of the anaerobic digesters to provide sufficient digestion capacity at ultimate buildout conditions.

With the gravity thickeners, the existing digesters meet the minimum solids retention time (SRT), HRT, and volatile solid loading criteria and past performance indicates they will comply with VAR criteria and produce Class B pathogen content biosolids with all digesters in operation. At ultimate buildout loading conditions, a digester can be taken out of service for cleaning and repair; however, the digesters will not meet the EPA's default time and temperature requirements for Class B biosolids. The biosolids produced with a digester out of service still may meet Class B pathogen requirements, as verified through testing, in which case they can be land applied or landfilled in the same manner as they are currently. If the biosolids do not meet the Class B criteria with respect to pathogens, then the biosolids can be buried in the landfill. Given that the City has both disposal options available, it is not required to construct an additional digester simply for redundant purposes.

5.1.2 Project #9: Biosolids Dewatering Improvements

BFPs are currently used to dewater the anaerobically digested sludge. The existing BFPs are producing an average biosolids cake concentration of 16.7%, which is on the low side of what is thought to be achievable with belt press dewatering of an anaerobically digested mixture of primary solids and WAS. However, recent research indicates that Bio-P removal may reduce the dewaterability of anaerobically digested sludge due to the release of monovalent cations (principally potassium), which are known to reduce floc strength. This may be the reason why the polymer dosage and costs needed to achieve the above noted cake solids seems unusually high (polymer costs are in excess of $100 per dry ton of cake solids).

The City should consider dewatering optimization trials to determine if acceptable results can be achieved at a lower chemical cost. Increasing the multi-valent cation content of the belt press feed sludge, such as through the addition of ferric chloride (upstream, within, or downstream of the digesters), may improve the dewaterability of the sludge and decrease polymer dosages at the same time. In addition to evaluating the use of ferric chloride, the type of polymer should be evaluated. Some polymers are capable of providing better coagulation and a drier cake concentration, which will lower hauling costs; however, the polymer might have a higher cost. Tetra Tech recommends that the plant perform an economic evaluation of polymers to determine what is most cost-effective for the plant at the time. Over time, the prices of polymers and hauling change; therefore, while the plant has done similar evaluations in the past, the evaluation should be re-done every time a new polymer and hauling contract is negotiated.

Bio-P removal is an important effluent quality benefit of the anaerobic selector, which greatly improves the settleability of the activated sludge biomass, enabling the City to get more capacity out of its highly-loaded aeration basins. Therefore, both the dewatering process and beneficial use land application program should be managed, if and as needed, to accommodate any side effects (and benefits) of the anaerobic selector.

In addition to optimizing polymer and chemical dosing, the City should evaluate other dewatering technologies that are available which produce a drier biosolids cake. Centrifuges can be used to increase the biosolids cake concentration to 20 to 22%. The higher cake concentration will decrease hauling costs; however, the electrical usage for centrifuges tends to be higher. Tetra Tech recommends that an economic evaluation be performed to determine whether it would be cost-effective to change dewatering technologies as the BFPs approach the end of their useful life.

5.1.3 Secondary Sludge Thickening GBTs

The GBTs are performing well with respect to thickened sludge solids concentration and overall solids recovery. However, it is likely that something less than 6.8% thickened solids and 99% solids recovery can be handled without negatively impacting the downstream biosolids handling facilities or recycle flow impacts to the liquid stream treatment process. If performance expectations can be appropriately adjusted, polymer usage and costs can decrease correspondingly, although the polymer dosage is already on the low side with this particular combination of WAS and GBTs.

5.1.4 Project #10: Struvite Formation Mitigation and Phosphorus Recovery

Typical Multi-Form Harvest Fluidized Bed Reactor Cone

The plant currently experiences problems with struvite formation in the pipes of the digesters. Struvite is a hard, crystalline compound that is ammonium-magnesium-phosphate. Once struvite forms in the pipes it is extremely difficult to remove and typically requires replacement of the pipe. The plant is prone to struvite formation in the digesters because the WAS contains PAOs that release large amounts of phosphorus into the digester supernatant. High phosphorus and ammonia concentrations in the digesters produce struvite crystals that tend to form hard encrustations in the filtrate piping. The City has been replacing filtrate piping due to struvite formation.

There are several ways to mitigate the formation of struvite including reducing the pH of the digesting sludge and filtrate, diluting the filtrate, using glass-lined filtrate pipe, adding chemicals to the digesters (such as ferric chloride), or recovering struvite in a side reactor. The City is currently using several of these techniques to minimize struvite problems in filtrate pipes; however, due to the PAOs in the WAS there is still a high struvite formation potential in the digesters and filtrate pipes. Additional chemical feed equipment could be installed for pH control, or the City could evaluate a phosphorus recovery process that would remove phosphorus via the controlled production of struvite, with the recovered material sold as a fertilizer. If some of the phosphorus is also stripped out of the WAS prior to digestion, struvite formation can be reduced in the digesters, BFPs, and filtrate lines. The filtrate would still be needed, primarily for its ammonia content, to generate struvite in the side stream reactor.

There are two contracting methods the City could use for phosphorus recovery. The first method includes the City purchasing the equipment and operating the process, while the second includes leasing the equipment with operations support from the vendor. There are two main companies that have phosphorus recovery processes; Ostara and Multi-Form Harvest. Both companies require that the struvite product be handled and sold by them, with a portion of the sale going to the City. If the City purchases and owns the equipment, they would receive a larger portion of the sale price from the struvite crystals than if they leased the equipment from the vendor. Either way, this project would reduce operations and maintenance by reducing/eliminating struvite formation within the digesters and digested biosolids handling facilities.

5.1.5 Project #7: Additional Odor Control

There is substantial corrosion and odor near the BFPs. The anaerobically digested sludge contains relatively high concentrations of hydrogen sulfide, which is off-gassed in the feed to the BFP. The gaseous hydrogen sulfide is then oxidized by oxygen in the air to form sulfuric acid which corrodes metal surfaces within the BFP room. The majority of the HVAC duct work and other metal surfaces need to be replaced with fiber glass and stainless steel where possible due to the corrosion. The steel roof framing members are also beginning to corrode and need to be recoated. In addition to corrosion problems, hydrogen sulfide is odorous at low airborne concentrations and a potential health and safety concerns if levels rise high enough. Hydrogen sulfide sensors should be installed to continuously monitor the hydrogen sulfide concentrations in the air to improve safety for the operations staff. It is recommended that these sensors be installed during Project #2 as one of the electrical improvements.

Tetra Tech recommends that the foul air collected in the BFP room be ducted and treated with a biofilter or biotower similar to the one used to treat foul air from the influent channels and primary clarifiers. By collecting and treating the air, the potential for corrosion is greatly reduced and the work environment for the operations staff is improved.

5.1.6 Project #11: Digester Gas Cogeneration

The process of anaerobic digestion creates methane (natural gas) as a byproduct of the breakdown of the organic matter within the digesters. Gas generated from properly functioning digesters typically contains approximately 60% methane and 40% carbon dioxide with trace concentrations of other gases. Currently, some of the gas is used to heat the digesters and the rest is flared. This operation prevents the release of methane into the atmosphere; however, it does not fully use the energy potential within the gas. A cogeneration system can be installed that runs on the digester gas produced.

The existing three mesophillic anaerobic digesters are performing exceedingly well with respect to VS destruction and gas production. The principal suggestion here is to consider making expanded use of this resource through electric power generation, by means of direct combustion. It is understood that fuel cells have been previously considered and determined to be economically unattractive at this time. Table 5-1 is a summary of sludge, digester gas, and potential co-generation power production estimates for the LWRP. The input parameters were adjusted based on historic data so that projected and digester gas production values matched up well. As shown, current annual average power generation potential is approximately 400 kW, although it could range from under 400 kW up to 700 kW under current conditions to 700 kW at ultimate buildout.

Table 5-1. Sludge, Digester Gas, and Potential Co-Generation Power Production Estimates

Parameter	Current Average Annual Loading (1)	Average Annual at Ultimate Buildout (2)	Maximum Month at Ultimate Buildout (3)
Primary Sludge Solids			
ppd/mgd	1,624	1,624	1,905
ppd	11,466	15,687	18,040
Secondary Sludge Solids			
ppd/mgd	954	954	1,119
ppd	6,734	9,213	10,595
Total Sludge			
ppd/mgd	2,578	2,578	3,024
ppd	18,200	24,900	28,635
Digested Sludge (4)			
ppd/mgd	1,154	1,154	1,353
ppd	8,145	11,143	12,814
Volatile Solids Destruction			
ppd/mgd	1,424	1,424	1,671
ppd	10,055	13,757	15,821
Digester Gas Production			
cfm/mgd (5)	15.8	15.8	18.6
cfm (Estimated)	111	153	176
Estimated Power Generation Capacity			
BTUs/min (6)	66,600	91,800	105,600
kW (7)	412	567	653

Notes:

1. Current average annual based on historical data from 2009 through June 2012
2. Average annual at buildout based on ratio of current ADWF of 6.93 mgd to ultimate ADWF of 9.47 time current average annual.
3. Maximum month at ultimate capacity based on ratio of current average annual to maximum month digester loading of 1.15
4. Based on a combined primary plus secondary sludge VS content of 85% and a VS destruction of 65%, at annual average, and maximum month conditions
5. Based on an average digester gas production rate of 16 cf per pound of VS destroyed at annual average, and maximum month conditions.
6. Based on a digester gas composition of 60% methane and 40% carbon dioxide and 1,000 BTUs per cf of methane.
7. Based on methane combustion to electric power conversion efficiency of 35%.

In addition to reducing the plant's power bill throughout the year, the digester gas may generate enough electricity to operate the liquid and solids stream treatment facilities during a loss of utility power except for activated sludge aeration, although a detailed electrical load study is required to confirm this possibility. However, the State may not consider digester gas a reliable enough fuel supply to make such a system qualify as a source of redundant power.

On-site power production could be "boosted" through co-digestion of food wastes, such as fats, oils, and grease (FOG) from local/regional restaurants. Depending upon the overall solids concentration of the FOG wastes, preliminary estimates suggest that each 1,000 gallons of this material could increase gas production by 4 to 5 cfm and power generation by about 15 to 20 kW. While other food wastes could be used, FOG has a very high VS content, much of which is amenable to anaerobic digestion. The digester gas so produced is reported to have methane content as high as 70%. The literature also reports that the addition of FOG improves the overall VS destruction of primary and secondary sludge solids, although VS reductions at the LWRP are normally on the order of 63 to 65%, so there is not much room for further improvement. However, more power generation capacity can be added depending upon the success and growth of the co-digestion program, if one is implemented.

Some utilities, such as the East Bay Municipal Utilities District, have embarked upon an aggressive co-digestion program with the intent of becoming net zero with respect to utility power usage. A more detailed study would show the payback potential of power generation at the LWRP and how much food waste, plus energy conservation measures throughout the plant, would be needed to reach a net zero position. Although client preferences and designs vary widely, the FOG handling system could include a truck receiving station, grit/sediment trap, screening, grinding, heating and mixing of the material, odor control, and metering the FOG into the digesters over a 24-hour period.

There are several ways to structure a cogeneration project. First, the City could build and operate the system itself. Using this approach the City would be responsible for all of the capital cost and operational labor; however, they would maximize the cost saving benefit of the electricity production. Other contract structure includes contracting with a company who would build and operate the system for the City. This company would sell the electricity produced to the City for a lower rate than the local utility. This contract method does not maximize the cost benefit of the electricity production; however, it minimizes the capital and operation cost for the City. Also a combination of the contracting mechanisms can also be negotiated.

5.2 Ultimate Disposal/Utilization

The City has implemented a dual disposal program for the anaerobically digested and belt press dewatered biosolids generated at the LWRP: beneficial use land application as a soil amendment at agricultural sites during the spring, summer, and fall, and landfill disposal during the winter. At the landfill, the preferred management approach is to beneficially use the biosolids as part of the daily soil cover. If needed, dewatered cake can be buried in the active landfill cells.

As detailed below, the City produces a high-quality anaerobically digested biosolids product that gives it the flexibility to (1) beneficially use this carbon-based material as a soil amendment and slow release fertilizer or (2) bury the dewatered cake in the landfill. With respect to federal law, beneficial use of all biosolids, regardless of pathogen content, requires that this material comply with the VAR criteria set forth in Section 40 of the Code of Federal Regulations, Part 503. It is common to call these regulations "EPA Part 503" requirements since enforcement is through EPA, either directly or through delegation of primacy to the state. For bulk land application of biosolids at controlled access sites, including as landfill cover, the biosolids must also meet the Class B pathogen reduction (PAR) requirements set forth in EPA Part 503.

The beneficial use outlets currently utilized by the City only require Class B biosolids with respect to pathogen content. For marketing and distribution to the public, biosolids must be further treated to meet Class A criteria for PAR. Following is a summary of Livermore's compliance posture with respect to federal biosolids quality requirements. Note that while state and local governments could set more stringent pathogen requirements for beneficial use of biosolids, there has not been significant momentum in this direction. Even so, this report will briefly address how Livermore can position itself to respond should the State of California or local jurisdictions require Class A pathogen quality for controlled access sites where biosolids are beneficially applied in bulk.

VAR – One of the VAR compliance pathways in the EPA Part 503 regulations, whether Class A or Class B pathogen quality is desired, is to provide volatile solids (VS) reduction of 38%. The anaerobic digesters at the LWRP provide consistently high levels of VS reductions, typically in the range of 60% to 65%, which easily comply with the 38% VS reduction criteria.

PAR Class B – For anaerobic digestion, the default time and temperature requirement to qualify as a Class B biosolids product is to provide a 15-day hydraulic retention time (HRT) at a minimum temperature of 95°F. Operating data indicate that actual HRTs are in excess of 20 days and the normal operating temperature is approximately 100°F. Therefore, regardless of the actual fecal coliform content of the digested biosolids, it qualifies as Class B with respect to pathogens.

PAR Class A – In the EPA Part 503 regulation, there are a number of methods by which Class A pathogen quality can be achieved. Although compliance with stringent numeric standards for fecal coliforms and several other microorganisms is an acceptable method, most Class A compliance pathways involve meeting minimum time and temperature default criteria. That is, exposing biosolids to a minimum temperature for a minimum amount of time: the higher the temperature the shorter the required exposure time. Given the existing facilities at the LWRP, it is logical to consider using thermophilic anaerobic digestion as the Class A pathogen compliance method of choice. However, it is recommended that the City consider other Class A compliance methods, as discussed below:

- Experience over the last 20 years indicates there is no evidence of widespread disease transmission when biosolids in compliance with VAR and Class B pathogen criteria are properly applied as a soil amendment at controlled access sites. Therefore, the City should only invest in producing a Class A biosolids product if it wants to (1) implement a public marketing and distribution program or (2) continue bulk land application at controlled sites and is required to meet Class A pathogen criteria to do so.
- Thermophilic anaerobic digestion is known to reduce the dewaterability of the biosolids, which is already less than optimum, as further discussed below. If thermophilic digestion is used, the normal approach is to follow that step with mesophillic digestion to restore good dewatering characteristics. This is an expensive way of achieving a Class A product.
- Other Class A pathogen compliance options potentially applicable to Livermore include off-site composting, either by the City or a private contractor. On-site composting creates the potential for off-site odor complaints and is not recommended unless a significant investment is made in odor control facilities. Even then, many municipal sludge composting facilities have failed because

odor control was not sufficient to meet the expectations of the public. Another Class A approach is indirect drying of the anaerobically digested and dewatered biosolids cake. This would also create the potential for off-site odor complaints, although to a lesser extent than composting.

- It is recommended that the City explore the potential for off-site privatized composting with contractors that are in the business of producing organic soil amendments for residential, commercial, or agricultural markets. Composting is widely practiced in the agricultural and food waste sectors of the economy. Some private composters have added municipal sludge composting to their range of services. Certain utilities have their own Class B biosolids application program and also send a portion of their sludge (digested or not) to a private composter, with the agreement that the composting contractor will take all the biosolids on short notice, if needed. Privatized composting could also be used as a biosolids management alternative for a portion of Livermore's dewatered sludge when one of the existing anaerobic digesters is down for cleaning or maintenance.
- It is not likely that Class A biosolids will be a requirement within the planning period of the Master Plan. Tetra Tech recommends that the next Master Plan update re-evaluate the potential need for Class A biosolids. No provisions for Class A biosolids were included in the CIP for this Master Plan Update. The most likely Class A biosolids technology for the LWRP is indirect drying, including odor control facilities, because it is economically feasible and can be independently implemented by the City on its LWRP site, providing Livermore with a reliable "back stop" should Class A become a future requirement. Alternatively, the City could pre-position so it can implement privatized composting or focus biosolids management on landfill burial, for which neither Class B nor Class A pathogen requirements apply.

5.2.1 Inorganic Quality

The inorganic quality of the biosolids is very good and cumulative loading limits for metals do not restrict biosolids application rates. The United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS) is becoming more aggressive in implementing its phosphorus index (P-index) and nitrogen index (N-index) criteria to reduce the potential for (1) water and wind erosion that can cause the transport of soil and phosphorus to off-site water bodies and (2) nitrate contamination of shallow groundwater or those used as a public water supply. The P-index and N-index requirements can be applied to private farms that are subject to a NRCS nutrient management plan. The City should determine if the NRCS nutrient indexing requirements will impose constraints on overall biosolids loading rates and the capacity of its beneficial use land application program. Although the NRCS guidelines do give credit to various farm site management activities, phosphorous recovery could be an important tool to facilitate application of biosolids at the agronomic rate for nitrogen, rather than something less than that, which reduces the fertilizer value of biosolids.

5.2.2 Landfill Burial

The dewatered biosolids also comply with landfill burial requirements, which require that the biosolids not release free water (i.e. pass the paint filter test) and be non-hazardous, the principal barometer for which is the toxicity characteristics leaching procedure (TCLP) test.

Overall, the City has good biosolids management flexibility and looks to be in solid position, both with respect to ultimate disposal capability and regulatory compliance. However, Livermore should pre-position with respect to the potential need for a Class A pathogen quality biosolids product, and additional research on NRCS nutrient indexing requirements may be warranted.

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6.0 OTHER ANCILLARY SYSTEMS

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6.0 OTHER ANCILLARY SYSTEMS

Tetra Tech visited the LWRP for the mechanical, structural and electrical assessment of the plant facilities on November 8 and 9, 2012. This section summarizes the field observations made during the site visits and provides recommendations for improvement of the facilities. Some of the recommended improvements noted in this section of have been included as part of projects noted in other sections of this report. Miscellaneous renewal and replacement items to replace or repair aging equipment and structures have been included as a single project which is summarized at the end of this section.

6.1 Electrical Evaluation

The electrical inspection covered the equipment from the 21 kilovolt (kV) switchgear to each motor control center (MCC) and panel board. During the inspection it was noted that some MCCs have been replaced and others are in the process of being replaced as part of the Electrical Distribution System Design Project which is scheduled for construction in the fall of 2013. Refer to the Technical Memorandum Water Reclamation Plant Electrical Distribution System Analysis prepared by Carollo Engineers (included in Appendix D) for changes to the existing system.

Over the past few years, the plant electrical system has undergone some changes, not all of which were documented. Tetra Tech reviewed as-built and proposed drawings, and talked to the plant personnel to get a solid understanding of the past changes that were made and proposed upgrades.

6.1.1 Project #2: Emergency and Standby Power

A discsussion on the emergency and standby power was presented in Section 4.1.2. Two options were discussed with plant personnel for providing back up electric power service. The first option is to get a second primary feed of 21kV from Pacific Gas and Electric (PG&E) and the second option is to use a diesel generator. The first option would be costly. Also, if the PG&E substation had a fault, power from both feeds would be lost so there is minimum advantage of having a second 21kV feed. The generator option seems a better choice for the current plant operation.

Plant personnel discussed different ideas and approaches for using a backup diesel generator. For example, some personnel did not like the permanent generator option and preferred the concept of renting one on an as-needed basis. The disadvantage of this approach is if there is a major area wide power failure, finding a generator to rent will be difficult unless the City pays an ongoing "first right of access fee" to assure the unit(s) is available when needed. Some personnel wanted to buy a permanent generator on a trailer and use it at various locations on an as-needed basis. This option has its drawback because of the upkeep of the cables and the work that is required to connect it when needed. Some personnel like a permanent generator with an automatic transfer switch that runs the whole plant.

Tetra Tech recommends a permanent diesel generator with an automatic transfer switch back to PG&E power. The generator should be installed on the main MCC that runs most of the critical plant load. In case of power outage, the generator would start and power up the main MCC.. Carollo Engineers, under separate contract with the City, performed an electrical system analysis and identified standby power requirements for the plant. Carollo recommended to install a functional standby generator, the electrical system throughout the plant would need to be improved. Two 480V transformers and a double-ended switch gear will be added to upgrade the electrical distribution system. Construction of these new systems is scheduled for the end of 2013. Based on the analysis performed as part of

Electrical Distribution System Analysis Technical Memorandum prepared by Carollo Engineers in 2013 (included as Appendix D), a 1,500 kW standby generator is recommended to supply backup power the LWRP. The Technical Memorandum also listed electrical improvements required for all the projects identified in 2012 Master Plan Update.

6.1.2 Project # 19: Power Equipment Upgrades

The following recommendations are provided in order to provide operations and maintenance staff with a clearer understanding of the plant electrical system. These recommendations should be included as part of Electrical Distribution System Design project currently in progress.

- Provide large size labels for all electrical equipment to be visible at a distanced of 20 feet.
- Update the single line diagram to reflect the latest changes that were made.
- Update all the new and existing MCC elevation drawings.
- Update all panel board load schedule to reflect latest equipment.

6.1.3 Project #14: Power System Studies

The plant personnel have done an in-house upgrade to some of the electrical equipment and the installations were well planned and the quality was high. Because some electrical equipment has been replaced and the new electrical system has different characteristics than the older ones, Tetra Tech recommends the following:

- Prepare electrical load flow study as necessary after the Electrical Distribution System Design Project.
- Perform overall electrical system coordination study because the new circuit breakers have different tripping setting then the older ones.
- Complete an Arc Flash study for each switchboard and MCC and affix the required signs that show the hazard category, safe operating distance, and the proper personal protective equipment for personnel.

6.2 Mechanical/Piping Evaluation

The mechanical inspection covered the review of the major equipment and piping to determine potential areas of corrosion and operational issues. The following sections provide summary of our findings and recommendations.

6.2.1 Influent Pump Station

- Three covered screw pumps each with a capacity of 4,000 gpm (2 duty, one stand-by). Space is provided for fourth pump.
- Monthly, quarterly, and annual maintenance of the screw bearings on the pumps are performed. Maintenance has not been done on the screws. All gearboxes have been replaced within the last five years. Recommend replacing bearings while applying coating on gearbox.
- Noticed corrosion on the spiral of the pumps for 1 and 2.
- Overall the pumps and piping appeared to be in good condition. Recommend to evaluate the extent of the corrosion on the spiral blades of the pumps and provide coatings as necessary. It is recommended replacing bearings while applying the coating on the screws.
- Screw inlet gates can be actuated to facilitate operation

6.2.2 Mechanical Screen

- Climber screen with conventional bar rack was installed in 2004.
- The overall condition of the mechanical bar screen is good.
- An in-channel comminute serves as backup to the bar screen. However, the comminute does not completely shred all rags.
- All equipment in the mechanical screen area appeared to be in good condition.
- Recommend adding a redundant mechanical screen or a second mechanical screen to initiate sequential screening as described as Project #3 in Section 4.1.3. Further evaluation is needed to locate a suitable location for another mechanical screen.
- Parshall flume downstream of the mechanical screen measures the influent flow.

6.2.3 Aerated Grit Tanks and Grit Classifier

- The recommendations for improvements were discussed in Sections 4.1.7 and 4.1.9. The City previously converted old primary tanks to two aeration tanks. Both were operated during peak wet weather flows.
- Grit pumps, valves and piping in good condition.
- Grit cyclone and classifier equipment is in good condition. The grit debris bin appeared to be in a temporary location. Need to evaluate the need for back up unit and a permanent location (Project #6).
- Top of grit shed is severely corroded. Grit shed need to be replaced. Provide second classifier and chute. Install catwalks and railings on top so that maintenance can access classifier (Project #6).
- Observed odor issue when the truck was pulling the debris bin. Since building is already piped to the odor control tower, need to evaluate if the air draw is sufficient for the longer distance.
- Grit pumps appeared to be in good condition. The piping needs to be painted and labeled.
- The blower is old and should be replaced with a more efficient blower. Needs further evaluation.

6.2.4 Primary Tanks

- All four rectangular tanks are used for WWFs. The tanks were constructed in 1958, 1982 and 1994.
- The connection between aerated grit tank and primary tank has a leak. GSE fixed the leak in 2011.
- Primary sludge pumps, scum pumps, associated valves and piping appeared to be in good condition.

6.2.5 Aeration Tanks

- One tank is down and one is operational.
- Observed leaking and corrosion at the flow control gates. The gates are being replaces as part of Project #4.
- Need to clean out reclaimed water spray piping and raise it above liquid level.
- Piping around the tanks needs to be labeled.
- Some pipes and valves showed signs of corrosion. Need to be painted.
- Tank 1 is out of service. Noticed deposits of sludge and plant growth. Need to renovate the tank and gates, and replace mud valves and in-basin air piping and diffusers as soon as possible to provide redundancy for the activated sludge portion of the treatment process. Renovation should be configured so this basin mimics Tank 2, including the anaerobic zone (Project #1).
- Aeration blowers are new and in good condition. Recommendation for the aeration tanks rehabilitation and upgrades are referenced in Section 4.1.1.

6.2.6 Project #17 - Secondary Clarifiers

- The Secondary Distribution Box connection to Clarifier 1 is leaking. Need to fix the leak and upgrade the box with automated gates so that the MLSS is evenly distributed to the three secondary clarifiers.
- Mechanical equipment for Secondary Clarifier #2 is 30 years old and observed corrosion. Replace all the mechanical equipment and recoat walls.
- Overall, the clarifier tanks appeared to be in good condition. Tanks will be taken out for maintenance in the future.
- RAS pumps appeared to be in good condition. Piping and valves need coating.
- WAS pumps appeared to be in good condition. Maintenance was done in September 2011 and valves were replaced in June 2010.

6.2.7 Gravity Belt Thickeners

- The two units, one duty and one stand-by, appeared to be in good condition.
- Piping and valves appeared to be in good condition.

6.2.8 Digesters

- Evaluated in 2006 Master Plan.
- Digester piping and valves appeared to be in good condition. However, the gas valves on all three digesters should be replaced.
- Heat exchangers were replaced recently and are in good condition.
- Digester recirculation pumps, valves and piping appeared to be in good condition. Digester gas flare area piping appeared to be in good condition.
- Polymer tank, pumps and associated piping appeared to be in good condition.

6.2.9 Belt Filter Presses

- The two units, one duty and one stand-by, are in good condition.
- Piping and valves appeared to be in good condition.
- Noticed corrosion of HVAC, piping and other equipment. Recommend coating the pipes and providing odor control at the building (Project #7).
- Label the process piping and provide direction of flow.
- Recommend recoating steel roof framing members.

6.2.10 Chlorine Contact Tank

- Piping needs to be labeled.
- Two gates are frozen in place and need to be replaced.
- Outfall gate stem shows signs of corrosion and needs to be recoated.

6.2.11 Old Chlorine Contact Tank

- No mechanical observations made. This tank is currently used as a wet well for recycled water.

6.2.12 Project #18: Emergency Holding Basin and Basin Return Pumps

- The size of the Emergency Holding Basin return pumps should be increased. The size of the return pumps should be sized to return water to the head of the plant during peak flow. The LAVWMA pumps can handle approximately 13.7 MGD which limits the maximum flow through the plant. Providing emergency holding basin return pumps that can handle flows 4.5 mgd should be adequate peak flows at build out as calculated by the difference of 13.7 mgd (maximum flow through the plant) and 9.47 mgd (buildout ADWF). Two 4.5 mgd pumps should be supplied to handle peak flows (with one pump being redundant), along with one 1 mgd pump to handle pumping back diurnal flows. Tetra Tech recommends the use of chopper pumps for this application considering during peak events the flow will not be screened prior to being diverted to the emergency holding basin.

- The piping from the emergency holding basin back to the headworks will need to be replaced with larger pipe to convey the increased flow from the return pumps. The existing 14 inch pipe should be replaced with 18 inch pipe.
- Piping needs to be labeled, painted and show flow direction.
- Piping around the steps needs to be fastened. Flow is limited during graveyard shift. Replace piping pad and install adjustable pipe supports. Evaluate the need for bigger pumps to pump more flow to the preliminary treatment facilities. Restrained piping joint was partially cast into the slab. Recommend isolating restrained joint from slab to keep piping from being dragged down as the slab settles.

6.2.13 Ferric Chloride Facility

- The structure and pumps appeared to be in good condition.
- Piping needs to be labeled, painted and show flow direction.
- Isolation valves and PRV need to be replaced.

6.2.14 Sodium Hypochlorite Facility

- The system is 20 years old. It appeared to be in good condition.
- Piping needs to be labeled and painted.
- Need to confirm whether the eye wash station meets OSHA standards.

6.2.15 Sodium Hydroxide Steel Tank Near Chlorine Contact Tank

- Piping needs to be labeled and painted.
- Tank does not appear to be anchored for seismic loading.

6.2.16 Project #19: Reclaimed Water Pumps

- Noticed signs of corrosion. Piping and valves need to be painted, labeled and show flow arrows.
- The surge tank needs to be replaced.
- Air compressor base shows signs of corrosion. Needs coating.
- Piping needs to be labeled and painted.
- Three pumps need to be replaced.

6.2.17 Tertiary Filters and Flocculation Tank

Overall, most of the process piping needs to be painted per process type, labeled, and flow direction indicated.

6.3 Project #15: Miscellaneous Structural Improvements

The structural inspection covered the review of the process tanks and other structures to determine potential areas of corrosion and concrete spalling. The following sections provide summary of our findings and recommendations which have been included as Project #15: Miscellaneous Structural Improvements.

6.3.1 Influent Pump Station

- No structural disturbances or signs of distress/deterioration observed.

6.3.2 Mechanical Screen

- No structural disturbances or signs of distress/deterioration observed.

6.3.3 Aerated Grit Tanks and Grit Classifier

- No structural disturbances or signs of distress/deterioration observed.

6.3.4 Primary Tanks

- Aluminum tank covers appeared to be in good condition. Minor concrete spalls/cracking at various locations; some have been patched. Recommend repairing cracks and spalls to protect steel reinforcement from corrosion. See Exhibit 10 in Section 6.3.18.
- Concrete damaged by hydrogen sulfide gas; recommend closer evaluation of concrete damage during shutdown and repairing/lining concrete to prevent further damage. See Exhibit 6 in Section 6.3.18.
- Observed minor/moderate corrosion at steel grating and guardrail. Recommend sandblasting and recoating to prevent further corrosion. There is severe corrosion of the metal gate brackets that are cemented in place. See Exhibits 11 and 12 in Section 6.3.18.
- No apparent lateral force resisting system for above-grade odor control piping.
- Recommendation: design/install lateral force resisting system at above-grade odor control piping. Lateral force resisting system may be in the form of diagonal bracing at existing columns. See Exhibit 1 in Section 6.3.18.

6.3.5 Aeration Tanks

- Minor concrete spalls/cracking at various locations; some have been patched. Recommend repairing cracks and spalls to protect steel reinforcement from corrosion. See Exhibit 10 in Section 6.3.18.
- Vertical through-cracks at walls are leaking. Recommend repairing cracks to protect steel reinforcement from corrosion. See Exhibit 7 in Section 6.3.18.
- Observed leakage through joint at west end of tanks into the adjacent subgrade. Recommend trying to stop/mitigate leak with hydrophilic polyurethane grout injection until more permanent repairs can be made during a shutdown. See Exhibit 8 in Section 6.3.18.

6.3.6 Secondary Clarifiers

- Secondary Distribution Box is leaking on one side into the adjacent subgrade. The cause of the leak was not observable. Recommend further observation/evaluation during shutdown to devise a permanent solution. As a short term fix, stop/mitigate leak with hydrophilic polyurethane grout injection. See Exhibit 8 in Section 6.3.18.

6.3.7 Gravity Belt Thickeners

- No structural disturbances or signs of distress/deterioration observed.

6.3.8 Digesters

- No structural disturbances or signs of distress/deterioration observed.
- Covers appeared to be in good condition.

6.3.9 Belt Filter Press

- No structural disturbances or signs of distress/deterioration observed.

6.3.10 Chlorine Contact Tank

- No structural disturbances or signs of distress/deterioration observed except as noted below.
- There are a few vertical wall cracks, for which the adjacent subgrade should be checked for possible signs of leakage. See Exhibit 7 in Section 6.3.18.

6.3.11 Old Chlorine Contact Tank

- Observed various concrete cracks, spalls. The tank is currently used as a wet well for the recycled water. Recommend repair of concrete.

6.3.12 Emergency Holding Basin and Basin Return Pumps

- No structural disturbances or signs of distress/deterioration observed except as noted below.
- Concrete is spalling at several locations.
- Stair nosings have spalled off. This is a safety issue (slip/trip hazard).
- Slab-on-grade has settled several inches. Recommend further evaluation to determine cause and remediation.

6.3.13 Ferric Chloride Facility

- No structural disturbances or signs of distress/deterioration observed except as noted below.
- Tank seismic restraints anchored to concrete slab are currently located outside of FRP grating and several inches away from tank. Recommend trimming grating and relocating restraints closer to tank, as well as tightening seismic anchor cables. See Exhibit 2 in Section 6.3.18.

6.3.14 Sodium Hypochlorite Facility

- The tanks are not in good condition.
- Tank anchorage for uplift appears to be inadequate; seismic cable connection to anchor bolt by a nut and washer is not recommended. See Exhibit 3 in Section 6.3.18.
- Cracking/spalling observed at tank pedestals. Recommend repair to restore concrete strength. See Exhibit 9 in Section 6.3.18.

6.3.15 Sodium Hydroxide Steel Tank Near Chlorine Contact Tank

- The steel tank is not in good condition.
- Concrete is spalling.
- Tank anchorage was not observed; recommend verifying presence/absence of tank anchorage. See Exhibit 4 in Section 6.3.18.

6.3.16 Reclaimed Water Pumps

- No structural disturbances or signs of distress/deterioration observed.

6.3.17 Tertiary Filters and Flocculation Tank

- Minor concrete spalls/exposed rebar at various locations. Recommend repairing spalls to protect reinforcement from possible corrosion. See Exhibit 10 in Section 6.3.18.

- Vertical cracks at walls; recommend checking adjacent subgrade for signs of leakage and repair as necessary. See Exhibit 7 in Section 6.3.18.

6.3.18 Seismic Upgrade Exhibits

Seismic upgrade recommendations are based upon field observations noted above.

Exhibit 1 – Odor Control Piping at Primary Tanks

Observation: No apparent lateral force resisting system for above-grade odor control piping.

Recommendation: Design/Install lateral force resisting system at above-grade odor control piping. Lateral force resisting system may be in the form of diagonal bracing at existing columns

Exhibit 2 – Ferric Chloride Tank

Observation: Seismic sliding restraint is outside of FRP grating and away from Ferric Chloride tank. Seismic cable is slack.

Recommendation: Trim FRP grating and relocate sliding restraints closer to tank. Tighten seismic cables to remove slack.

Exhibit 3 – Sodium Hypochlorite Tank

Observation: Sodium hypochlorite tank anchorage appears to be inadequate.

Recommendation: Evaluate/replace existing tank anchorage with anchorage designed in accordance with current code requirements.

Exhibit 4 – Sodium Hydroxide Tank

Observation: Sodium hydroxide tank anchorage is not apparent.

Recommendation: Verify presence/absence of tank anchorage. Provide tank anchorage in accordance with current code requirements if none exists.

Exhibit 5 – Polyethylene/Fiberglass Tank Seismic Cables

Observation: Polyethylene/fiberglass tank seismic cables are slack.

Recommendation: Tighten seismic cables at all tanks as required to remove slack.

6.3.19 Concrete Repair

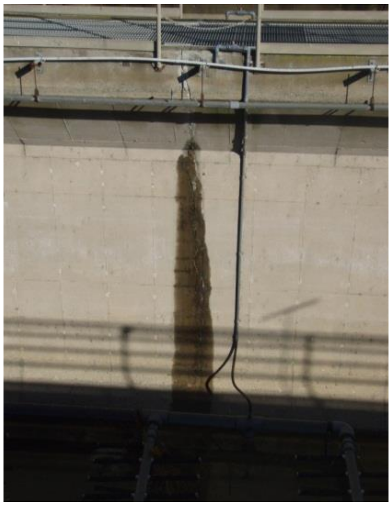
Concrete repair recommendations are based upon field observations noted above.

Exhibit 6 – Concrete Corrosion at Primary Tanks

Observation: Concrete corrosion due to hydrogen sulfide gas at water conveyance channel near Primary Effluent Pumps.

Recommendation: Repair/patch damaged concrete to replace lost concrete cover and line with polyurethane coating such as Sancon or Zebron.

Exhibit 7 – Concrete Wall Cracks/Joints Exhibiting Leakage



Leaking Crack at Aeration Basin

Potentially Leaking Crack at Chlorine Contact Tank

Potentially Leaking Crack at Tertiary Filters/Flocculation Tank

Observation: Through-cracks at water-retaining structures that are leaking or may be leaking.

Recommendation: Verify whether leakage is occurring. For leaking cracks, repair by crack injection using hydrophilic polyurethane chemical grout such as SikaFix HH Hydrophilic, manufactured by Sika Corporation. The grout is pumped via injection ports through holes that are drilled at a 45 degree angle to the wall surface into the crack at the center of the wall. The grout reacts with water to form expansive, flexible foam that seals the crack, and in most cases can be done without draining the water out of the structure.

Exhibit 8 – Leakage at Aeration Basin and Mixed Liquor Box

Aeration Basin

Mixed Liquor Box

Observation: Leakage at Aeration Basin and Mixed Liquor Box.

Recommendation: Temporary leak mitigation may be achieved by injecting hydrophilic polyurethane chemical grout such as SikaFix HH Hydrophilic, manufactured by Sika Corporation. Permanent leak repairs can be made during a shutdown once the optimal method of leak repair is determined.

Exhibit 9 – Concrete Cracks at Sodium Hypochlorite Tank Pedestals

Observation: Cracking at Sodium Hypochlorite Tank pedestals.

Recommendation: Structurally repair concrete with epoxy such as Sikadur 35, Hi-mod LV LPL, manufactured by Sika Corporation.

Exhibit 10 – Miscellaneous Concrete Spalls

Observation: Spalling at various locations (Primary Sedimentation Tank Top Slab Shown).

Recommendation: Repair spalls with concrete repair mortar such as SikaTop 122 Plus, manufactured by Sika Corporation. Existing spall material should be removed and area to be repaired should be chipped down to provide a minimum thickness of 1/8-inch repair mortar throughout with neat edges around the perimeter. For spalls that expose concrete reinforcement, chip concrete down so that a one-inch thickness of repair mortar can be placed behind the reinforcement. Reinforcement should be cleaned of all traces of rust and primed per manufacturer's recommendations. Substrate preparation, product application and curing should be performed in accordance with manufacturer's recommendations. Provide joint/joint filler as necessary at spall repairs adjacent to existing concrete.

6.3.20 Metal Corrosion Repair

Metal corrosion repair recommendations are based upon field observations noted above.

Exhibit 11 – Metal Corrosion at Gates

Observation: Severe corrosion at various gate locations (Aeration Basin shown).

Recommendation: Replace gates.

Exhibit 12 – Miscellaneous Metal Corrosion

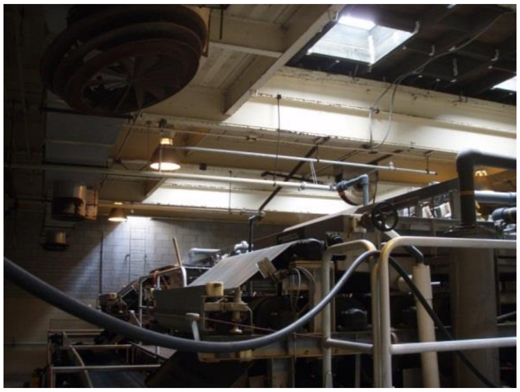
Observation: Miscellaneous metal corrosion at various locations.

Recommendation: Repair/recoat corroded metals, replace as required for severe corrosion.

Exhibit 13 – Minor Metal Corrosion at Solid Handling Building Roof Framing

Observation: Minor metal corrosion at Solids Handling Building roof framing. HVAC, piping and equipment also has corrosion. The ducting should be replaced as part of Project #7.

Recommendation: Recoat steel roof framing members and other equipment to prevent further corrosion.



6.4 Project #19: Miscellaneous Improvements

Based on the electrical, structural, and mechancial evaluations, there are some miscellaneous improvements that are required at the LWRP. Descriptions for each of the items are provied in Sections 6.1, and 6.2. A bulleted list of improvements identified that are not covered by other projects is provided below:

- The screws inside the influent pumps should be inspected for corrosion. The screws should be recoated as necessary and bearing should be replaced.
- The piping surrounding the grit basin and grit pumps should be labeled and repainted.

- The blower powering the grit pumps is old. An evaluation of the blower should be completed and replaced if necessary. If grit basins are retro-fitted with vortex grit removal, the blower should not be replaced.
- Piping around the aeration basins should be repainted and labeled.
- All of the gas valves for the anaerobic digesters should be replaced.
- Piping surrounding the chlorine contact basin should be labeled.
- The gates at the chlorine contact basin should be replaced.
- The gate leading to the outfall structure should be recoated.
- The piping at the ferric chloride tank should be recoated and labeled.
- The isolation valves and the PRV for the ferric chloride system should be replaced.
- The piping near the sodium hypochlorite system should be recoated and labeled.
- The piping near the tertiary filters should be recoated and labeled.
- Provide large size labels for all electrical equipment to be visible at a distanced of 20 feet.
- Update the single line diagram to reflect the latest changes that were made.
- Update all the new and existing MCC elevation drawings.
- Update all panel board load schedule to reflect latest equipment.

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7.0 RECOMMENDED CAPITAL IMPROVEMENTS PLAN

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7.0 Recommended Capital Improvements Plan

7.0 RECOMMENDED CAPITAL IMPROVEMENTS PLAN

This section summarizes the recommended improvements that emerged during preparation of this 2012 Master Plan Update. The recommended Capital Improvements Program (CIP) for the LWRP was subdivided into three phases over a 20 -year period.

7.1 Recommended Projects

Based on this evaluation, the following improvements are recommended to meet present and future conditions:

- Project #1 (refer to Section 4.1.1 for a detailed description):
  - Replace the air piping and diffusers within Aeration Tank #1. Add an anaerobic selector similar to Aeration Tank #2. Rehabilitate the gates that control the step-feed flow control capability for Aeration Tank #1. Rehabilitate or replace the gate actuators. Repair the frames and replace the seals around the gates.
- Project #2 (refer to Sections 4.1.2 and 6.1 for a detailed description):
  - Install standby generator to power critical processes and equipment.
  - Perform overall electrical system coordination study to minimize tripping in case of a fault.
- Project #3 (refer to Section 4.1.3 for a detailed description):
  - Install a new fine screen downstream of and in series with the existing screen. Configure channels so each screen can serve as the redundant unit to the other.
- Project #4 (refer to Section 4.1.4 for a detailed description):
  - Provide the following improvements to aid process control and improve energy optimization:
    - Install additional DO probes and air flow control valves to add two additional airflow control zones to each of the aeration basins.
    - Install TSS meters in each aeration basin
    - Install automatic gate actuators on the slide gates that control the flow entering aeration basins for step-feed mode.
    - Install a suspended solids probe in the WAS line to the GBTs so the operators can monitor the WAS concentration on a real-time basis.
- Project #5 (refer to Section 4.1.5 for a detailed description):
  - For reuse treatment, install new UV disinfection equipment for the reuse system with improved automatic cleaning system and the capability to control the target delivered UV dosage based on flow and UVT variations.
- Project #6 (refer to Sections 4.1.6 and 4.1.7 for a detail description):
  - Install slide gates equipped with hand-wheel actuators at primary clarifiers.
  - Install an additional grit classifier.
- Project #7 (refer to Sections 4.1.8 and 5.1.5 for a detailed description):
  - Provide additional odor control at several locations in the plant.
- Project #8 (refer to Section 4.1.9 for a detailed description):
  - Replace the aerated grit removal system with either a vortex or headcell grit removal system.

- Project #9 (refer to Section 5.1.2 for a detailed description):
  - Perform an economic evaluation study to determine whether it would be cost-effective to change dewatering technologies as the BFPs approach the end of their useful life.
- Project #10 (refer to Section 5.1.4 for a detailed description):
  - Perform study to evaluate the costs and benefits for installation of a phosphorus recovery system. For CIP planning, assume construction of such a system.
- Project #11 (refer to Section 5.1.6 for a detailed description).
  - Perform a study to determine the payback potential of power generation at the LWRP. For CIP planning, assume construction of cogeneration facility.
- Project #12 (refer to Section 5.1.1 for a detailed description):
  - Convert abandoned DAFT unit to a gravity thickener
  - Install a second 25-ft gravity thickener
  - Gravity thickeners should be installed when the first of the following occurs:
    - ADWF exceeds 7.911 mgd (90% of 8.79 mgd)
    - Maximum month digester loading exceeds 23,900 lb/day (90% of maximum month loading at 8.79 mgd ADWF which is 26,563 lb/day).
    - The aerated grit system is replaced with vortex or headcell grit removal (Project #8)
    - BNR is implemented (Project #13).
- Project #13 (refer to Section 4.2.1 for a detailed description):
  - Upgrade the activated sludge system to at least a three-stage BNR process.
- Project #14 (refer to Section 6.1.3 for a detailed description):
  - Update 2008 arc flash study for each switchboard and MCC and apply the required signs that show the hazard category, safe operating distance and the proper personal protective equipment for personnel.
- Project #15 (refer to Section 6.3 for a detailed description):
  - Implement miscellaneous structural improvements.
- Project #16 (refer to Section 4.1.11 for a detailed description):
  - Install a fourth screw pump at the headworks to improve influent pumping capacity.
- Project #17: (refer to Section 6.2.6 for a detailed description):
  - Replace the mechanism in Secondary Clarifier #2
  - Recoat launder and walls, RAS piping and valves
  - Install automated gates in the Secondary Distribution Box
- Project #18: (refer to Section 6.2.12 for a detailed description):
  - Upgrade the emergency holding basin return pumps.
  - Install two 4.5 mgd chopper pumps for peak flow and one 1 mgd chopper pump for returning diurnal flow.
  - Replace piping from emergency holding basin to the headworks with new 18 inch pipe
- Project #19: (refer to Section 6.4 for a detailed description):
  - This project includes miscellaneous improvements that are required throughout the LWRP.

- Project #20: Electrical Distribution System Upgrades (refer to Appendix D- Electrical Distribution System Analysis Technical Memorandum prepared by Carollo Engineers in 2013
  - Add new 21-kV fuses in existing 21-kV main switchgear to supply power to new double-ended unit substation transformers.
  - Replace existing transformers TC-1 and TC-2 with two liquid-filled 21-kV,480-volt transformers (rated 1,500/1,680 kVA each).
  - Replace existing main switchboards MSBD-A and MSBD-B with new double-ended, draw-out type, NEMA 3R, walk-in switchgear.
  - Install new feeder cables between the new sections of 21-kV main switchgear and new liquid-filled transformers.
  - Install new feeder cables between the new liquid-filled transformers and the new double-ended switchgear.
  - Install new feeder cables between the new double-ended switchgear and the existing Motor Control Centers (MCCs).
  - Install new ductbank between the new double-ended switchgear and a new underground pullbox near the switchgear.
- Project # 21: MCC Replacement (refer to Appendix D- Electrical Distribution System Analysis Technical Memorandum prepared by Carollo Engineers in 2013
  - Replace the older MCCs (MCC-A, -B, -C, -CE, -D, -E, and -F) with new MCCs.
  - Replace feeders from the older vintage MCCs and field equipment with new feeders.

The recommended treatment plant projects are grouped into three phases and the following tables' present projects in each phase.

Table 7-1. Phase I Recommended Improvement Projects (2013 – 2017)

Project No.	Phase	Area	Description
1	1a / 2013	Secondary Process	Aeration equipment replacement
4	1a / 2013	Plant Process	Process control improvements
2	1b / 2014	Plant Electrical	Electrical upgrades and standby power
14	1b / 2014	Plant Electrical	Update 2008 Arc Flash Study
3	1c / 2016	Headworks	Finer mechanical screening equipment
6	1c / 2016	Primary	Primary clarifier gate actuation and redundant grit classifier
11	1c/ 2017	Solids Handling	Cogeneration
15	1c / 2016	Structural	Miscellaneous structural improvements
19	1c / 2016	Plant Wide	Miscellaneous improvements
20	1 c/2016	Plant Electrical	Electrical distribution system upgrades

Table 7-2. Phase II Recommended Improvement Projects (2018 – 2022)

Project No.	Phase	Area	Description
5	2 / 2018	Tertiary	UV system replacement
8	2 / 2019	Headworks	Grit system improvements
16	2 / 2019	Influent Headworks	Additional influent screw pump
12	2 / 2021	Solids Handling	Gravity thickeners
13	2 / 2021	Secondary	BNR upgrades
17	2 / 2021	Secondary Clarifier	Replace Secondary Clarifier #2 mechanism

Table 7-3. Phase III Recommended Improvement Projects (2023 – 2033)

Project No.	Phase	Area	Description
18	3 / 2023	Basin Return Pump Upgrade	Headworks, emergency basin
7	3 / 2023	Plant	Additional odor control
9	3 / 2023	Solids Handling	Dewatering improvements
10	3 / 2023	Solids Handling	Phosphorus recovery
21	3/2023	Plant Electrical	MCC replacement

7.2 Estimated Project Costs

The planning level estimated costs for each of the improvement projects have been prepared.

7.2.1 Cost Estimating Assumptions

Preliminary cost estimates were prepared for each of the project alternatives. The project cost estimating was performed using the Association for the Advancement of Cost Engineering (AACE) International's cost estimating classification system, which defines five separate classes of cost estimates. For a study or feasibility level report, this is considered a Class 4 estimate. The cost estimates are also based on Tetra Tech's experience with a variety of similar construction projects

Construction costs consist of site work, mechanical equipment, concrete, pumps, chemical metering equipment, piping, valves, structural, electrical and instrumentation, etc. Bonds and insurance have been included at 2% and contractor's overhead and profit is assumed to be 10%. A 30% construction cost contingency is included for this planning level stage. The total capital cost includes a 20% cost allowance for preparing engineering plans, specifications, bidding and construction phase services, on-site inspection, incidental permits, survey, geotechnical, legal, and City administrative costs. The cost estimates are based on the latest Engineering News Record (ENR) Construction Cost Index (CCI) of 10,360 as of October, 2013 for the San Francisco, California area.

7.2.2 Total Project Cost Estimates

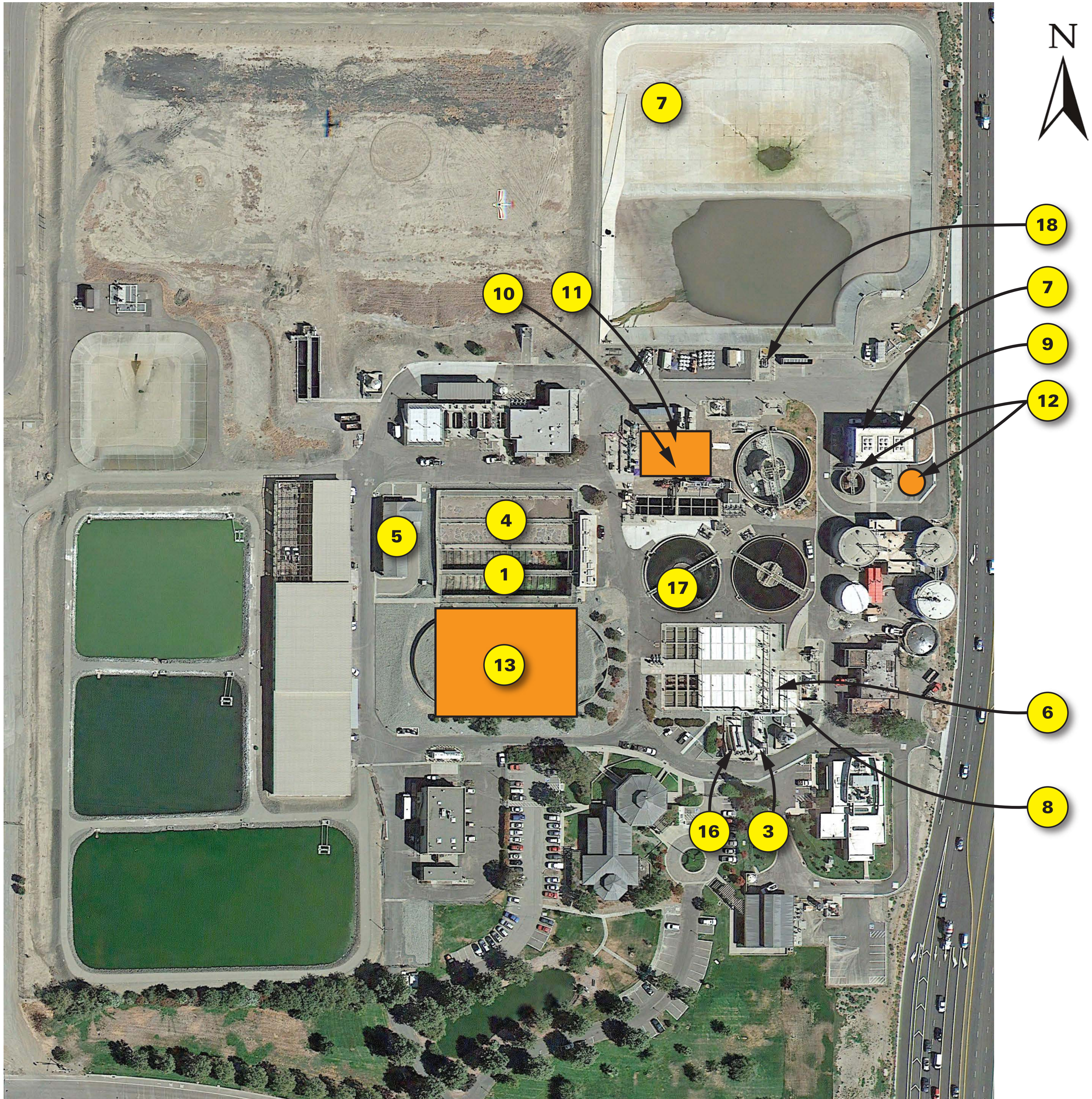
Table 7-4 provides summary of the proposed CIP for the LWRP. Details of project costs are included in Appendix E. The total CIP program for the Livermore WRP is estimated at approximately $53 million for the three phase program, with the bulk of the expenditures occurring during Phase II. In addition to the total project costs, each project cost was further delineated into the approximate amounts attributed to existing rate payers (e.g., maintenance, replacement, upgrades) and capacity expansion (increase in plant flows, loadings, etc). Approximately 22% of the costs for Phase I improvements can be attributed to capacity expansion. Some of the estimated costs for Projects 10 and 11 (phosphorus recovery and cogeneration, respectively) are rough allowances estimates since the conceptual elements need to be refined by additional studies and evaluation.

7.3 Implementation Schedule

A preliminary project implementation schedule for improvements in the LWRP 2012 Master Plan Update was developed based on the preliminary and final design requirements, and construction activities. Figure 7-1 shows a preliminary implementation schedule.

Table 7-4. Estimated Project Cost Summary

Project No.	Description	Total Cost	Capacity Cost Component	Existing User Costs
Phase I Capital Improvement Program				
1	Aeration equipment replacement	$940,900	$665,000	$275,900
4	Process control improvements	$712,200	$0	$712,100
2	Electrical upgrades and standby power	$3,560,100	$712,000	$2,848,100
14	Update 2008 Arc Flash Study	$65,000	$0	$65,000
3	Finer mechanical screening equipment	$1,183,100	$856,500	$326,600
6	Primary clarifier gate actuation and redundant grit classifier	$668,500	$357,000	$311,500
11	Cogeneration	$5,171,700	$0	$5,171,700
15	Miscellaneous Structural Improvements	$410,500	$0	$410,500
19	Miscellaneous Improvements	$150,000	$0	$150,000
20	Electrical Distribution System Upgrades	$4,545,000	$1,340,000	$3,205,000
	Total Phase I	$17,406,900	$3,930,500	$13,476,400
Phase II Capital Improvement Program				
5	UV system replacement	$3,709,400	$0	$3,709,400
8	Grit system improvements	$1,153,100	$900,000	$253,100
16	Additional Influent Screw Pump	$232,400	$232,400	$0
12	Gravity Thickener	$1,205,600	$1,205,600	$0
13	BNR Upgrades	$15,480,100	$12,650,000	$2,830,100
17	Secondary Clarifier #2 mechanism replacement	$270,000	$0	$270,000
	Total Phase II	$22,050,600	$14,988,000	$7,062,600
Phase III Capital Improvement Program				
18	Basin Return Pumps Upgrades	$438,500	$438,500	$0
7	Additional odor control	$1,367,300	$0	$1,367,300
9	Dewatering improvements	$3,695,400	$1,800,000	$1,895,400
10	Phosphorus recovery	$3,910,300	$0	$3,910,300
21	MCC Replacement	$4,165,500	$0	$4,165,500
	Total Phase III	$13,577,000	$2,238,500	$11,338,500
	Total CIP (Phases I through III)	**$53,034,500**	**$21,157,000**	**$31,877,500**



LEGEND

1. Aeration Diffuser Replacement
2. Electrical Improvements & Standby Power (Plant-wide)
3. Sequential Screening
4. Process Control Improvements
5. UV System Replacement
6. Primary Clarifier Gates & Grit Cyclone
7. Odor Control Improvements
8. Grit System Replacement
9. Dewatering Improvements Evaluation
10. Phosphorus Recovery Evaluation
11. Cogeneration Evaluation
12. Gravity Thickener & DAFT Conversion
13. BNR Improvements
14. Arc Flash Study (Plant-wide)
15. Miscellaneous Structural Improvements (Plant-wide)
16. Install Fourth Screw Pump
17. Secondary Clarifier #2 Mechanism Replacement
18. Emergency Holding Basin Return Pumps Improvements
19. Miscellaneous Plant Improvements (Plant-wide)

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Figure 7-1

Recommended Projects Site Plan

LIVERMORE WRP 2012 MASTER PLAN UPDATE

Scale: Not to Scale

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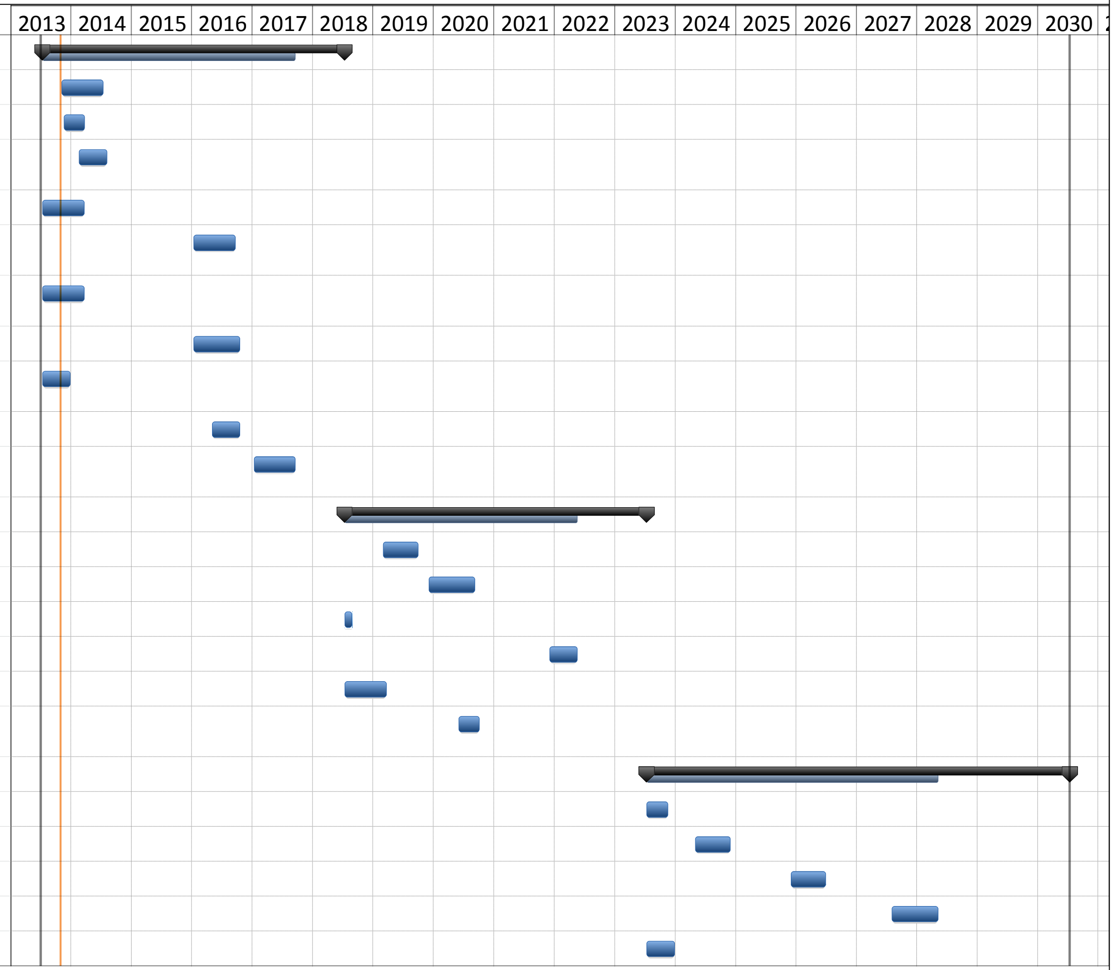
Livermore Water Reclamation Plant 2012 Master Plan Update
Proposed Projects Implementation Schedule

Task Name	Duration	Start	Finish
Phase I Improvements	**1305 days**	**Wed 7/10/13**	**Tue 7/10/18**
Aeration equipment replacement	180 days	Mon 11/4/13	Fri 7/11/14
Process control improvements	90 days	Mon 11/18/13	Fri 3/21/14
Electrical upgrades and standby power	120 days	Mon 2/17/14	Fri 8/1/14
Update 2008 Arch Flash Study	180 days	Wed 7/10/13	Tue 3/18/14
Finer mechanical screening equipment	180 days	Mon 1/11/16	Fri 9/16/16
Primary clarifier gate actuation and redundant grit classifier	180 days	Wed 7/10/13	Tue 3/18/14
Cogeneration	200 days	Mon 1/11/16	Fri 10/14/16
Miscellaneous Structural Improvements	120 days	Wed 7/10/13	Tue 12/24/13
Miscellaneous Improvements	120 days	Mon 5/2/16	Fri 10/14/16
Electrical Distribution System Upgrades	180 days	Mon 1/9/17	Fri 9/15/17
Phase II Improvements	**1305 days**	**Wed 7/11/18**	**Tue 7/11/23**
UV system replacement	150 days	Fri 3/1/19	Thu 9/26/19
Grit system improvements	200 days	Mon 12/2/19	Fri 9/4/20
Additional Influent Screw Pump	30 days	Wed 7/11/18	Tue 8/21/18
Gravity Thickener	120 days	Wed 12/1/21	Tue 5/17/22
BNR Upgrades	180 days	Wed 7/11/18	Tue 3/19/19
Secondary Clarifier #2 Mechanism Replacement	90 days	Mon 6/1/20	Fri 10/2/20
Phase III Improvements	**1828 days**	**Wed 7/12/23**	**Fri 7/12/30**
Basin Return Pumps Upgrades	90 days	Wed 7/12/23	Tue 11/14/23
Additional odor control	150 days	Wed 5/1/24	Tue 11/26/24
Dewatering improvements	150 days	Mon 12/1/25	Fri 6/26/26
Phosphorus recovery	200 days	Mon 8/2/27	Fri 5/5/28
MCC Replacement	120 days	Wed 7/12/23	Tue 12/26/23



LIVERMORE WATER RECLAMATION PLANT

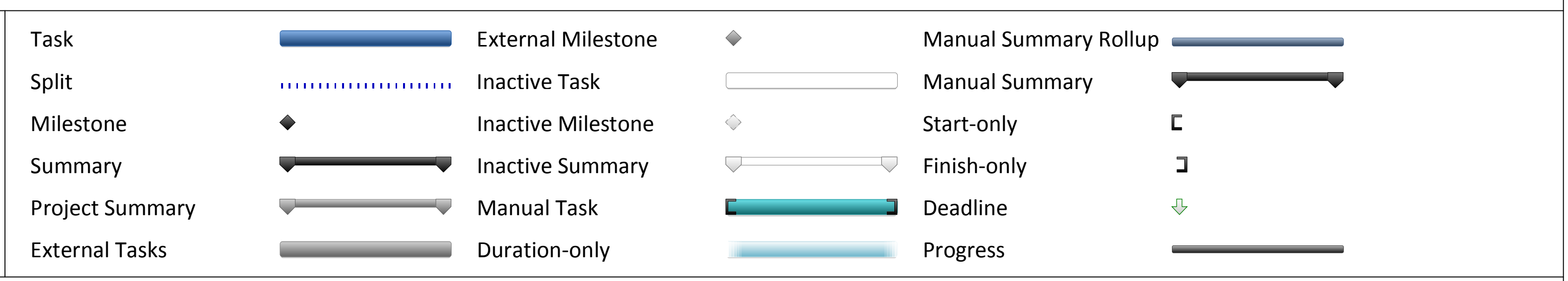


Figure 7-2

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APPENDIX A – LAVWMA Wet Weather Storage Analysis

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APPENDIX A – LAVWMA Wet Weather Storage Analysis

201 North Civic Drive, Suite 115
Walnut Creek, CA 94596

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May 15, 2013

Letter Report

Joel Waxdeck
City of Livermore
101 West Jack London Boulevard
Livermore, CA 94551 144412

Subject: Wastewater Storage Design Support

Dear Mr. Waxdeck:

At your request, Brown and Caldwell reviewed its project files for the 2005 Wastewater Disposal Master Plan to determine the amount of time required to empty the Emergency Storage Holding Basin under the 20-year design conditions assuming future ultimate flows (with TODs) and a maximum discharge rate of 12.4 mgd to LAVWMA. This work was performed under a subagreement with Tetra Tech dated April 4, 2013 for the Livermore Water Reclamation Master Plan Update project.

Previous Analysis

Brown and Caldwell prepared the 2005 Wastewater Disposal Master Plan (Disposal Master Plan) for the City of Livermore (City). The analysis considered several planning horizons including ultimate buildout with Transit Oriented Developments (TOD). The flow projections were based on the City's land use planning documents that were current at the time of the project and the projected average dry weather wastewater flow (ADWF) for ultimate buildout with TOD was 9.47 mgd. This flow is used in the analysis in this letter report. Wastewater flows vary during the day in a typical diurnal pattern. The diurnal flow pattern is shown on Figure 1.

The City's Water Reclamation Plant (WRP) connects to the Livermore Amador Valley Wastewater Management Authority (LAVWMA), which has a regional effluent disposal system. The Disposal Master Plan evaluated various options including an option to increase the City's allocated capacity in the LAVWMA system to 12.4 mgd.

The WRP has an Emergency Storage Holding Basin which is used to store flows that are in excess of the capacity in the LAVWMA system. The Disposal Master Plan projected that peak dry weather flows would exceed the 12.4 mgd allocated capacity in the LAVWMA pipeline necessitating daily use of the Basin.

During wet weather, flows to the WRP increase and exceed the 12.4 mgd allocated capacity in the LAVWMA pipeline for extended periods of time. Wet weather flows are affected by many factors including rainfall intensity, soil moisture, and the diurnal dry weather flows. A continuous simulation analysis was performed using MOUSE, a commercially available hydraulic modeling program, and 47 years of hourly rainfall data. The MOUSE model was calibrated with flow data from 1998 and was adjusted to account for increased development within the City.

MOUSE calculated the amount of storage required on an hourly basis by storing flow when the hourly flow exceeded the 12.4 mgd allocated capacity in LAVWMA pipeline. A probabilistic analysis was performed on the storage volumes to determine the amount of storage that would be exceeded once every 20 years. The analysis was performed using calendar years and the results are presented on Figure 2. The data points on the figure represent peak annual storage volumes projected using the historical rainfall data and ultimate buildout with TOD.

The Disposal Master Plan did not evaluate the amount of time required to empty wet weather flows from the Basin.

Additional Analysis

The amount of time required to empty the Basin after a wet weather event is specific to each individual storm. The analysis to determine the typical time to empty the storage basins under large storm conditions considers the six storm events that required the largest wet weather storage. These events are indicated on Figure 2. The storage requirements for each event are shown on Figures 3 through 7. Storage was required continuously for these events for several days including several days while the basin was emptying after the event ended. Storage times are summarized in Table 1. Events 1 and 2 occurred in later December and early January of the following year. Although several days of little or no rainfall occurred between the events, MOUSE projected that the storage did not empty after the December event and before the January event. Consequently, these are considered as a single event for this analysis.

Table 1. Basin Emptying Time Summary

Event	Approximate Storage Return Period, years	Total Wet Weather Storage, days	Wet Weather Storage After Peak, days
1 and 2	Very long	15	10
3	22	7	3.5
4	19	12	5
5	9	4	2.5
6	8	4	2.5

Two points are important to consider when evaluating the storage emptying time.

1. The time of the peak storage required does not necessarily represent the end of the event. Some rainfall may have occurred after the time of peak storage, but the rainfall did not cause the volume of wastewater in the Basin to increase.
2. As noted above, the peak dry weather flow was projected to be greater than the 12.4 mgd allocated capacity in the LAVWMA system. This resulted in some storage of flow every day. Consequently, it is difficult to determine exactly when wet weather storage ended. Storage durations are therefore reported in half day intervals.

Brown and Caldwell appreciates that the City and Terta Tech has requested our services in assisting with this project. Should you have any questions, please do not hesitate to call me at 925-210-2386.

Very truly yours,

Brown and Caldwell

Pete Bellows, PE
Walnut Creek

PB:dem

Attachments: Figures 1-7

cc: Venu Kolli, Tetra Tech
Alex Park, Brown and Caldwell

Figure 1. Dry Weather Flow
Ultimate Buildout with TOD

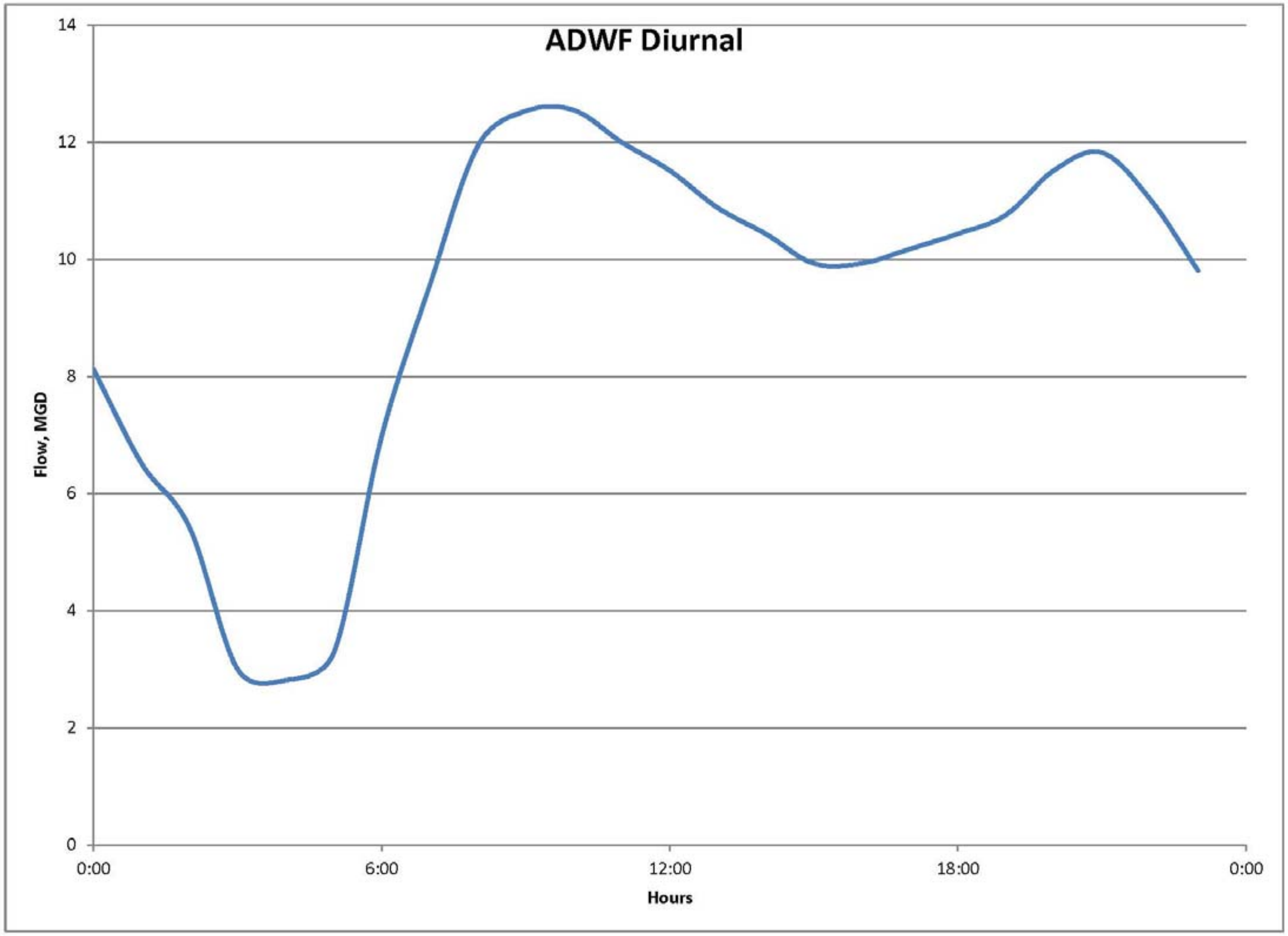


Figure 2. Storage Analysis
Ultimate Buildout with TOD LAVWMA Allocation 12.4 mgd

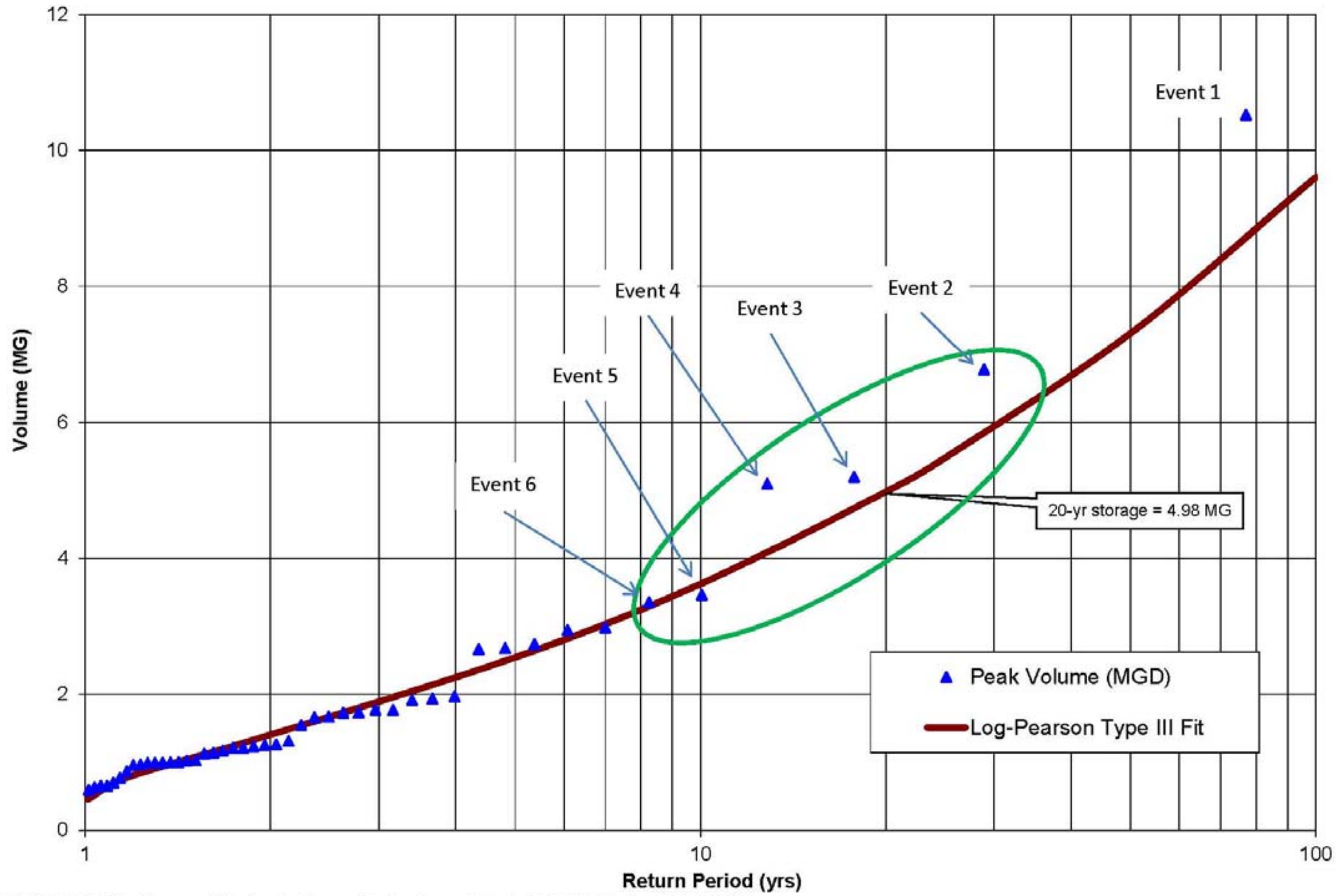


Figure 3. Events 1 and 2

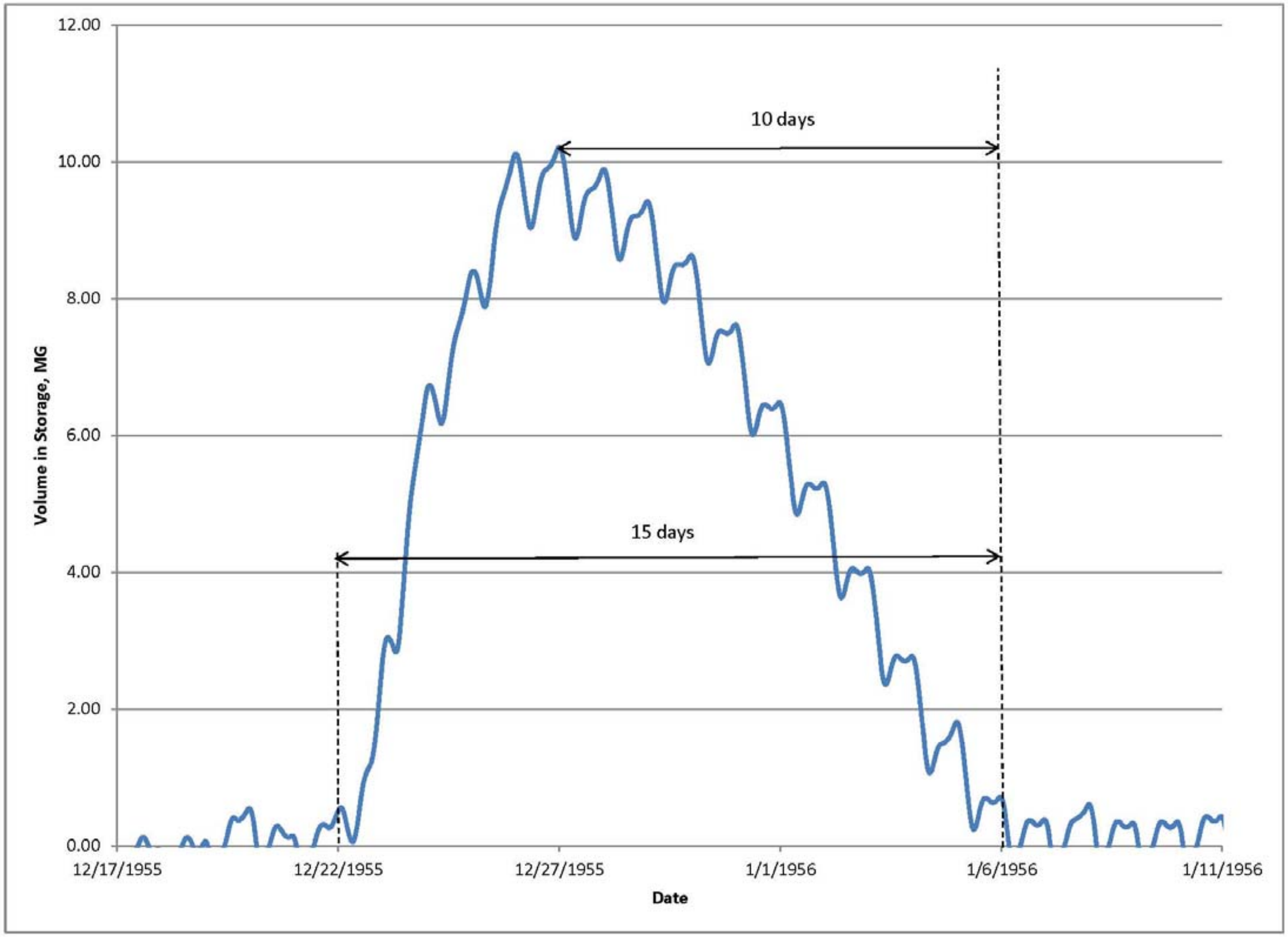


Figure 4. Event 3

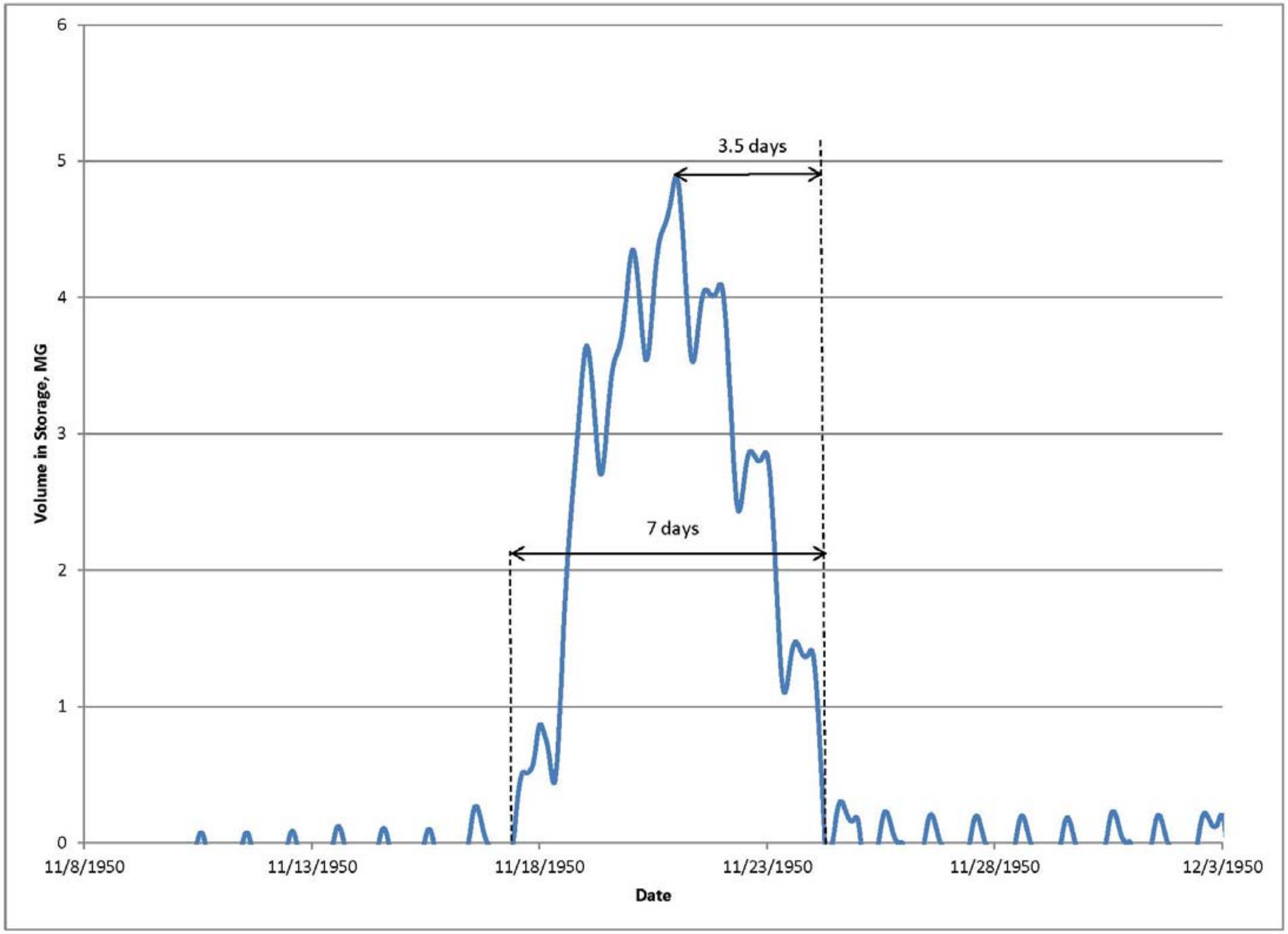


Figure 5. Event 4

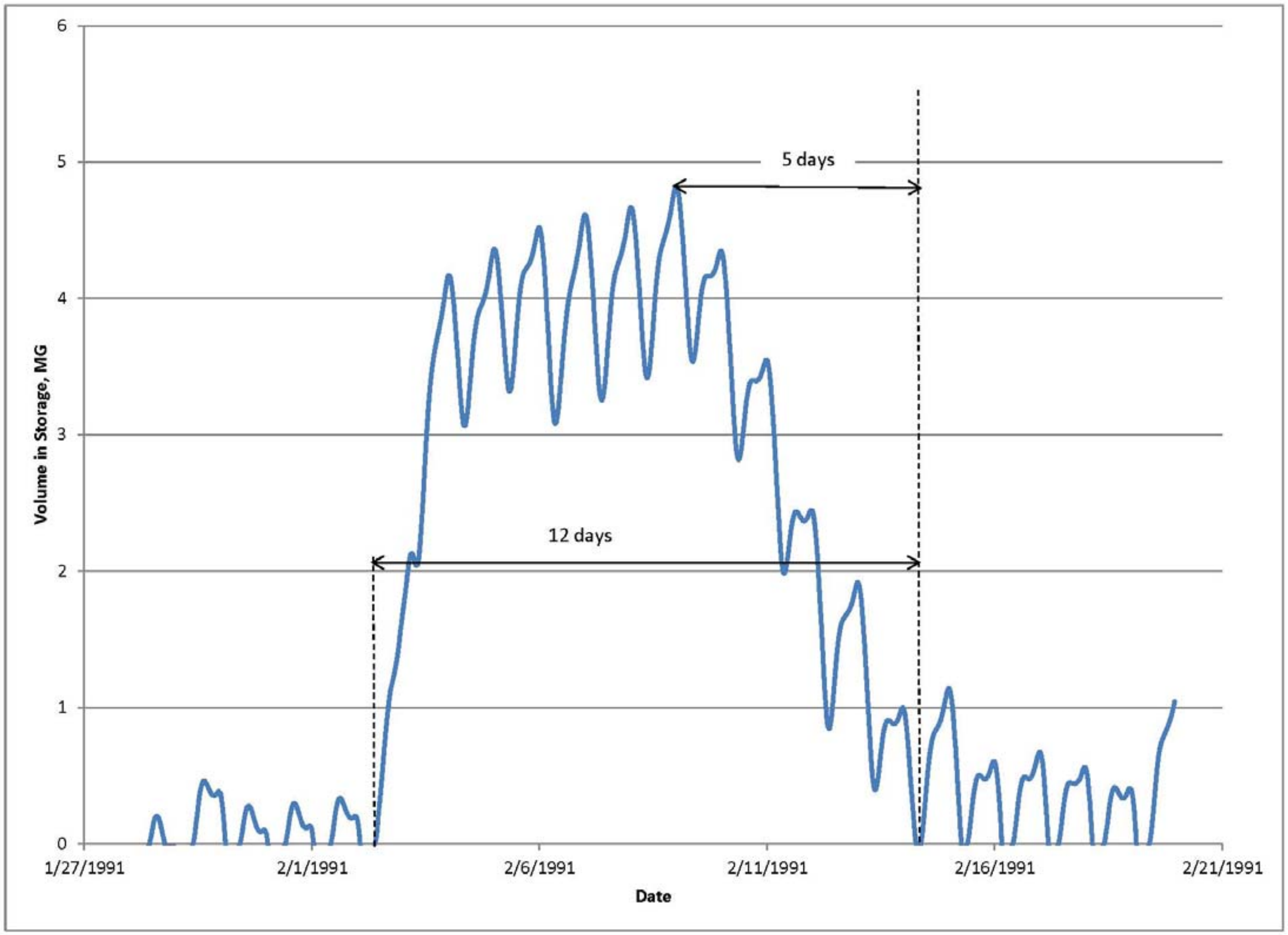


Figure 6. Event 5

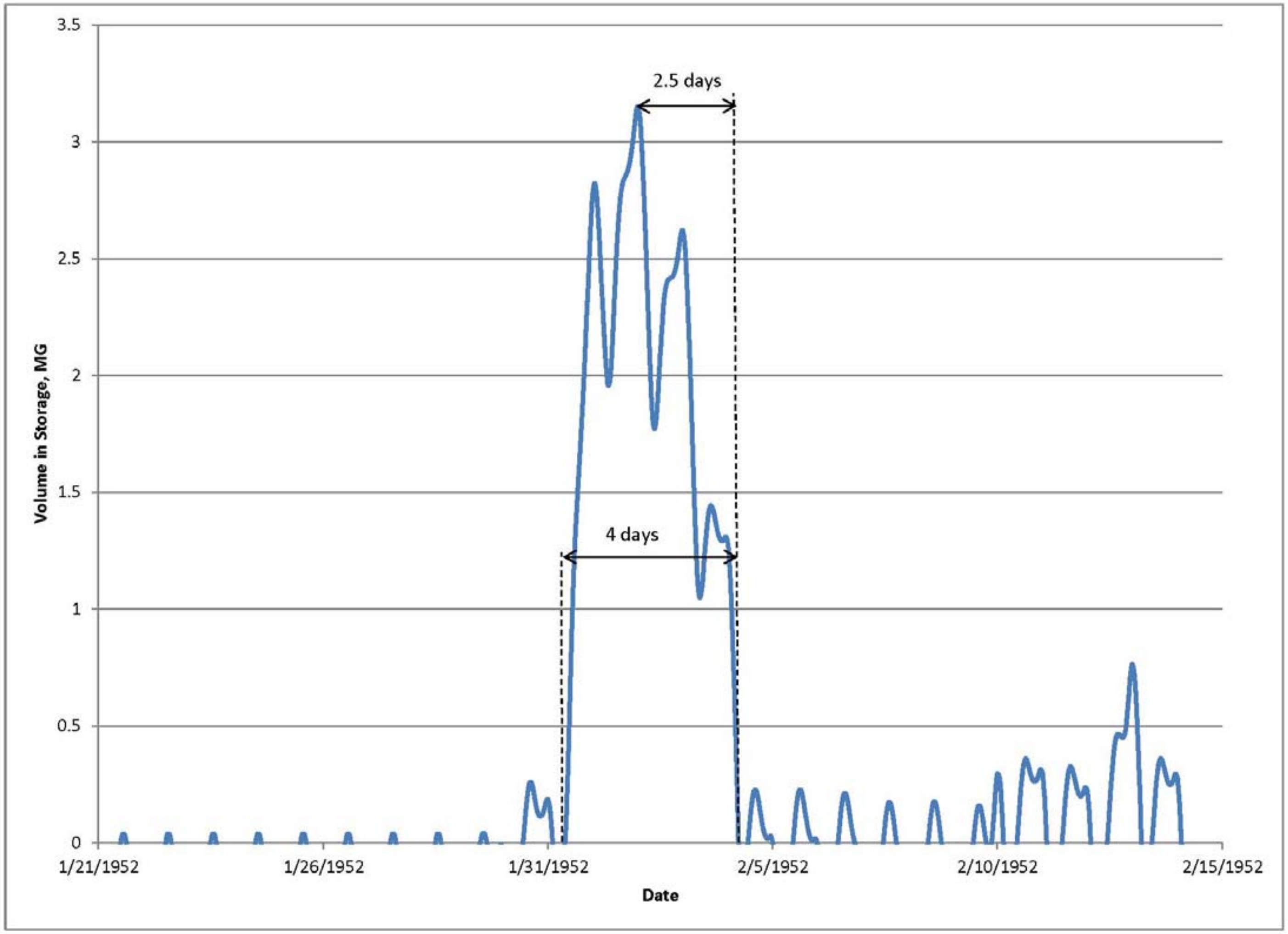
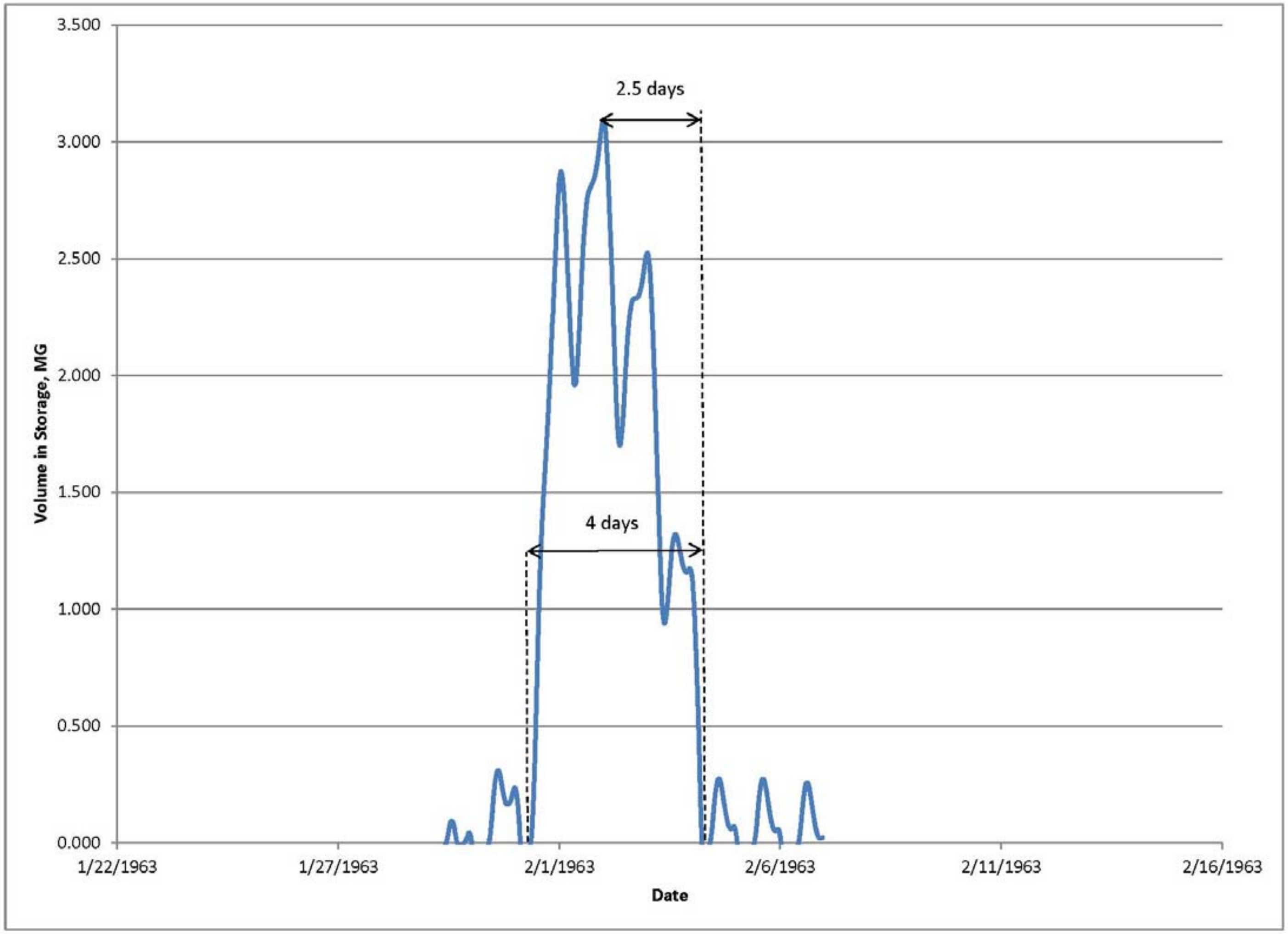


Figure 7. Event 6



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APPENDIX B –
LWRP Hydraulic Model

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APPENDIX B –
LWRP Hydraulic Model

17885 Von Karman Avenue, Suite 500, Irvine, CA 92614
Tel: 949.809.5000
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Client:	City of Livermore	Sheet No.	1 of 8
Project:	Water Reclamation Plant	Job No.	135-29480-12001
	Hydraulic Profile Calculations	Computed by:	BSE
		Checked by:	KAB/SE Date: 8/23/13

Objective: Calculate the Hydraulic Profile for the following scenarios.

- ADWF of 8.5 mgd – Existing Rated Capacity
- Peak hourly wet weather flow of 15.5 mgd – Phase V Design Capacity
- Ultimate build-out flow of 9.47 mgd ADWF
- Projected Peak Hourly flow of 26.1 mgd
- Projected Peak Day flow of 15.29 mgd
- LAVWMA peak wet weather flow of 12.4 mgd
- Flow at which overflow occurs at Primary and Secondary Process

Assumptions:

1. Shaded orange cells in Step 5 indicate that the user must input a value.
2. Per Phase V HGL Profile Plan, Peak Hourly Flowrate is 15.5 MGD (Phase V peka hourly design capacity)
3. Per Phase V HGL Profile Plan, Average Daily Flowrate is 8.5 MGD (existing plant rated capacity)
4. The Hazen-Williams C-factors are assumed to be as follows:
   Aging Pipe = 120
5. The minor losses are taken from "Pumping Station Design" pgs. 898-900.
6. Both of the pre-aeration tanks are operational
7. All primary sedimentation tanks are operational
8. RAS flow is 30% of the influent flow and enters into the process upstream of the aeration tanks.
9. Scenario 1: One aeration tank is out of service all flow to one tank.
   Scenario 2 : Both aeration tanks are operational
10. The height of the bottom of the secondary clarifier #1 V-notch weir is 407.00 scaled from the 1965 Ph. II plans. The weirs are assumed to be 12" O.C.
11. On secondary clarifier #2, the V-notch weirs are assumed to be 12" O.C.

12 Scenario 1: Two secondary clarifiers operate during the summer and three operate during the winter. This model provides the headlosses for the summer condition for worst case headlosses.

13. Scenario 2: All three clarifiers in operation

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Step 1 ***Calculate Pipe Friction Losses***

The hydraulic profile will be evaluated from the effluent pump station back to the influent screens

Hazen-Williams Equation: $h_L = 10.44 * L(ft) * Q^{1.85}(gpm) / C^{1.85} * D^{4.87}(inches)$

Segment	Description	Pipe Dia (in)	Length (L.F.)	C Factor (Assumed)
A	42" Raw Water from Influent MH to Raw Sewage PS	42	45	120
B	48" Aeration Influent Pipe from Aeration Feed PS to Aeration Basins	48	130	120
C	36" Mixed Liquor- From Aeration Basins to Secondary Distribution Box	36	170	120
D1*	36" RCP - From Secondary Distribution Box to Secondary Clarifiers 1 & 2	36	125	120
D2*	36" RCP - From Secondary Distribution Box to Secondary Clarifier 3	36	150	120
E*	36" Secondary Effluent From Secondary Clarifiers to Tertiary Diversion Box	36	220	120
F1*	48" Secondary Effluent Pipe from Tertiary Diversion Structure to Filter Bypass MH	48	185	120
F2*	36" Secondary Effluent Pipe from Secondary Clarifier #3 to Effluent MH 'C'	36	290	120
F3*	36" Secondary Effluent Pipe from Effluent MH 'C' to Filter Bypass MH	36	18	120
G	36" Secondary Effluent Pipe from Filter Bypass MH to Overflow Structure	36	106	120
H	27" CCP - From Overflow Structure to LAVWMA Chlorine Contact Tank	27	250	120

*D1, E, and F1 apply to secondary clarifiers 1 & 2 only.
D2, F2, and F3 apply to secondary clarifier 3 only

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Step 2 ***Calculate Minor Losses***

Minor Losses Equation: $h_M = Kv^2/2g$

Segment A- 42" Raw Water from Influent MH to Raw Sewage PS

Pipe Dia (in)	Fitting	K Values	Quantity	K Total
42	Entrance Loss	0.50	1	0.5
42	Exit Loss	1.00	1	1.00
Total K Value for Segment A Pipe				**1.50**

Segment B- 48" Aeration Influent Pipe from Aeration Feed PS to Aeration Basins

Pipe Dia (in)	Fitting	K Values	Quantity	K Total
48	Entrance Loss	0.50	1	0.50
48	45-Elbow	0.18	2	0.36
48	48x24 Reducer	1.00	2	2.00
48	Exit Loss	1.00	1	1.00
Total K Value for Segment B Pipe				**3.86**

Segment C- 36" Mixed Liquor- From Aeration Basins to Secondary Distribution Box

Pipe Dia (in)	Fitting	K Values	Quantity	K Total
36	Entrance Loss	0.50	1	0.50
36	45-Elbow	0.18	1	0.18
36	Exit Loss	1.00	1	1.00
Total K Value for Segment C Pipe				**1.68**

Segment D1- 36" Secondary Effluent From Secondary Distribution Box to Secondary Clarifiers

Pipe Dia (in)	Fitting	K Values	Quantity	K Total
36	Entrance Loss	0.50	1	0.5
36	Exit Loss	1.00	1	1.00
Total K Value for Segment D1 Pipe				**1.50**

Segment D2- 36" Secondary Effluent From Secondary Distribution Box to Secondary Clarifiers

Pipe Dia (in)	Fitting	K Values	Quantity	K Total
36	Entrance Loss	0.50	1	0.5
36	45-Elbow	0.18	1	0.18
36	Exit Loss	1.00	1	1.00
Total K Value for Segment D2 Pipe				**1.68**

Segment E- 36" Secondary Effluent From Secondary Clarifiers to Tertiary Diversion Box

Pipe Dia (in)	Fitting	K Values	Quantity	K Total
36	Entrance Loss	0.50	1	0.5
36	45-Elbow	0.18	3	0.54
36	90-Elbow	0.25	1	0.25
36	Exit Loss	1.00	1	1.00
Total K Value for Segment E Pipe				**2.29**

Segment F1- 48" Secondary Effluent Pipe
from Tertiary Diversion Structure to Filter Bypass MH

Pipe Dia (in)	Fitting	K Values	Quantity	K Total
48	Entrance Loss	0.50	1	0.5
48	45-Elbow	0.18	2	0.36
48	Exit Loss	1.00	1	1.00
Total K Value for Segment F1 Pipe				**1.86**

Segment F2- from Secondary Clarifier #3
to Effluent MH 'C'

Pipe Dia (in)	Fitting	K Values	Quantity	K Total
36	Entrance Loss	0.50	1	0.5
36	90-Elbow	0.25	2	0.50
36	Exit Loss	1.00	1	1.00
Total F2 Value for Segment F Pipe				**2.00**

Segment F3- 36" Secondary Effluent from Effluent MH 'C' to Filter Bypass MH

Pipe Dia (in)	Fitting	K Values	Quantity	K Total
36	Entrance Loss	0.50	1	0.5
36	Exit Loss	1.00	1	1.00
Total F3 Value for Segment F Pipe				**1.50**

Segment G- 36" Secondary Effluent from Filter Bypass MH
to Overflow Structure

Pipe Dia (in)	Fitting	K Values	Quantity	K Total
36	Entrance Loss	0.50	1	0.5
36	45-Elbow	0.18	2	0.36
36	Exit Loss	1.00	1	1.00
Total K Value for Segment F Pipe				**1.86**

Segment H- 27" CCP - From Overflow Structure
to LAVWMA Chlorine Contact Tank

Pipe Dia (in)	Fitting	K Values	Quantity	K Total
27	Entrance Loss	0.50	1	0.5
27	Exit Loss	1.00	1	1.00
Total K Value for Segment F Pipe				**1.50**

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Step 3 ***Summarize Bar Screen Information***

For Bar Screens $h = (1/0.7)*((V_1^2-V_2^2)/2g)$

where:
h = headloss (ft)
V_1 = velocity through bar opening (ft/sec)
V_2 = approach velocity (ft/sec)
g = acceleration due to gravity = 32.2 ft/sec^2
0.7 = headloss coefficient

Bar Screen Geometry	
Clear channel width (ft)	4
Clear spacing between bars (in)	0.625
Bar size width (in)	0.375
Bar size depth (in)	2.5
Angle of inclination from horizontal	80
Open space between bars (ft)	2.5

Step 4 ***Summarize Weir Information***

For Rectangular Weir $h_W = (Q/3.33b)^{2/3}$

where:
h_W = height over weir (ft)
Q = flow (cfs)
b = Weir width (ft)

For V-Notch Weir (90°) $h_W = (Q/2.5)^{2/5}$

where:
h_W = height over weir (ft)
Q = flow (cfs)

Quantity	Description	Weir Elev	Total Length (ft)	Type
1	Influent MH Weir	400.25	11	Rectangular
432	Sedimentation Basin Weirs*	406.9	216	V-Notch
1	Aeration Tank 1 Weir	410.5	22.83	Rectangular
1	Aeration Tank 2 Weir	410.5	22.83	Rectangular
1	Secondary Distribution Box Weir	408.00	4.75	Rectangular
1	Secondary Clarifier #1 Influent Box*	408.00	263.89	Rectangular (circular)
206	Secondary Clarifier #1 Effluent Weir*	407.00	206.00	V-Notch
1.00	Secondary Clarifier #2 Influent Weir*	407.10	62.83	Rectangular (circular)

270.18	Secondary Clarifier #2 Effluent Weir*	407.10	270.18	V-Notch (circular channel)
1.00	Secondary Clarifier #3 Influent Weir^	407.10	62.83	Rectangular (circular)
270.18	Secondary Clarifier #3 Effluent Weir^	407.10	270.18	V-Notch (circular channel)
1	Tertiary Diversion Box	404.67	9	Rectangular
1	Overflow Structure	399.00	6	Rectangular
1	LAVWMA Chlorine Contact Tank	399.00	5	Rectangular

* Is total length and number of weirs assuming one basin is out of service.
^ Due to lack of information on record drawings, Secondary clarifier 3 weirs are assumed to be similar to Secondary clarifier 2.

Step 4 ***Summarize Parshall Flume Information***

$$Q= K*b*H_a^n$$

Q= flow in cfs
K= Parshall flume constant based on throat width b K=4 for b=2'
b= width of throat (ft)
H_a= Head / water surface height at plume approach
n= $1.522*b^{0.026}$

K= 4
b= 2
n= 1.54967787
H_a= (Q/(K*b))^(1/n)

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Phase V - ADWF and Peak Hourly Flow

This option assumes only one Aeration Tank in service and only Secondary Clarifiers 1, & 2 are operational

Step 5 ***Determine Flowrate***

Peak Hourly Flow Rate:	**15.5**	**Phase V Peak Hour**
Average Daily Flow Rate:	**8.5**	**Phase V, ADWF**

RAS Flow= 30% of Influent Flow
RAS Flow enters upstream of Aeration Basins

RAS Flow (Peak Hour):	**4.65**
RAS Flow (Average Daily Flow):	**2.55**

Step 6 ***Determine Hydraulic Profile of the WRP***

Flow Condition	**Top of structure elev/ WS elev limit**	**Peak Hourly Flowrate:**		**Phase V HGL As-Built Plans (1993):**	
		Q (MGD):	**15.50**	*Q (MGD):*	**15.50**
		Q (gpm):	**10764**	*Q (gpm):*	**10764**
		Q (cfs):	**23.99**	*Q (cfs):*	**23.99**
Description		**Headloss, H_L, H_M, H_W (ft)**	**Water Surface Or Weir Elev**		**Water Surface**
Influent Manhole	408.00	0.75	**401.00**		-
Influent Manhole Weir			400.25		
42" Raw Wastewater		0.17			
Raw Sewage Lift Station			Force Main		410.00
Bar Screen Chamber	413.33	0.66	**410.66**		410.40
Parshall Flume	413.33	2.04	**408.62**		409.04
Pre-Aeration Tanks	409.00		-		407.37
Primary Sedimentation Tanks	408.17	0.13	**407.03**		407.05
Primary Sedimentation Tanks Weir Elev			406.90		
Primary Effluent Pumps HWL Elev			405.82		405.82
48" Aeration Basin Influent Pipe		0.04	Force Main		
Aeration Tank 2	412.50	0.55	**411.05**		410.91
Aeration Tank 2 Weir Elev			410.50		
36" Mixed Liquor Pipe		0.82	**410.39**		
Secondary Distribution Box	410.50	1.57	**409.57**		408.86
Secondary Distribution Box Weir			408.00		408.00
36" RCP Pipe (separate pipes for each clarifier)		0.18			
Secondary Clarifier #1 Influent	409.00	0.07	**408.07**		407.58
Secondary Clarifier #1 inlet box			408.00		407.10
Secondary Clarifier #1 Effluent	409.00	0.25	**407.25**		407.08
Secondary Clarifier #1 Weir Elev			407.00		407.10
Secondary Clarifier #2 Influent	409.00	0.18	**407.28**		407.58
Secondary Clarifier #2 Influent Weir			407.10		407.10
Secondary Clarifier #2 Effluent	409.00	0.22	**407.32**		407.08
Secondary Clarifier #2 Effluent Weir			407.10		407.10
36" Secondary Effluent Pipe (separate pipes from each clarifier 1&2 only) to Tertiary Div. Box		0.17	**405.70**		405.40
Tertiary Diversion Box	407.00	0.86	**405.53**		405.01
Tertiary Diversion Box Weir Elev			404.67		404.67
48" Secondary Effluent Pipe (Tertiary Div Box to Filter Bypass MH)		0.16			
Filter Bypass Manhole	407.00	-	-		-
36" Secondary Effluent Pipe		0.12	**400.25**		
Overflow Structure	406.00	1.13	**400.13**		
Overflow Structure Weir Elev			399.00		
27" CCP Secondary Effluent Pipe		1.99			
LAVWMA Chlorine Tank	404.50	1.28	**400.28**		401.30
LAVWMA Chlorine Tank Weir Elev			399.00		
27" LAVWMA Effluent Pipe Invert at LAVWMA Chlorine Tank Outlet		-	389.00		389.00

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Projected ADWF

This option assumes only one Aeration Tank is in service and only Secondary Clarifiers 1, & 2 are operational

Step 5 ***Determine Flowrate***

		Projected
Ultimate Buildout Flow Rate:	**9.47**	Avg Annual

RAS Flow= 30% of Influent Flow
RAS Flow enters upstream of Aeration Basins

RAS Flow (Peak Hour):	**2.841**	mgd
RAS Flow (Average Daily Flow):	**2.55**	mgd

Step 6 ***Determine Hydraulic Profile of the WRP***

Flow Condition	**Top of structure elev/ WS elev limit**	**Peak Hourly Flowrate:**		**Phase V HGL As-Built Plans (1993):**	
		Q (MGD):	**9.47**	*Q (MGD):*	**15.50**
		Q (gpm):	**6577**	*Q (gpm):*	**10764**
		Q (cfs):	**14.66**	*Q (cfs):*	**23.99**
Description		**Headloss, H_L, H_M, H_W (ft)**	**Water Surface Or Weir Elev**		**Water Surface**
Influent Manhole	408.00	0.54	**400.79**		-
Influent Manhole Weir			400.25		
42" Raw Wastewater		0.06			
Raw Sewage Lift Station			Force Main		410.00
Bar Screen Chamber	413.33	0.25	**410.25**		410.40
Parshall Flume	413.33	1.48	**408.77**		409.04
Pre-Aeration Tanks	409.00		-		407.37
Primary Sedimentation Tanks	408.17	0.10	**407.00**		407.05
Primary Sedimentation Tanks Weir Elev			406.90		
Primary Effluent Pumps HWL Elev			405.82		405.82
48" Aeration Basin Influent Pipe		0.01	Force Main		
Aeration Tanks 2	412.50	0.40	**410.90**		410.91
Aeration Tanks 2 Weir Elev			410.50		
36" Mixed Liquor Pipe		0.31	**409.45**		
Secondary Distribution Box	410.50	1.13	**409.13**		408.86
Secondary Distribution Box Weir			408.00		408.00
36" RCP Pipe (separate pipes for each clarifier)		0.07			
Secondary Clarifier #1 Influent	409.00	0.05	**408.05**		407.58
Secondary Clarifier #1 inlet box			408.00		407.10
Secondary Clarifier #1 Effluent	409.00	0.20	**407.20**		407.08
Secondary Clarifier #1 Weir Elev			407.00		407.10
Secondary Clarifier #2 Influent	409.00	0.13	**407.23**		407.58
Secondary Clarifier #2 Influent Weir			407.10		407.10
Secondary Clarifier #2 Effluent	409.00	0.18	**407.28**		407.08
Secondary Clarifier #2 Effluent Weir			407.10		407.10
36" Secondary Effluent Pipe (separate pipes from each clarifier 1&2 only) to Tertiary Div. Box		0.07	**405.36**		405.40
Tertiary Diversion Box	407.00	0.62	**405.29**		405.01
Tertiary Diversion Box Weir Elev			404.67		404.67
48" Secondary Effluent Pipe (Tertiary Div Box to Filter Bypass MH)		0.06			
Filter Bypass Manhole	407.00	-	-		-
36" Secondary Effluent Pipe		0.05	**399.86**		
Overflow Structure	406.00	0.81	**399.81**		
Overflow Structure Weir Elev			399.00		
27" CCP Secondary Effluent Pipe		0.78			
LAVWMA Chlorine Tank	404.50	0.92	**399.92**		401.30
LAVWMA Chlorine Tank Weir Elev			399.00		
27" LAVWMA Effluent Pipe Invert at LAVWMA Chlorine Tank Outlet		-	389.00		389.00

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Projected Peak Hour Flow

This option assumes only one Aeration Tank is in service and only Secondary Clarifiers 1, & 2 are operational

Step 5 ***Determine Flowrate***

Ultimate Buildout Flow Rate:	**26.1**	Projected Peak Hour
RAS Flow= 30% of Influent Flow		
RAS Flow enters upstream of Aeration Basins		
RAS Flow (Peak Hour):	**7.83**	mgd
RAS Flow (Average Daily Flow):	**2.55**	mgd

Step 6 ***Determine Hydraulic Profile of the WRP***

Flow Condition	Top of structure elev/ WS elev limit	Peak Hourly Flowrate:		Phase V HGL As-Built Plans (1993):	
		Q (MGD):	**26.10**	*Q (MGD):*	**15.50**
		Q (gpm):	**18125**	*Q (gpm):*	**10764**
		Q (cfs):	**40.39**	*Q (cfs):*	**23.99**
Description		**Headloss, H_L, H_M, H_W (ft)**	**Water Surface Or Weir Elev**		**Water Surface**
Influent Manhole	408.00	1.07	**401.32**		-
Influent Manhole Weir			400.25		
42" Raw Wastewater		0.47			
Raw Sewage Lift Station			Force Main		410.00
Bar Screen Chamber	413.33	1.88	**411.88**		410.40
Parshall Flume	413.33	2.86	**409.02**		409.04
Pre-Aeration Tanks	409.00		-		407.37
Primary Sedimentation Tanks	408.17	0.15	**407.05**		407.05
Primary Sedimentation Tanks Weir Elev			406.90		
Primary Effluent Pumps HWL Elev			405.82		405.82
48" Aeration Basin Influent Pipe		0.09	Force Main		
Aeration Tanks 2	412.50	0.78	**411.28**		410.91
Aeration Tanks 2 Weir Elev			410.50		
36" Mixed Liquor Pipe		2.26	**412.48**		
Secondary Distribution Box	410.50	2.23	**410.23**		408.86
Secondary Distribution Box Weir			408.00		408.00
36" RCP Pipe (separate pipes for each clarifier)		0.49			
Secondary Clarifier #1 Influent	409.00	0.10	**408.10**		407.58
Secondary Clarifier #1 inlet box			408.00		407.10
Secondary Clarifier #1 Effluent	409.00	0.30	**407.30**		407.08
Secondary Clarifier #1 Weir Elev			407.00		407.10
Secondary Clarifier #2 Influent	409.00	0.25	**407.35**		407.58
Secondary Clarifier #2 Influent Weir			407.10		407.10
Secondary Clarifier #2 Effluent	409.00	0.27	**407.37**		407.08
Secondary Clarifier #2 Effluent Weir			407.10		407.10
36" Secondary Effluent Pipe (separate pipes from each clarifier 1&2 only) to Tertiary Div. Box		0.47	**406.36**		405.40
Tertiary Diversion Box	407.00	1.22	**405.89**		405.01
Tertiary Diversion Box Weir Elev			404.67		404.67
48" Secondary Effluent Pipe (Tertiary Div Box to Filter Bypass MH)		0.43			
Filter Bypass Manhole	407.00	-	-		-
36" Secondary Effluent Pipe		0.31	**400.91**		
Overflow Structure	406.00	1.60	**400.60**		
Overflow Structure Weir Elev			399.00		
27" CCP Secondary Effluent Pipe		5.40			
LAVWMA Chlorine Tank	404.50	1.81	**400.81**		401.30
LAVWMA Chlorine Tank Weir Elev			399.00		
27" LAVWMA Effluent Pipe Invert at LAVWMA Chlorine Tank Outlet		-	389.00		389.00

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Projected Peak Day Flow

This option assumes only one Aeration Tank is in service and only Secondary Clarifiers 1, & 2 are operational

Step 5 ***Determine Flowrate***

		Projected Peak
Ultimate Buildout Flow Rate:	**15.29**	Hour

RAS Flow= 30% of Influent Flow
RAS Flow enters upstream of Aeration Basins

RAS Flow (Peak Hour):	**4.587**	mgd
RAS Flow (Average Daily Flow):	**2.55**	mgd

Step 6 ***Determine Hydraulic Profile of the WRP***

Flow Condition	**Top of structure elev/ WS elev limit**	**Peak Hourly Flowrate:**		**Phase V HGL As-Built Plans (1993):**	
		Q (MGD):	**15.29**	*Q (MGD):*	**15.50**
		Q (gpm):	**10619**	*Q (gpm):*	**10764**
		Q (cfs):	**23.67**	*Q (cfs):*	**23.99**
Description		**Headloss, H_L, H_M, H_W (ft)**	**Water Surface Or Weir Elev**		**Water Surface**
Influent Manhole	408.00	0.75	**401.00**		-
Influent Manhole Weir			400.25		
42" Raw Wastewater		0.16			
Raw Sewage Lift Station			Force Main		410.00
Bar Screen Chamber	413.33	0.65	**410.65**		410.40
Parshall Flume	413.33	2.02	**408.62**		409.04
Pre-Aeration Tanks	409.00		-		407.37
Primary Sedimentation Tanks	408.17	0.12	**407.02**		407.05
Primary Sedimentation Tanks Weir Elev			406.90		
Primary Effluent Pumps HWL Elev			405.82		405.82
48" Aeration Basin Influent Pipe		0.04	Force Main		
Aeration Tanks 2	412.50	0.55	**411.05**		410.91
Aeration Tanks 2 Weir Elev			410.50		
36" Mixed Liquor Pipe		0.80	**410.36**		
Secondary Distribution Box	410.50	1.56	**409.56**		408.86
Secondary Distribution Box Weir			408.00		408.00
36" RCP Pipe (separate pipes for each clarifier)		0.17			
Secondary Clarifier #1 Influent	409.00	0.07	**408.07**		407.58
Secondary Clarifier #1 inlet box			408.00		407.10
Secondary Clarifier #1 Effluent	409.00	0.25	**407.25**		407.08
Secondary Clarifier #1 Weir Elev			407.00		407.10
Secondary Clarifier #2 Influent	409.00	0.18	**407.28**		407.58
Secondary Clarifier #2 Influent Weir			407.10		407.10
Secondary Clarifier #2 Effluent	409.00	0.22	**407.32**		407.08
Secondary Clarifier #2 Effluent Weir			407.10		407.10
36" Secondary Effluent Pipe (separate pipes from each clarifier 1&2 only) to Tertiary Div. Box		0.17	**405.69**		405.40
Tertiary Diversion Box	407.00	0.85	**405.52**		405.01
Tertiary Diversion Box Weir Elev			404.67		404.67
48" Secondary Effluent Pipe (Tertiary Div Box to Filter Bypass MH)		0.15			
Filter Bypass Manhole	407.00	-	-		-
36" Secondary Effluent Pipe		0.12	**400.24**		
Overflow Structure	406.00	1.12	**400.12**		
Overflow Structure Weir Elev			399.00		
27" CCP Secondary Effluent Pipe		1.94			
LAVWMA Chlorine Tank	404.50	1.26	**400.26**		401.30
LAVWMA Chlorine Tank Weir Elev			399.00		
27" LAVWMA Effluent Pipe Invert at LAVWMA Chlorine Tank Outlet		-	389.00		389.00

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LAVWMA Wet Weather Flow

This option assumes only one Aeration Tank is in service and only Secondary Clarifiers 1, & 2 are operational

Step 5 ***Determine Flowrate***

LAVWMA PWWF Rate: **12.4** mgd

RAS Flow= 30% of Influent Flow
RAS Flow enters upstream of Aeration Basins

RAS Flow (Peak Hour): **3.72** mgd

Step 6 ***Determine Hydraulic Profile of the WRP***

Flow Condition	Top of structure elev/ WS elev limit	Max Capacity Flowrate:		Phase V HGL As-Built Plans (1993):	
		Q (MGD):	**12.40**	*Q (MGD):*	**15.50**
		Q (gpm):	**8612**	*Q (gpm):*	**10764**
		Q (cfs):	**19.19**	*Q (cfs):*	**23.99**
Description		**Headloss, H_L, H_M, H_W (ft)**	**Water Surface Or Weir Elev**		**Water Surface**
Influent Manhole	408.00	0.65	**400.90**		-
Influent Manhole Weir			400.25		
42" Raw Wastewater		0.11			
Raw Sewage Lift Station			Force Main		410.00
Bar Screen Chamber	413.33	0.42	**410.42**		410.40
Parshall Flume	413.33	1.77	**408.66**		409.04
Pre-Aeration Tanks	409.00		-		407.37
Primary Sedimentation Tanks	408.17	0.11	**407.01**		407.05
Primary Sedimentation Tanks Weir Elev			406.90		
Primary Effluent Pumps HWL Elev			405.82		405.82
48" Aeration Basin Influent Pipe		0.02	Force Main		
Aeration Tanks 2	412.50	0.48	**410.98**		410.91
Aeration Tanks 2 Weir Elev			410.50		
36" Mixed Liquor Pipe		0.53	**409.89**		
Secondary Distribution Box	410.50	1.35	**409.35**		408.86
Secondary Distribution Box Weir			408.00		408.00
36" RCP Pipe (separate pipes for each clarifier)		0.11			
Secondary Clarifier #1 Influent	409.00	0.06	**408.06**		407.58
Secondary Clarifier #1 inlet box			408.00		407.10
Secondary Clarifier #1 Effluent	409.00	0.23	**407.23**		407.08
Secondary Clarifier #1 Weir Elev			407.00		407.10
Secondary Clarifier #2 Influent	409.00	0.15	**407.25**		407.58
Secondary Clarifier #2 Influent Weir			407.10		407.10
Secondary Clarifier #2 Effluent	409.00	0.20	**407.30**		407.08
Secondary Clarifier #2 Effluent Weir			407.10		407.10
36" Secondary Effluent Pipe (separate pipes from each clarifier 1&2 only) to Tertiary Div. Box		0.11	**405.52**		405.40
Tertiary Diversion Box	407.00	0.74	**405.41**		405.01
Tertiary Diversion Box Weir Elev			404.67		404.67
48" Secondary Effluent Pipe (Tertiary Div Box to Filter Bypass MH)		0.10			
Filter Bypass Manhole	407.00	-	-		-
36" Secondary Effluent Pipe		0.08	**400.05**		
Overflow Structure	406.00	0.97	**399.97**		
Overflow Structure Weir Elev			399.00		
27" CCP Secondary Effluent Pipe		1.30			
LAVWMA Chlorine Tank	404.50	1.10	**400.10**		401.30
LAVWMA Chlorine Tank Weir Elev			399.00		
27" LAVWMA Effluent Pipe Invert at LAVWMA Chlorine Tank Outlet		-	389.00		389.00

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Projected ADWF

This option assumes both Aeration Tanks 1 & 2, and Secondary Clarifiers 1, 2, & 3 are operational
Note: This model assumes 2 different process paths if all 3 secondary clarifiers are in service
1. For Secondary clarifiers 1 & 2 the process and flows sent from each point is as follows:
Secondary Distribution Box (1/3Q +1/3Q) -> Secondary Clarifiers 1 & 2 (2/3Q) -> Tertiary Diversion Box (2/3Q) -> Filter Bypass Manhole (Q)
2. For Secondary clarifier 3 the process and flows sent from each point is as follows:
Secondary Distribution Box (1/3Q) -> Secondary Clarifier 3 (1/3Q) -> Effluent MH 'C' (1/3Q) -> Filter Bypass Manhole (Q)

Step 5 — ***Determine Flowrate***

Ultimate Buildout Flow Rate: **9.47** mgd

RAS Flow= 30% of Influent Flow
RAS Flow enters upstream of Aeration Basins

RAS Flow (Peak Hour): **2.841** mgd
RAS Flow (Average Daily Flow): **2.55** mgd

Step 6 — ***Determine Hydraulic Profile of the WRP***

Flow Condition	Top of structure elev/ WS elev limit	Peak Hourly Flowrate:		Phase V HGL As-Built Plans (1993):	
		Q (MGD):	**9.47**	*Q (MGD):*	**15.50**
		Q (gpm):	**6577**	*Q (gpm):*	**10764**
		Q (cfs):	**14.66**	*Q (cfs):*	**23.99**
Description		**Headloss, H_L, H_M, H_W (ft)**	**Water Surface Or Weir Elev**		**Water Surface**
Influent Manhole	408.00	0.54	**400.79**		-
Influent Manhole Weir			400.25		
42" Raw Wastewater		0.06			
Raw Sewage Lift Station			Force Main		410.00
Bar Screen Chamber	413.33	0.25	**410.25**		410.40
Parshall Flume	413.33	1.48	**408.77**		409.04
Pre-Aeration Tanks	409.00		-		407.37
Primary Sedimentation Tanks	408.17	0.10	**407.00**		407.05
Primary Sedimentation Tanks Weir Elev			406.90		
Primary Effluent Pumps HWL Elev			405.82		405.82
48" Aeration Basin Influent Pipe		0.01	Force Main		
Aeration Tanks 1	412.50	0.25	**410.75**		410.91
Aeration Tanks 1 Weir Elev			410.50		
Aeration Tanks 2	412.50	0.25	**410.75**		410.91
Aeration Tanks 2 Weir Elev			410.50		
36" Mixed Liquor Pipe		0.31	**409.45**		
Secondary Distribution Box	410.50	1.13	**409.13**		408.86
Secondary Distribution Box Weir			408.00		408.00
36" RCP Pipe (separate pipes for each clarifier 1& 2 only)		0.05			
36" RCP Pipe (separate pipes for each clarifier 3 only)		0.06			
Secondary Clarifier #1 Influent	409.00	0.04	**408.04**		407.58
Secondary Clarifier #1 inlet box			408.00		407.10
Secondary Clarifier #1 Effluent	409.00	0.17	**407.17**		407.08
Secondary Clarifier #1 Weir Elev			407.00		407.10
Secondary Clarifier #2 Influent	409.00	0.10	**407.20**		407.58
Secondary Clarifier #2 Influent Weir			407.10		407.10
Secondary Clarifier #2 Effluent	409.00	0.15	**407.25**		407.08
Secondary Clarifier #2 Effluent Weir			407.10		407.10
Secondary Clarifier #3 Influent	409.00	0.10	**407.20**		407.58
Secondary Clarifier #3 Influent Weir			407.10		407.10
Secondary Clarifier #3 Effluent	409.00	0.15	**407.25**		407.08
Secondary Clarifier #3 Effluent Weir			407.10		407.10

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36" Secondary Effluent Pipe (separate pipes from each clarifier 1&2 only) to Tertiary Div. Box		0.05	**405.20**		405.40
Tertiary Diversion Box	407.00	0.47	**405.14**		405.01
Tertiary Diversion Box Weir Elev			404.67		404.67
48" Secondary Effluent Pipe from Tertiary Div Box to Filter Bypass MH (Secondary Clarifier 1&2 only)		0.03			
36" Secondary Effluent Pipe (from Secondary Clarifier 3 only) to Effluent MH 'C'		0.03			
36" Secondary Effluent Pipe from Effluent MH 'C'to Filter Bypass Manhole (for Secondary Clarifier 3 route only)		0.01			
Filter Bypass Manhole		-	-		-
36" Secondary Effluent Pipe		0.17	**399.99**		
Overflow Structure	406.00	0.81	**399.81**		
Overflow Structure Weir Elev			399.00		
27" CCP Secondary Effluent Pipe		0.78			
LAVWMA Chlorine Tank	404.50	0.92	**399.92**		401.30
LAVWMA Chlorine Tank Weir Elev			399.00		
27" LAVWMA Effluent Pipe Invert at LAVWMA Chlorine Tank Outlet		-	389.00		389.00

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Projected Peak Hour Flow

This option assumes both Aeration Tanks 1 & 2, and Secondary Clarifiers 1, 2, & 3 are operational
Note: This model assumes 2 different process paths if all 3 secondary clarifiers are in service
1. For Secondary clarifiers 1 & 2 the process and flows sent from each point is as follows:
Secondary Distribution Box (1/3Q +1/3Q) -> Secondary Clarifiers 1 & 2 (2/3Q) -> Tertiary Diversion Box (2/3Q) -> Filter Bypass Manhole (Q)
2. For Secondary clarifier 3 the process and flows sent from each point is as follows:
Secondary Distribution Box (1/3Q) -> Secondary Clarifier 3 (1/3Q) -> Effluent MH 'C' (1/3Q) -> Filter Bypass Manhole (Q)

Step 5 ***Determine Flowrate***

Ultimate Buildout Flow Rate: **26.1** Projected Peak Hour

RAS Flow= 30% of Influent Flow
RAS Flow enters upstream of Aeration Basins

RAS Flow (Peak Hour): **7.83** mgd
RAS Flow (Average Daily Flow): **2.55** mgd

Step 6 ***Determine Hydraulic Profile of the WRP***

Flow Condition	**Top of structure elev/ WS elev limit**	**Peak Hourly Flowrate:**		**Phase V HGL As-Built Plans (1993):**	
		Q (MGD):	**26.10**	*Q (MGD):*	**15.50**
		Q (gpm):	**18125**	*Q (gpm):*	**10764**
		Q (cfs):	**40.39**	*Q (cfs):*	**23.99**
Description		**Headloss, H_L, H_M, H_W (ft)**	**Water Surface Or Weir Elev**		**Water Surface**
Influent Manhole	408.00	1.07	**401.32**		-
Influent Manhole Weir			400.25		
42" Raw Wastewater		0.47			
Raw Sewage Lift Station			Force Main		410.00
Bar Screen Chamber	413.33	1.88	**411.88**		410.40
Parshall Flume	413.33	2.86	**409.02**		409.04
Pre-Aeration Tanks	409.00		-		407.37
Primary Sedimentation Tanks	408.17	0.15	**407.05**		407.05
Primary Sedimentation Tanks Weir Elev			406.90		
Primary Effluent Pumps HWL Elev			405.82		405.82
48" Aeration Basin Influent Pipe		0.09	Force Main		
Aeration Tanks 1	412.50	0.49	**410.99**		410.91
Aeration Tanks 1 Weir Elev			410.50		
Aeration Tanks 2	412.50	0.49	**410.99**		410.91
Aeration Tanks 2 Weir Elev			410.50		
36" Mixed Liquor Pipe		2.26	**412.48**		
Secondary Distribution Box	410.50	2.23	**410.23**		408.86
Secondary Distribution Box Weir			408.00		408.00
36" RCP Pipe (separate pipes for each clarifier 1& 2 only)		0.40			
36" RCP Pipe (separate pipes for each clarifier 3 only)		0.45			
Secondary Clarifier #1 Influent	409.00	0.07	**408.07**		407.58
Secondary Clarifier #1 inlet box			408.00		407.10
Secondary Clarifier #1 Effluent	409.00	0.26	**407.26**		407.08
Secondary Clarifier #1 Weir Elev			407.00		407.10
Secondary Clarifier #2 Influent	409.00	0.19	**407.29**		407.58
Secondary Clarifier #2 Influent Weir			407.10		407.10
Secondary Clarifier #2 Effluent	409.00	0.23	**407.33**		407.08
Secondary Clarifier #2 Effluent Weir			407.10		407.10

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Secondary Clarifier #3 Influent	409.00	0.19	**407.29**		407.58
Secondary Clarifier #3 Influent Weir			407.10		407.10
Secondary Clarifier #3 Effluent	409.00	0.23	**407.33**		407.08
Secondary Clarifier #3 Effluent Weir			407.10		407.10
36" Secondary Effluent Pipe (separate pipes from each clarifier 1&2 only) to Tertiary Div. Box		0.38	**405.98**		405.40
Tertiary Diversion Box	407.00	0.93	**405.60**		405.01
Tertiary Diversion Box Weir Elev			404.67		404.67
48" Secondary Effluent Pipe from Tertiary Div Box to Filter Bypass MH (Secondary Clarifier 1&2 only)		0.20			
36" Secondary Effluent Pipe (from Secondary Clarifier 3 only) to Effluent MH 'C'		0.23			
36" Secondary Effluent Pipe from Effluent MH 'C'to Filter Bypass Manhole (for Secondary Clarifier 3 route only)		0.09			
Filter Bypass Manhole		-	-		-
36" Secondary Effluent Pipe		1.26	**401.86**		
Overflow Structure	406.00	1.60	**400.60**		
Overflow Structure Weir Elev			399.00		
27" CCP Secondary Effluent Pipe		5.40			
LAVWMA Chlorine Tank	404.50	1.81	**400.81**		401.30
LAVWMA Chlorine Tank Weir Elev			399.00		
27" LAVWMA Effluent Pipe Invert at LAVWMA Chlorine Tank Outlet		-	389.00		389.00

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Projected Peak Day Flow

This option assumes both Aeration Tanks 1 & 2, and Secondary Clarifiers 1, 2, & 3 are operational
Note: This model assumes 2 different process paths if all 3 secondary clarifiers are in service
1. For Secondary clarifiers 1 & 2 the process and flows sent from each point is as follows:
Secondary Distribution Box (1/3Q +1/3Q) -> Secondary Clarifiers 1 & 2 (2/3Q) -> Tertiary Diversion Box (2/3Q) -> Filter Bypass Manhole
2. For Secondary clarifier 3 the process and flows sent from each point is as follows:
Secondary Distribution Box (1/3Q) -> Secondary Clarifier 3 (1/3Q) -> Effluent MH 'C' (1/3Q) -> Filter Bypass Manhole (Q)

Step 5 ***Determine Flowrate***

Ultimate Buildout Flow Rate: **15.29** Projected Peak Day

RAS Flow= 30% of Influent Flow
RAS Flow enters upstream of Aeration Basins

RAS Flow (Peak Hour): **4.587** mgd
RAS Flow (Average Daily Flow): **2.55** mgd

Step 6 ***Determine Hydraulic Profile of the WRP***

Flow Condition	**Top of structure elev/ WS elev limit**	**Peak Hourly Flowrate:**		**Phase V HGL As-Built Plans (1993):**	
		Q (MGD):	**15.29**	*Q (MGD):*	**15.50**
		Q (gpm):	**10619**	*Q (gpm):*	**10764**
		Q (cfs):	**23.67**	*Q (cfs):*	**23.99**
Description		**Headloss, H_L, H_M, H_W (ft)**	**Water Surface Or Weir Elev**		**Water Surface**
Influent Manhole	408.00	0.75	**401.00**		-
Influent Manhole Weir			400.25		
42" Raw Wastewater		0.16			
Raw Sewage Lift Station			Force Main		410.00
Bar Screen Chamber	413.33	0.65	**410.65**		410.40
Parshall Flume	413.33	2.02	**408.62**		409.04
Pre-Aeration Tanks	409.00		-		407.37
Primary Sedimentation Tanks	408.17	0.12	**407.02**		407.05
Primary Sedimentation Tanks Weir Elev			406.90		
Primary Effluent Pumps HWL Elev			405.82		405.82
48" Aeration Basin Influent Pipe		0.04	Force Main		
Aeration Tanks 1	412.50	0.34	**410.84**		410.91
Aeration Tanks 1 Weir Elev			410.50		
Aeration Tanks 2	412.50	0.34	**410.84**		410.91
Aeration Tanks 2 Weir Elev			410.50		
36" Mixed Liquor Pipe		0.80	**410.36**		
Secondary Distribution Box	410.50	1.56	**409.56**		408.86
Secondary Distribution Box Weir			408.00		408.00
36" RCP Pipe (separate pipes for each clarifier 1& 2 only)		0.14			
36" RCP Pipe (separate pipes for each clarifier 3 only)		0.16			
Secondary Clarifier #1 Influent	409.00	0.05	**408.05**		407.58
Secondary Clarifier #1 inlet box			408.00		407.10
Secondary Clarifier #1 Effluent	409.00	0.21	**407.21**		407.08
Secondary Clarifier #1 Weir Elev			407.00		407.10
Secondary Clarifier #2 Influent	409.00	0.13	**407.23**		407.58
Secondary Clarifier #2 Influent Weir			407.10		407.10
Secondary Clarifier #2 Effluent	409.00	0.19	**407.29**		407.08

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Secondary Clarifier #2 Effluent Weir			407.10		407.10
Secondary Clarifier #3 Influent	409.00	0.13	**407.23**		407.58
Secondary Clarifier #3 Influent Weir			407.10		407.10
Secondary Clarifier #3 Effluent	409.00	0.19	**407.29**		407.08
Secondary Clarifier #3 Effluent Weir			407.10		407.10
36" Secondary Effluent Pipe (separate pipes from each clarifier 1&2 only) to Tertiary Div. Box		0.13	**405.45**		405.40
Tertiary Diversion Box	407.00	0.65	**405.32**		405.01
Tertiary Diversion Box Weir Elev			404.67		404.67
48" Secondary Effluent Pipe from Tertiary Div Box to Filter Bypass MH (Secondary Clarifier 1&2 only)		0.07			
36" Secondary Effluent Pipe (from Secondary Clarifier 3 only) to Effluent MH 'C'		0.08			
36" Secondary Effluent Pipe from Effluent MH 'C'to Filter Bypass Manhole (for Secondary Clarifier 3 route only)		0.03			
Filter Bypass Manhole		-	-		-
36" Secondary Effluent Pipe		0.44	**400.56**		
Overflow Structure	406.00	1.12	**400.12**		
Overflow Structure Weir Elev			399.00		
27" CCP Secondary Effluent Pipe		1.94			
LAVWMA Chlorine Tank	404.50	1.26	**400.26**		401.30
LAVWMA Chlorine Tank Weir Elev			399.00		
27" LAVWMA Effluent Pipe Invert at LAVWMA Chlorine Tank Outlet		-	389.00		389.00

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LAVWMA Wet Weather Flow

This option assumes both Aeration Tanks 1 & 2, and Secondary Clarifiers 1, 2, & 3 are operational
Note: This model assumes 2 different process paths if all 3 secondary clarifiers are in service
1. For Secondary clarifiers 1 & 2 the process and flows sent from each point is as follows:
Secondary Distribution Box (1/3Q +1/3Q) -> Secondary Clarifiers 1 & 2 (2/3Q) -> Tertiary Diversion Box (2/3Q) -> Filter Bypass Manhole
2. For Secondary clarifier 3 the process and flows sent from each point is as follows:
Secondary Distribution Box (1/3Q) -> Secondary Clarifier 3 (1/3Q) -> Effluent MH 'C' (1/3Q) -> Filter Bypass Manhole (Q)

Step 5 ***Determine Flowrate***

Ultimate Buildout Flow Rate: **12.4**

RAS Flow= 30% of Influent Flow
RAS Flow enters upstream of Aeration Basins

RAS Flow (Peak Hour): **3.72** mgd
RAS Flow (Average Daily Flow): **2.55** mgd

Step 6 ***Determine Hydraulic Profile of the WRP***

Flow Condition	**Top of structure elev/ WS elev limit**	**Peak Hourly Flowrate:**		**Phase V HGL As-Built Plans (1993):**	
		Q (MGD): *Q (gpm):* *Q (cfs):*	**12.40** **8612** **19.19**	*Q (MGD):* *Q (gpm):* *Q (cfs):*	**15.50** **10764** **23.99**
Description		**Headloss, H_L, H_M, H_W (ft)**	**Water Surface Or Weir Elev**		**Water Surface**
Influent Manhole	408.00	0.65	**400.90**		-
Influent Manhole Weir			400.25		
42" Raw Wastewater		0.11			
Raw Sewage Lift Station			Force Main		410.00
Bar Screen Chamber	413.33	0.42	**410.42**		410.40
Parshall Flume	413.33	1.77	**408.66**		409.04
Pre-Aeration Tanks	409.00		-		407.37
Primary Sedimentation Tanks	408.17	0.11	**407.01**		407.05
Primary Sedimentation Tanks Weir Elev			406.90		
Primary Effluent Pumps HWL Elev			405.82		405.82
48" Aeration Basin Influent Pipe		0.02	Force Main		
Aeration Tanks 1	412.50	0.30	**410.80**		410.91
Aeration Tanks 1 Weir Elev			410.50		
Aeration Tanks 2	412.50	0.30	**410.80**		410.91
Aeration Tanks 2 Weir Elev			410.50		
36" Mixed Liquor Pipe		0.53	**409.89**		
Secondary Distribution Box	410.50	1.35	**409.35**		408.86
Secondary Distribution Box Weir			408.00		408.00
36" RCP Pipe (separate pipes for each clarifier 1& 2 only)		0.09			
36" RCP Pipe (separate pipes for each clarifier 3 only)		0.11			
Secondary Clarifier #1 Influent	409.00	0.04	**408.04**		407.58
Secondary Clarifier #1 inlet box			408.00		407.10
Secondary Clarifier #1 Effluent	409.00	0.19	**407.19**		407.08
Secondary Clarifier #1 Weir Elev			407.00		407.10
Secondary Clarifier #2 Influent	409.00	0.12	**407.22**		407.58
Secondary Clarifier #2 Influent Weir			407.10		407.10
Secondary Clarifier #2 Effluent	409.00	0.17	**407.27**		407.08

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Secondary Clarifier #2 Effluent Weir			407.10		407.10
Secondary Clarifier #3 Influent	409.00	0.12	**407.22**		407.58
Secondary Clarifier #3 Influent Weir			407.10		407.10
Secondary Clarifier #3 Effluent	409.00	0.17	**407.27**		407.08
Secondary Clarifier #3 Effluent Weir			407.10		407.10
36" Secondary Effluent Pipe (separate pipes from each clarifier 1&2 only) to Tertiary Div. Box		0.09	**405.32**		405.40
Tertiary Diversion Box	407.00	0.57	**405.24**		405.01
Tertiary Diversion Box Weir Elev			404.67		404.67
48" Secondary Effluent Pipe from Tertiary Div Box to Filter Bypass MH (Secondary Clarifier 1&2 only)		0.05			
36" Secondary Effluent Pipe (from Secondary Clarifier 3 only) to Effluent MH 'C'		0.05			
36" Secondary Effluent Pipe from Effluent MH 'C'to Filter Bypass Manhole (for Secondary Clarifier 3 route only)		0.02			
Filter Bypass Manhole		-	-		-
36" Secondary Effluent Pipe		0.29	**400.27**		
Overflow Structure	406.00	0.97	**399.97**		
Overflow Structure Weir Elev			399.00		
27" CCP Secondary Effluent Pipe		1.30			
LAVWMA Chlorine Tank	404.50	1.10	**400.10**		401.30
LAVWMA Chlorine Tank Weir Elev			399.00		
27" LAVWMA Effluent Pipe Invert at LAVWMA Chlorine Tank Outlet		-	389.00		389.00

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Plant Hydraulic Limitation Flow - Secondary Effluent Distribution Box

This option assumes both Aeration Tanks 1 & 2, and Secondary Clarifiers 1, 2, & 3 are operational
Note: This model assumes 2 different process paths if all 3 secondary clarifiers are in service
1. For Secondary clarifiers 1 & 2 the process and flows sent from each point is as follows:
Secondary Distribution Box (1/3Q +1/3Q) -> Secondary Clarifiers 1 & 2 (2/3Q) -> Tertiary Diversion Box (2/3Q) -> Filter Bypass Manhole (Q)
2. For Secondary clarifier 3 the process and flows sent from each point is as follows:
Secondary Distribution Box (1/3Q) -> Secondary Clarifier 3 (1/3Q) -> Effluent MH 'C' (1/3Q) -> Filter Bypass Manhole (Q)

Step 5 ***Determine Flowrate***

Plant Hydraulic Limitatin Flow Rate: **32** mgd

RAS Flow= 30% of Influent Flow
RAS Flow enters upstream of Aeration Basins

RAS Flow (Peak Hour): **9.6** mgd
RAS Flow (Average Daily Flow): **2.55** mgd

Step 6 ***Determine Hydraulic Profile of the WRP***

Flow Condition	**Top of structure elev/ WS elev limit**	**Peak Hourly Flowrate:**		**Phase V HGL As-Built Plans (1993):**	
		Q (MGD):	**32.00**	*Q (MGD):*	**15.50**
		Q (gpm):	**22223**	*Q (gpm):*	**10764**
		Q (cfs):	**49.52**	*Q (cfs):*	**23.99**
Description		**Headloss, H_L, H_M, H_W (ft)**	**Water Surface Or Weir Elev**		**Water Surface**
Influent Manhole	408.00	1.22	**401.47**		-
Influent Manhole Weir			400.25		
42" Raw Wastewater		0.71			
Raw Sewage Lift Station			Force Main		410.00
Bar Screen Chamber	413.33	2.83	**412.83**		410.40
Parshall Flume	413.33	3.27	**409.56**		409.04
Pre-Aeration Tanks	409.00		-		407.37
Primary Sedimentation Tanks	408.17	0.17	**407.07**		407.05
Primary Sedimentation Tanks Weir Elev			406.90		
Primary Effluent Pumps HWL Elev			405.82		405.82
48" Aeration Basin Influent Pipe		0.14	Force Main		
Aeration Tanks 1	412.50	0.56	**411.06**		410.91
Aeration Tanks 1 Weir Elev			410.50		
Aeration Tanks 2	412.50	0.56	**411.06**		410.91
Aeration Tanks 2 Weir Elev			410.50		
36" Mixed Liquor Pipe		3.35	**413.90**		
Secondary Distribution Box	410.50	2.55	**410.55**		408.86
Secondary Distribution Box Weir			408.00		408.00
36" RCP Pipe (separate pipes for each clarifier 1& 2 only)		0.60			
36" RCP Pipe (separate pipes for each clarifier 3 only)		0.68			
Secondary Clarifier #1 Influent	409.00	0.08	**408.08**		407.58
Secondary Clarifier #1 inlet box			408.00		407.10
Secondary Clarifier #1 Effluent	409.00	0.28	**407.28**		407.08
Secondary Clarifier #1 Weir Elev			407.00		407.10
Secondary Clarifier #2 Influent	409.00	0.22	**407.32**		407.58
Secondary Clarifier #2 Influent Weir			407.10		407.10
Secondary Clarifier #2 Effluent	409.00	0.25	**407.35**		407.08

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Secondary Clarifier #2 Effluent Weir			407.10		407.10
Secondary Clarifier #3 Influent	409.00	0.22	**407.32**		407.58
Secondary Clarifier #3 Influent Weir			407.10		407.10
Secondary Clarifier #3 Effluent	409.00	0.25	**407.35**		407.08
Secondary Clarifier #3 Effluent Weir			407.10		407.10
36" Secondary Effluent Pipe (separate pipes from each clarifier 1&2 only) to Tertiary Div. Box		0.56	**406.30**		405.40
Tertiary Diversion Box	407.00	1.07	**405.74**		405.01
Tertiary Diversion Box Weir Elev			404.67		404.67
48" Secondary Effluent Pipe from Tertiary Div Box to Filter Bypass MH (Secondary Clarifier 1&2 only)		0.29			
36" Secondary Effluent Pipe (from Secondary Clarifier 3 only) to Effluent MH 'C'		0.33			
36" Secondary Effluent Pipe from Effluent MH 'C'to Filter Bypass Manhole (for Secondary Clarifier 3 route only)		0.14			
Filter Bypass Manhole		-	-		-
36" Secondary Effluent Pipe		1.87	**402.71**		
Overflow Structure	406.00	1.83	**400.83**		
Overflow Structure Weir Elev			399.00		
27" CCP Secondary Effluent Pipe		7.99			
LAVWMA Chlorine Tank	404.50	2.07	**401.07**		401.30
LAVWMA Chlorine Tank Weir Elev			399.00		
27" LAVWMA Effluent Pipe Invert at LAVWMA Chlorine Tank Outlet		-	389.00		389.00

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Plant Hydraulic Limitation Flow - Bar Screen Chamber

This option assumes both Aeration Tanks 1 & 2, and Secondary Clarifiers 1, 2, & 3 are operational
Note: This model assumes 2 different process paths if all 3 secondary clarifiers are in service
1. For Secondary clarifiers 1 & 2 the process and flows sent from each point is as follows:
Secondary Distribution Box (1/3Q +1/3Q) -> Secondary Clarifiers 1 & 2 (2/3Q) -> Tertiary Diversion Box (2/3Q) -> Filter Bypass Manhole (Q)
2. For Secondary clarifier 3 the process and flows sent from each point is as follows:
Secondary Distribution Box (1/3Q) -> Secondary Clarifier 3 (1/3Q) -> Effluent MH 'C' (1/3Q) -> Filter Bypass Manhole (Q)

Step 5 ***Determine Flowrate***

Plant Hydraulic Limitatin Flow Rate: **35** mgd

RAS Flow= 30% of Influent Flow
RAS Flow enters upstream of Aeration Basins

RAS Flow (Peak Hour): **10.5** mgd
RAS Flow (Average Daily Flow): **2.55** mgd

Step 6 ***Determine Hydraulic Profile of the WRP***

Flow Condition	Top of structure elev/ WS elev limit	Peak Hourly Flowrate:		Phase V HGL As-Built Plans (1993):	
		Q (MGD):	**35.00**	*Q (MGD):*	**15.50**
		Q (gpm):	**24306**	*Q (gpm):*	**10764**
		Q (cfs):	**54.16**	*Q (cfs):*	**23.99**
Description		**Headloss, H_L, H_M, H_W (ft)**	**Water Surface Or Weir Elev**		**Water Surface**
Influent Manhole	408.00	1.30	**401.55**		-
Influent Manhole Weir			400.25		
42" Raw Wastewater		0.85			
Raw Sewage Lift Station			Force Main		410.00
Bar Screen Chamber	413.33	3.38	**413.38**		410.40
Parshall Flume	413.33	3.46	**409.92**		409.04
Pre-Aeration Tanks	409.00		-		407.37
Primary Sedimentation Tanks	408.17	0.17	**407.07**		407.05
Primary Sedimentation Tanks Weir Elev			406.90		
Primary Effluent Pumps HWL Elev			405.82		405.82
48" Aeration Basin Influent Pipe		0.16	Force Main		
Aeration Tanks 1	412.50	0.60	**411.10**		410.91
Aeration Tanks 1 Weir Elev			410.50		
Aeration Tanks 2	412.50	0.60	**411.10**		410.91
Aeration Tanks 2 Weir Elev			410.50		
36" Mixed Liquor Pipe		3.99	**414.70**		
Secondary Distribution Box	410.50	2.71	**410.71**		408.86
Secondary Distribution Box Weir			408.00		408.00
36" RCP Pipe (separate pipes for each clarifier 1& 2 only)		0.71			
36" RCP Pipe (separate pipes for each clarifier 3 only)		0.81			
Secondary Clarifier #1 Influent	409.00	0.09	**408.09**		407.58
Secondary Clarifier #1 inlet box			408.00		407.10
Secondary Clarifier #1 Effluent	409.00	0.29	**407.29**		407.08
Secondary Clarifier #1 Weir Elev			407.00		407.10
Secondary Clarifier #2 Influent	409.00	0.23	**407.33**		407.58
Secondary Clarifier #2 Influent Weir			407.10		407.10
Secondary Clarifier #2 Effluent	409.00	0.26	**407.36**		407.08

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Secondary Clarifier #2 Effluent Weir			407.10		407.10
Secondary Clarifier #3 Influent	409.00	0.23	**407.33**		407.58
Secondary Clarifier #3 Influent Weir			407.10		407.10
Secondary Clarifier #3 Effluent	409.00	0.26	**407.36**		407.08
Secondary Clarifier #3 Effluent Weir			407.10		407.10
36" Secondary Effluent Pipe (separate pipes from each clarifier 1&2 only) to Tertiary Div. Box		0.67	**406.47**		405.40
Tertiary Diversion Box	407.00	1.13	**405.80**		405.01
Tertiary Diversion Box Weir Elev			404.67		404.67
48" Secondary Effluent Pipe from Tertiary Div Box to Filter Bypass MH (Secondary Clarifier 1&2 only)		0.35			
36" Secondary Effluent Pipe (from Secondary Clarifier 3 only) to Effluent MH 'C'		0.40			
36" Secondary Effluent Pipe from Effluent MH 'C'to Filter Bypass Manhole (for Secondary Clarifier 3 route only)		0.16			
Filter Bypass Manhole		-	-		-
36" Secondary Effluent Pipe		2.23	**403.18**		
Overflow Structure	406.00	1.94	**400.94**		
Overflow Structure Weir Elev			399.00		
27" CCP Secondary Effluent Pipe		9.49			
LAVWMA Chlorine Tank	404.50	2.20	**401.20**		401.30
LAVWMA Chlorine Tank Weir Elev			399.00		
27" LAVWMA Effluent Pipe Invert at LAVWMA Chlorine Tank Outlet		-	389.00		389.00

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APPENDIX C – LAVWMA Pump Station Hydraulic Analysis

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APPENDIX C –LAVWMA Pump Station Hydraulic Analysis

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City Of Livermore
Water Reclamation Plant
LAVWMA Effluent PS Hydraulics

Sheet No. 1 of
Job No. 135-29480-12001
Computed by: BSE
Checked by: SE/VK Date: 5/13/2013

Objective: Determine the System Curve for the LAVWMA Pump Station and determine flow conditions with existing pump curves

Assumptions: Flow from the LAVWMA Peaking Pond feeds the LAVWMA Effluent Pumps which pump to the 30"/ 27" Livermore Trunk Line (gravity) discharging at the junction box (pipe reduced to 16") at the junction box

1. Bottom of wetwell elevation per plans is	382.55	ft
2. Assume LWL is 3' above bottom, so LWL is	385.55	ft
3. Assume HWL is same el as wetwell inlet, so HWL is	390.75	ft
4. Per plans inv of 20" pump discharge is	392.67	ft
5. Invert at Junction Box is	321.00	ft

8.5 MGD= 5902.74 gpm
12.4 MGD= 8611.06 gpm

Step 1 ***Calculate Pipe Friction Losses***

Hazen-Williams Equation: h_f=10.44*L(ft)*$Q^{1.85}$(gpm)/$C^{1.85}$*$D^{4.87}$(inches)

Pipe Dia (in)	Length (L.F.)	Material	C Factor (Assumed)	Flow
30	10	Steel	120	Q
20	19.5	Steel	120	Q
27	33486	Steel	120	Q
16	18	Steel	120	Q

Step 2 ***Calculate Minor Losses***

Minor Losses Equation: $h_m=Kv^2/2g$

Pipe Dia (in)	Fitting	K Values	Quantity	K Total
20	Check Valve	1	1	1.00
20	Butterfly Valve	0.35	1	0.35
20	Tee (branch)	0.75	1	0.75
Total K Value for 20" Pipe				**2.10**

Pipe Dia (in)	Fitting	K Values	Quantity	K Total
30	90° bend	0.3	1	0.30
Total K Value for 30" Pipe				**0.30**

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Pipe Dia (in)	Fitting	K Values	Quantity	K Total
27	Wye	0.5	1	0.50
27	Reducer	0.5	1	0.50
Total K Value for 27" Pipe				**1.00**

Pipe Dia (in)	Fitting	K Values	Quantity	K Total
16	Reducer	0.5	1	0.50
16	Exit	1	1	1.00
Total K Value for 16" Pipe				**1.50**

Step 3 ***Determine static head***

Max Static Lift		***Min Static Lift***	
Discharge Header El	393.50	Discharge Header El	393.50
Clearwell LWL	385.55	Clearwell HWL	390.75
$H_{(static\text{-}max)}=$	7.95	$H_{(static\text{-}min)}=$	2.75

Step 4 ***Determine System Curve***

System Curve for Max Static Lift

Q (gpm)	Friction H_L (ft)	Minor H_L (ft)	Static Lift (ft)	TDH (ft)
0	0.0	0.0	8.0	8.0
500	0.5	0.0	8.0	8.5
1000	1.9	0.1	8.0	10.0
1500	4.0	0.2	8.0	12.2
2000	6.9	0.4	8.0	15.2
2194	8.2	0.5	8.0	16.6
2500	10.4	0.6	8.0	19.0
3000	14.6	0.9	8.0	23.4
3500	19.4	1.2	8.0	28.5
4000	24.8	1.6	8.0	34.3
5000	37.5	2.5	8.0	47.9
5500	44.7	3.0	8.0	55.6
5903	50.9	3.5	**8.0**	**62.3**
6500	60.9	4.2	8.0	73.0
7000	69.8	4.9	8.0	82.6
7500	79.3	5.6	8.0	**92.8**
8000	89.4	6.4	8.0	103.7
8500	100.0	7.2	8.0	115.1

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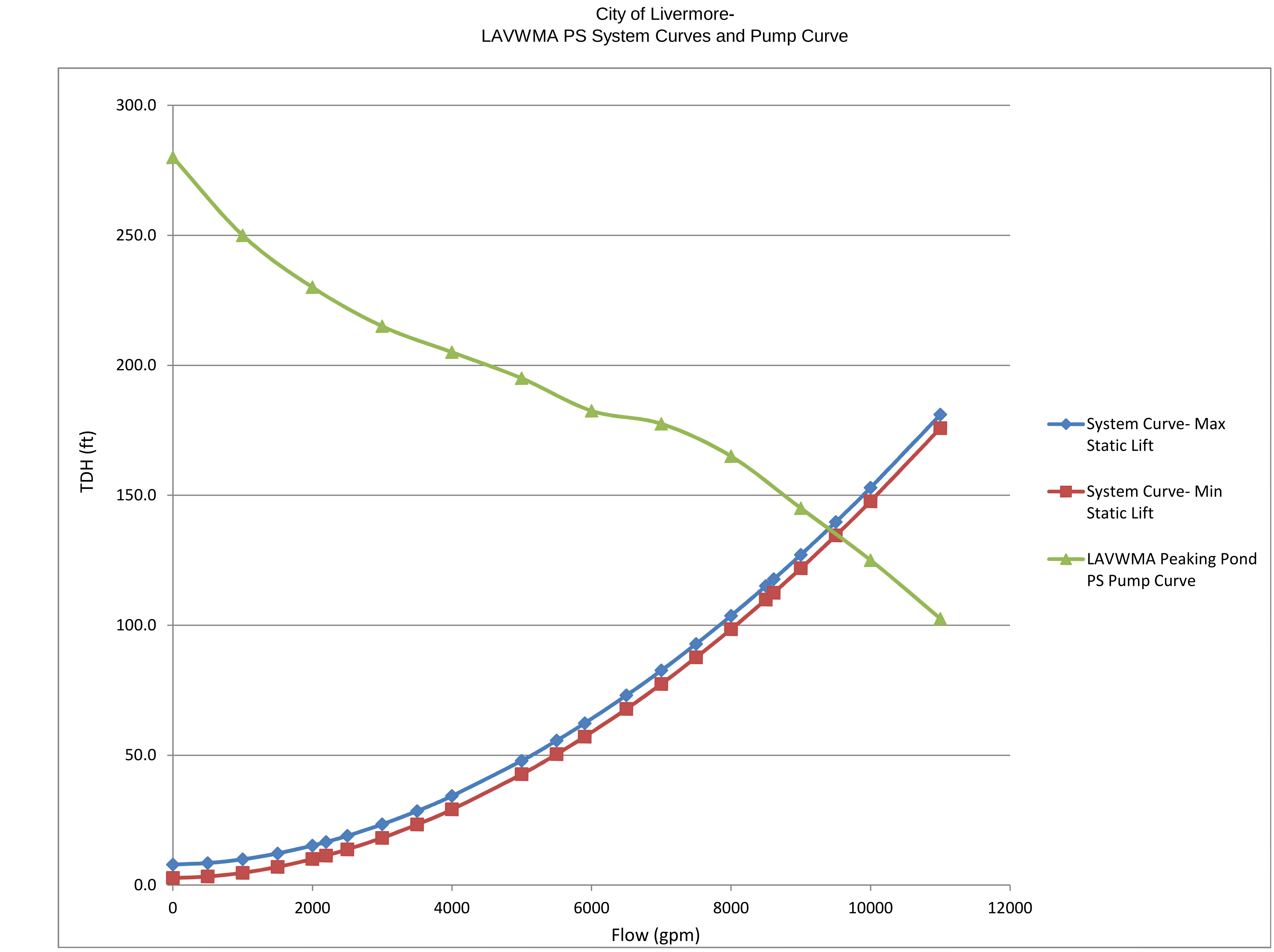
8611	102.4	7.4	8.0	117.7
9000	111.1	8.0	8.0	127.1
9500	122.8	9.0	8.0	139.7
10000	135.0	9.9	8.0	152.9
11000	161.1	12.0	8.0	181.0

System Curve for Min Static Lift

Q (gpm)	Friction H_L (ft)	Minor H_L (ft)	Static Lift (ft)	TDH (ft)
0	0.0	0.0	2.8	2.8
500	0.5	0.0	2.8	3.3
1000	1.9	0.1	2.8	4.8
1500	4.0	0.2	2.8	7.0
2000	6.9	0.4	2.8	10.0
2194	8.2	0.5	2.8	11.4
2500	10.4	0.6	2.8	13.8
3000	14.6	0.9	2.8	18.2
3500	19.4	1.2	2.8	23.3
4000	24.8	1.6	2.8	29.1
5000	37.5	2.5	2.8	42.7
5500	44.7	3.0	2.8	50.4
5903	50.9	3.5	**2.8**	**57.1**
6500	60.9	4.2	2.8	67.8
7000	69.8	4.9	2.8	77.4
7500	79.3	5.6	2.8	87.6
8000	89.4	6.4	2.8	98.5
8500	100.0	7.2	2.8	109.9
8611	102.4	7.4	2.8	112.5
9000	111.1	8.0	2.8	121.9
9500	122.8	9.0	2.8	134.5
10000	135.0	9.9	2.8	147.7
11000	161.1	12.0	2.8	175.8

Existing Pump Curve

Flow	TDH
0	280
1000	250
2000	230
3000	215
4000	205
5000	195
6000	182.5
7000	177.5
8000	165
9000	145
10000	125
11000	102.5


City of Livermore-
LAVWMA PS System Curves and Pump Curve
300.0
250.0
200.0
150.0
100.0
50.0
0.0
TDH (ft)
0
2000
4000
6000
8000
10000
12000
Flow (gpm)
System Curve- Max Static Lift
System Curve- Min Static Lift
LAVWMA Peaking Pond PS Pump Curve

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APPENDIX D –
Electrical System Analysis

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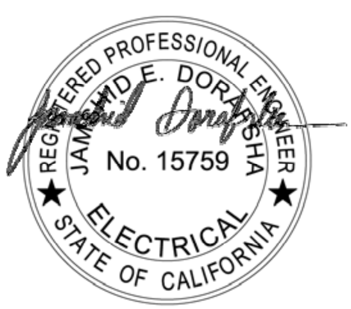
APPENDIX D –
Electrical System Analysis

10/18/2013



10/18/2013

CITY OF LIVERMORE, CALIFORNIA
WATER RECLAMATION PLANT

TECHNICAL MEMORANDUM

WATER RECLAMATION PLANT ELECTRICAL DISTRIBUTION SYSTEM ANALYSIS

FINAL
October 2013

CITY OF LIVERMORE, CALIFORNIA
WATER RECLAMATION PLANT

TECHNICAL MEMORANDUM

WATER RECLAMATION PLANT ELECTRICAL DISTRIBUTION SYSTEM ANALYSIS

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WATER RECLAMATION PLANT ELECTRICAL DISTRIBUTION SYSTEM ANALYSIS

1.0 PURPOSE

The purpose of this technical memorandum (TM) is to identify the necessary electrical improvements to the electrical distribution system at the City of Livermore's (City) Water Reclamation Plant (WRP) based on recently completed studies. The TM will also analyze the impact of the future loads identified in the 2012 Master Plan Update on the electrical distribution system to identify the necessary improvements.

The following equations are used for conversion between kilowatts (kW), kilovolt amperes (kVA), and amperes throughout this report:

kW = Power Factor (PF) x kVA; where PF is assumed to be 0.8.

kVA = Volt x Amps x 1.7321 or Amps = kVA / (Volts x 1.7321).

2.0 SUMMARY OF FINDINGS AND RECOMMENDATIONS

The key findings and recommendations of this TM are summarized below:

- Phase I – Electrical Distribution System Design:
  - Following are Phase I recommended improvements outlined in TM1, dated October 2007:
    - Add new 21-kV fuses in existing 21-kV main switchgear to supply power to new double-ended unit substation transformers.
    - Replace existing transformers TC-1 and TC-2 with two liquid-filled 21-kV, 480-volt transformers (rated 1,500/1,680 kVA each).
    - Replace existing main switchboards MSBD-A and MSBD-B with new double-ended, draw-out type, NEMA 3R, walk-in switchgear.
    - Install new feeder cables between the new sections of 21-kV main switchgear and new liquid-filled transformers.
    - Install new feeder cables between the new liquid-filled transformers and the new double-ended switchgear.
    - Install new feeder cables between the new double-ended switchgear and the existing Motor Control Centers (MCCs).
    - Install new ductbank between the new double-ended switchgear and a new underground pullbox near the switchgear.

* The planning level cost estimate for the Phase I Improvements outlined above was estimated at approximately $9,018,000 in TM1, dated October 2007.

– Following are improvements made by the City since TM1 was submitted in October 2007:

  * Three 21-kV fused switch sections were added to the main 21-kV switchgear as part of Livermore-Amador Valley Water Management Agency (LAVWMA) Pump Station upgrade. The planning level cost estimate for installation of 21-kV sections, including contingencies was estimated at approximately $259,000 in TM1, dated October 2007.

  * Ductbanks and underground pull boxes were installed on east side of the plant. This work included installation of new pull boxes EHH-1, EHH-2, EHH-3, EHH-4, EHH-5, EHH-6, and EHH-7. The planning level cost estimate for installation of new ductbanks and underground pull boxes on the east side of the plant, including contingencies was estimated at approximately $1,288,000 in TM1, dated October 2007.

  * Portions of existing ductbanks will be utilized in lieu of providing new ductbanks for feeding MCC-B, MCC-G and Panel-PM. The planning level cost estimate for installation of new ductbanks and underground pull boxes for these MCCs including contingencies was estimated at approximately $1,716,000 in TM1, dated October 2007.

– The planning level cost estimate for remainder of Phase I improvements is estimated at approximately $4,545,000.

– The planning level cost estimate for remainder of Phase I improvements should be equal to the difference between the original planning level cost estimate of $9,018,000 and planning level cost estimate of $1,547,000 ($259,000 + $1,288,000) for work already done by the City plus planning level cost estimate of $1,716,000 for reusing existing ductbanks, which is approximately $5,755,000 ($9,018,000 - $1,547,000 - $1,716,000). However, this amount is higher than the estimated planning level cost of $4,545,000 because of lower allowances for anticipated civil/site work and instrumentation, which was estimated at $1,210,000.

– There will be adequate capacity to provide power under the peak load conditions to the existing loads and future loads identified in the 2012 Master Plan Update, which is calculated to be approximately 2,884 kVA. It should be noted that the design philosophy accepted by the City for the future 480-volt transformers and double-ended switchgear would have adequate capacity only if both transformers are on-line at the same time. During routine transformer maintenance condition or a transformer failure where one of the transformers is offline, only up to 1,680-kilovolt-ampere (kVA) of loads in WRP can be operated. The design philosophy accepted by the City will prevent purchase of oversized transformers and offers significant cost savings.

- Phase II – MCC Replacement Project:
  - Following are Phase II recommended improvements outlined in TM1, dated October 2007:
    - Replace the older MCCs (MCC-A, -B, -C, -CE, -D, -E, and -F) with new MCCs.
    - Replace feeders from the older vintage MCCs and field equipment with new feeders.
    - The estimated planning level cost of the Phase II Improvements outlined in TM1, dated October 2007 was approximately $4,361,000.
  - Following are improvements made by City staff since TM1 was submitted in October 2007:
    - MCC-B has been replaced in-place with a new MCC-B by City staff.
    - MCC-CE has been replaced with new MCC-T by City staff.
    - MCC-F has been replaced in-place with new MCC-F by City staff.
    - Feeder cables between the new MCCs replaced by City staff and field equipment was not replaced as recommended in TM1.
  - Replace the remaining older MCCs (MCC-A, C, D, and E) with new MCCs.
  - Replace feeders from all older vintage MCCs and field equipment with new feeders.
  - The estimated planning level cost of the remaining Phase II Improvements for replacing MCC-A, C, D, and E, and feeders between all MCCs and field equipment, is approximately $4,165,500.
- Phase III – 2012 Master Plan Update:
  - Following improvements are necessary to the electrical distribution system for the future projects identified in the 2012 Master Plan Update:
    - With the exception of the miscellaneous structural improvements project No. 15, all other projects will require general electrical improvements including: addition of new breakers in MCCs, new conduits, new ductbanks, new cables, new controls, etc.
    - Add new sections to MCC-F. This is required by Projects 7, 9, 10, and 12.
    - Add new breaker, ductbank, and conductors between the main switchgear and cogeneration facility.

  * Add new MCC-B1 in the aeration basin area to support the BNR Upgrades (Project 13). This new MCC will require a new ductbank from switchgear for the main feeder cables and a new feeder breaker in the switchgear.
  * Add new MCC-PS to the RAS/WAS building to replace Panel PS. This is required by Project 18. The conduits for the feeders to this new MCC shall be installed in the Electrical Distribution System Design Project to be cost-effective.
- Phase IV – Solids Expansion Project:
  * Provide new MCC-K in the digester control building to support the Digestion Facility Expansion Project. New conduits to MCC-K are included in the Electrical Distribution System Design Project.
  * Provide new feeder cables between switchgear and MCC-K.
  * Provide new conduits and feeder cables between MCC-K and new loads.

3.0 BACKGROUND

The electrical distribution system at the WRP is deteriorating, is past its useful life, and needs replacement. In October 2007, Carollo Engineers performed an evaluation of the existing electrical distribution system and suggested necessary improvements. This study is documented in “TM1 - Electrical Distribution System Upgrade Evaluation Report by Carollo Engineers, dated October 2007,” and summarized in Section 4.0 below (Phase I). Later in February 2008, Carollo Engineers performed an evaluation of the standby power generation system and suggested necessary improvements. This study is documented in “TM2 - Standby Power Generation System Upgrade Evaluation Report by Carollo Engineers, dated February 2008,” and summarized in Section 6.1.2 below (Phase III).

In 2012, Tetra Tech evaluated the existing facilities and future needs at the WRP and prepared a master plan update (2012 Master Plan Update). In the 2012 Master Plan Update, Tetra Tech identified several future projects, which increased the total connected electrical load. Electrical improvements required for projects identified in the master plan are summarized in Section 6.0 below (Phase III).

The City asked Carollo to summarize the above listed studies to identify the necessary improvements to the electrical distribution system and to analyze the impact of the future projects on the electrical distribution system.

4.0 PHASE I - ELECTRICAL DISTRIBUTION SYSTEM DESIGN PROJECT

The purpose of this design project is to implement the Phase I improvements recommended in TM1, dated October 2007. Phase I of TM1 evaluated the capacity and condition of the existing major electrical equipment at the City of Livermore's (City) Water Reclamation Plant (WRP) as far as meeting current and future electrical loads.

TM1 evaluated only the capacity of the 21-kV and 480-V power distribution and did not address the power quality issues (e.g., transients, other under- or over- voltage conditions that result from switching operations, motor starting, lightning disturbances, switching of capacitors, electric welding, harmonics, power factor correction, etc.) of the overall power system. The information presented in Phase I and Phase II of TM1 is intended to be used to identify modifications that are needed to improve the existing power distribution system and/or support expansions to the various process areas.

4.1 Existing Power Distribution System

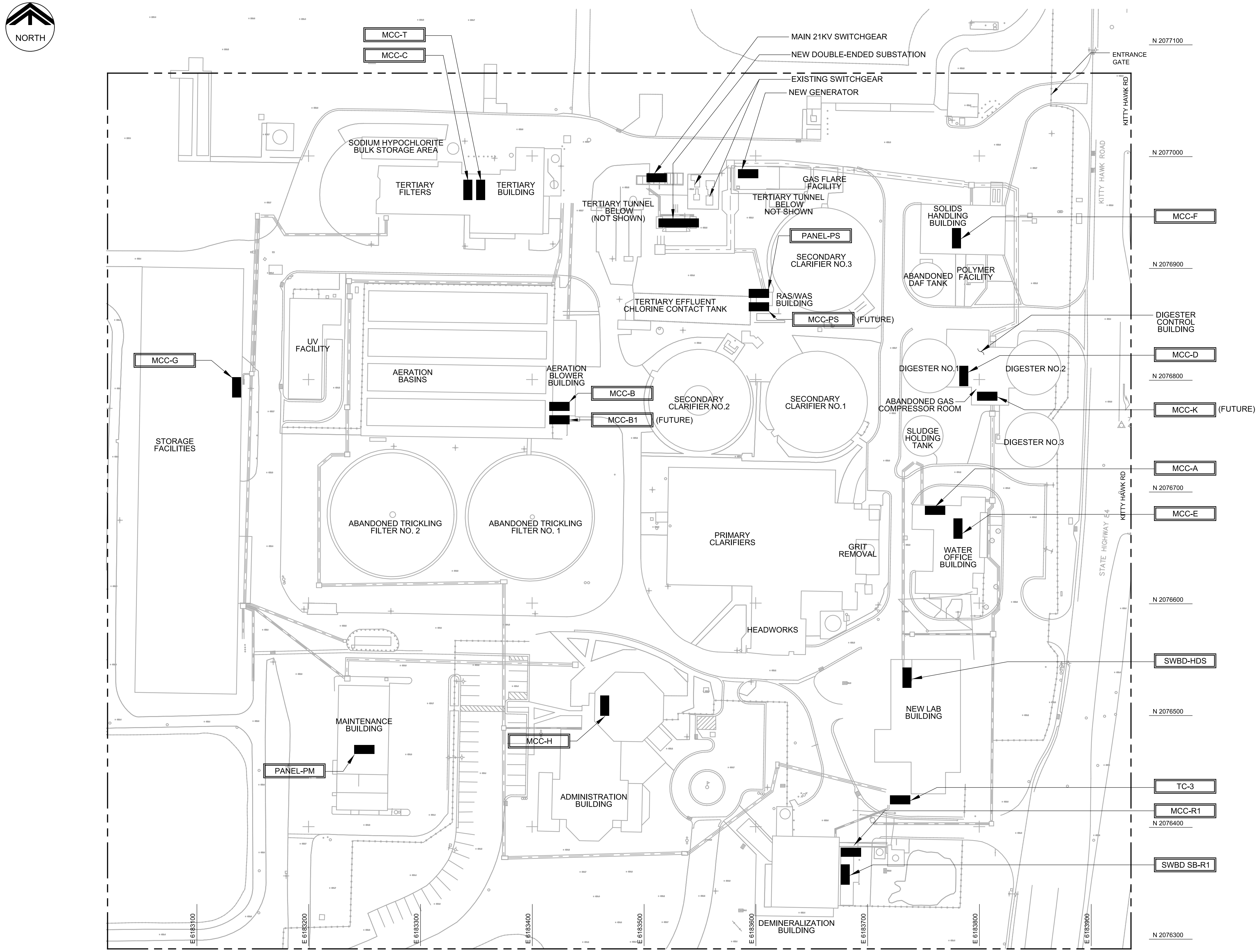
This section summarizes the condition of existing major electrical equipment and power distribution system at the WRP.

Figure 1 presents an overall site plan that shows the location of the major electrical equipment. Figure 2 shows the overall one-line diagram of the existing electrical distribution system at the WRP including the modifications and deletions required by the Electrical Distribution System Design Project. Figures 3 and 4 show the one-line diagram for the new double ended 480-V switchgear proposed in the Electrical Distribution System Design Project.

Power is currently supplied to the WRP from a single Pacific Gas & Electric (PG&E) 21-kV distribution feeder. The service lateral originates from an underground PG&E vault located on the East side of plant on Kitty Hawk Road, and is routed along the North side of the Solids Handling Building to the main 21-kV service switchgear for the plant. The main 21-kV service switchgear feeds existing transformers TC-1, TC-2, and TC-5, which subsequently feed MSBD-A, MSBD-B, SB-R1, and remotely located LAVWMA MCC. The power distribution system is configured as a radial distribution system. Switchboards MSBD-A, MSBD-B and SWBD SB-R1 are single-ended switchboards and power the individual plant loads through local MCCs. According to plant staff, the PG&E service feeder has generally been very reliable.

4.2 Main 21-kV Power Distribution Switchgear

The main 21-kV service switchgear utilizes a vacuum circuit breaker for the main. It also contains the utility metering equipment, devices, and two fused feeder switches. The main switchgear was manufactured by Cutler Hammer in the 1990s and appears to be in good condition.



A **OVERALL SITE PLAN**

SCALE: 1"=50'-0"
FILE:

Figure No. 1

OVERALL SITE PLAN

WRP ELECTRICAL DISTRIBUTION SYSTEM ANALYSIS
CITY OF LIVERMORE CALIFORNIA

carollo®

Plot Date: 27-SEP-2013 7:22:15 AM

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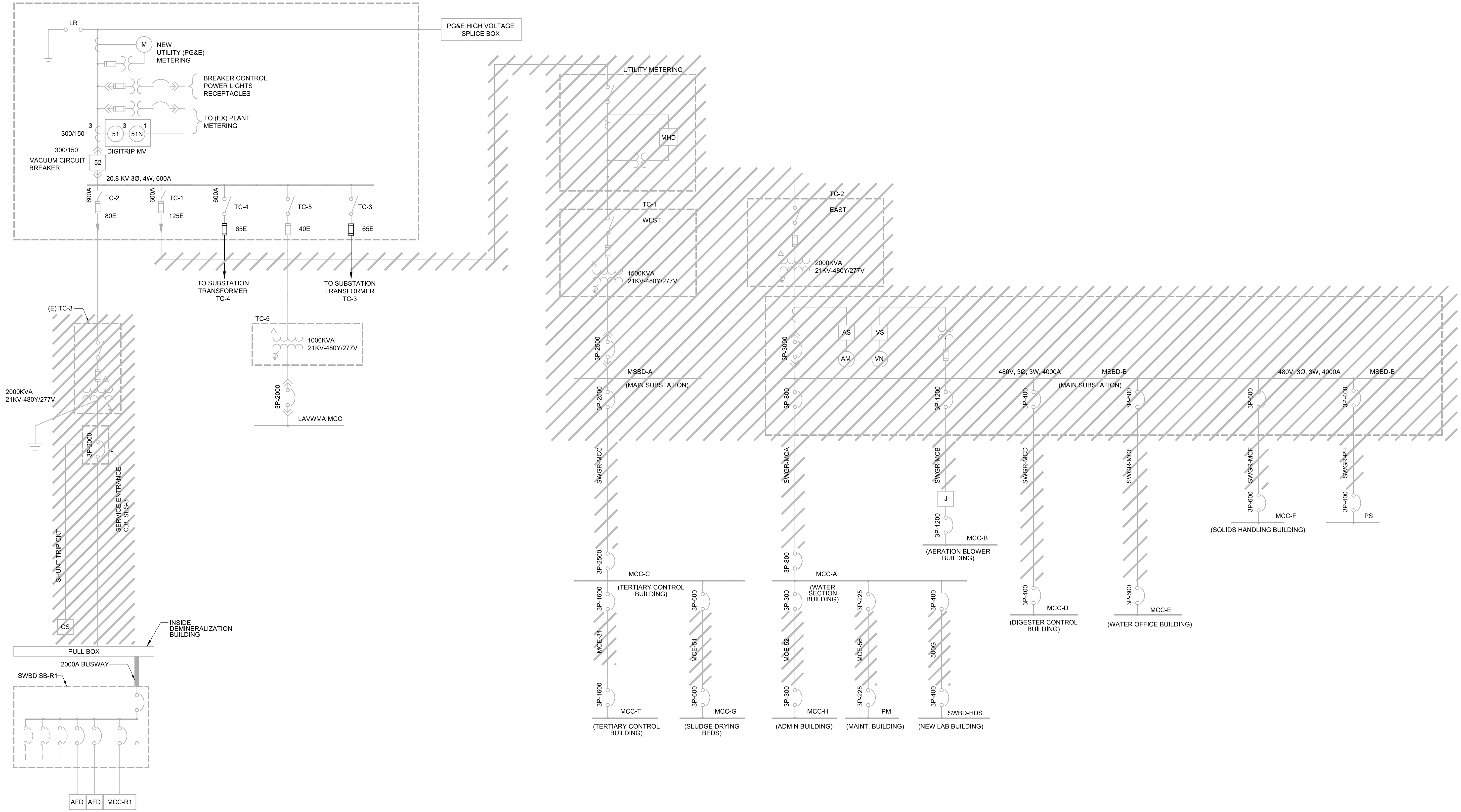

Figure No. 2

EXISTING ONE LINE DIAGRAM MODIFICATIONS

WRP ELECTRICAL DISTRIBUTION SYSTEM ANALYSIS
CITY OF LIVERMORE CALIFORNIA

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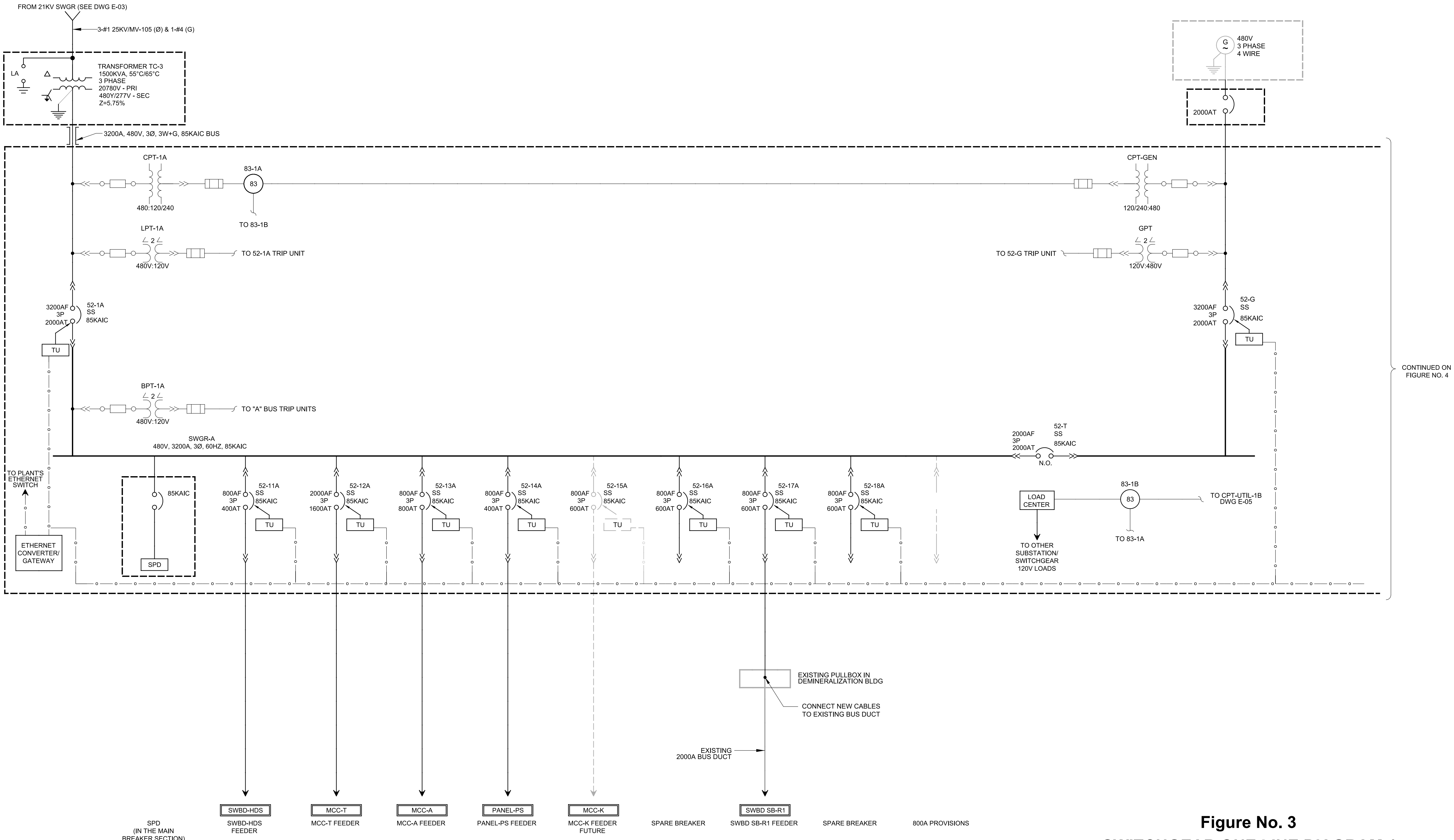

Figure No. 3

SWITCHGEAR ONE LINE DIAGRAM 1

WRP ELECTRICAL DISTRIBUTION SYSTEM ANALYSIS
CITY OF LIVERMORE CALIFORNIA

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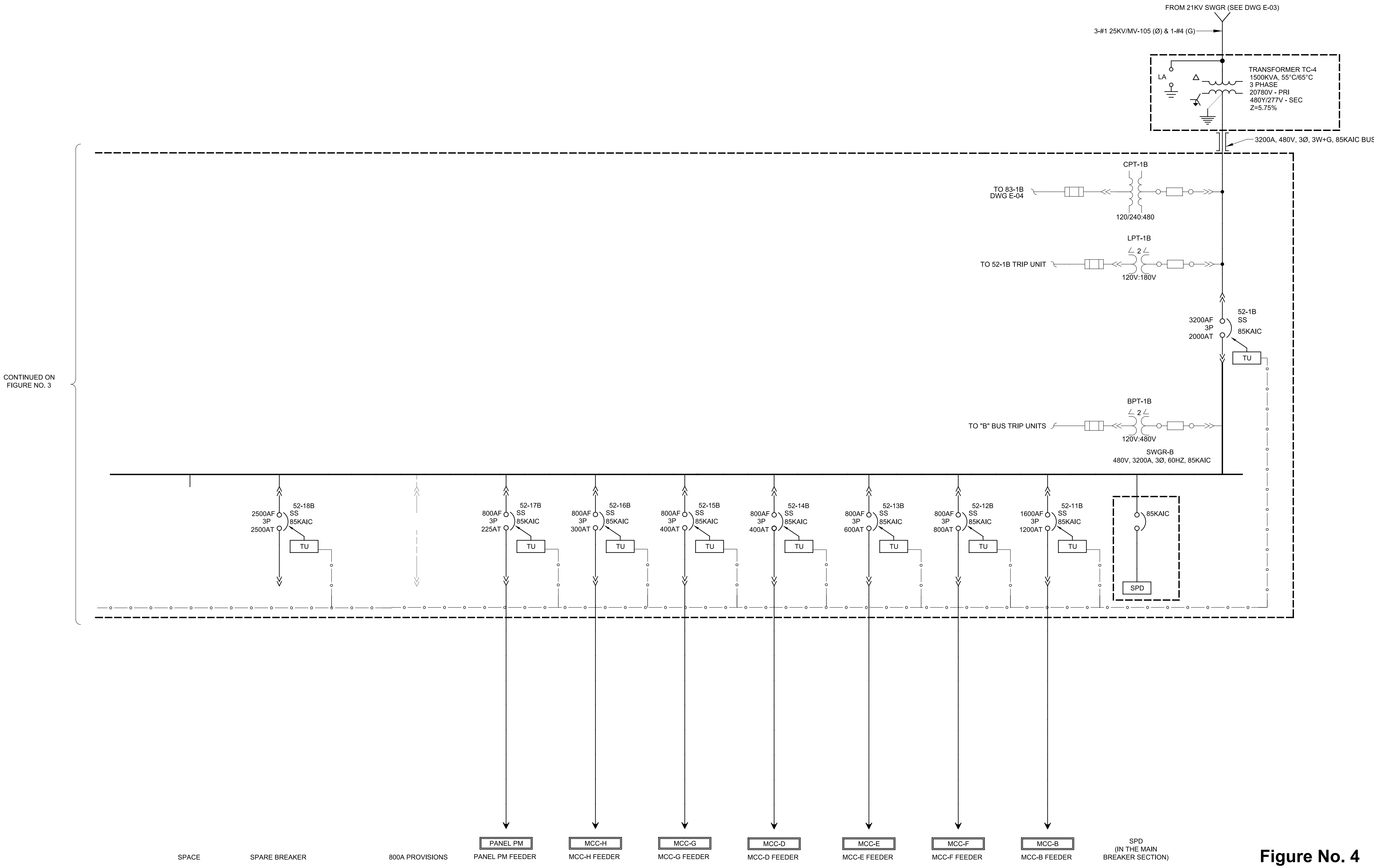

Figure No. 4

SWITCHGEAR ONE LINE DIAGRAM 2

WRP ELECTRICAL DISTRIBUTION SYSTEM ANALYSIS
CITY OF LIVERMORE CALIFORNIA

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As shown on the existing distribution system, One-Line Diagram in Figure 2, one fused feeder feeds transformers TC-1 and TC-2, which in turn feeds the single-ended switchboards MSBD-A and MSBD-B, respectively. The second fused feeder feeds an outdoor type transformer TC-3, which feeds switchboard SWBD SB-R1.

A third fused feeder was added to the end of the 21-kV switchgear as a part of the LAVWMA Pump Station Project.

SKM System Analysis Power Tools Software was used in TM1, dated October 2007 to model and calculate the available short-circuit current within WRP's power distribution system. The study has been updated for this TM with the results shown in Table 1. Because most of the electrical equipment in the plant is extremely old, assumptions were made in order to estimate a horsepower or Ampere value for unknown loads in order to complete the SKM distribution system model. These assumptions included:

- The horsepower or kVA (kilo-Volt-Ampere) values that could not be documented are estimated at 80 percent of their respective feeder protective devices (e.g., load without a horsepower value and a 20-Amp feeder breaker was estimated as 0.8 x 20 = 16-Amp load). This assumption is conservative and represents the worse case loading scenario for this study.
- The 30- to 40-year old switchboards and motor control centers without a short-circuit current rating label are assumed to have 22,000 Amp short-circuit current rating.

Unit substation transformers TC-1 and TC-2 and single-ended switchboards MSBD-A and MSBD-B were constructed by General Electric and are approximately 40 years old. These switchboards and their breakers are extremely old and do not have nameplates identifying their short-circuit current ratings.

These low voltage circuit breakers interrupt the fault current during the first one to three cycles of a short-circuit. Therefore, these low voltage circuit breakers must have interrupting ratings greater than all fault contribution from utility, generators and motors, including the DC component (asymmetrical factor) of the fault waveform calculated at first half cycle.

The symmetrical short-circuit current and asymmetrical short-circuit current at 1/2 cycle for the existing system is shown in Table 1. As shown on this table, the available asymmetrical 1/2 cycle fault current at SWBD SB-R1, MSBD-A and MSBD-B is 26,853 Amps, 40,737 amps and 54,409 amps, respectively. Because the actual short-circuit current rating for this equipment was not found during our field visits, we have assumed a rating of 30,000 amps for switchboards and 22,000 amps for MCCs. Based upon this assumption the available fault current at MSBD-A and MSBD-B exceeds the assumed rating and consequently the equipment must be replaced in order to comply with the requirements of National Electrical Code (NEC).

Table 1	SKM Power Analysis Software Calculation Data for Existing System WRP Electrical Distribution System Analysis City of Livermore, California				
Component Name	**Continuous Rating (A)**	**Demand Load (A)**	**Demand Load (kVA)**	**Symmetrical (A)**	**Asymmetrical 1/2 Cycle (A)**
21 kV Switchgear	1,200	146	5,293	3,517	4,815
MCC-A	800	698	580	17,019	18,462
MCC-B	1,200	777	646	22,953	26,628
MCC-C	1,200	1,603	1,333	24,735	29,536
MCC-D	600	350	291	12,846	13,193
MCC-E	600	300	249	15,486	16,426
MCC-F	600	199	165	15,097	15,785
MCC-G	600	350	291	11,650	12,055
MCC-H	600	175	145	10,388	10,659
PANEL-PS	600	213	177	12,479	12,673
MCC-R1	600	30	25	8,023	8,235
MCC-T	1,600	1,603	1,333	24,735	29,536
MSBD-A	2,500	1,603	1,333	31,825	40,737
MSBD-B	4,000	2,535	2,108	41,890	54,409
PANEL-PM	100	120	100	15,777	16,862
SWBD-HDS	600	246	205	10,529	11,302
SWBD SB-R1	2,000	591	491	23,567	26,853

Furthermore, these substations are single-ended and this configuration does not offer redundancy in the power distribution system. In the event of a fault or failure within this equipment, all the loads powered from that equipment will be without power.

4.3 Recommended Improvements

- The following improvements shall be done under the Electrical Distribution System Design Project. A double-ended switchgear (SWGR-A, SWGR-B) and two new unit substation transformers will be provided to replace the existing 480-V electrical distribution equipment. Construction of this project is scheduled to start towards the end of 2013. The two future transformers in the Electrical Distribution System Design Project are rated up to 1,680 kVA (2,020 amps) each, for a total capacity of 3,360 kVA. Figure 1 (Overall Site Plan) shows the proposed location of the new double-ended switchgear and existing MCCs in WRP. Figure 2 (Existing One-Line Diagram) depicts the current electrical distribution system with proposed modification shown in the Electrical Distribution System Design Project. Figures 3 and 4

(Switchgear One-Line Diagrams) depict the future electrical distribution system with the new double-ended switchgear replacing the existing 480-Volt switchboards as designed in the Electrical Distribution System Design Project.

– New transformers and switchgear sizing criteria: With assistance from the City staff, a list of peak demand/duty loads for each MCC was prepared and a preliminary investigation and research of plant process systems and peak loads was performed to identify the maximum demand loads required to operate the plant during a peak demand condition. Our evaluation revealed that a total of 2,336 kVA (1,869 kW or 2,810 amps) of peak demand load would be connected to the one end of new double-ended switchgear (SWGR-A), and a total of 2,006 kVA (1,604 kW or 2,412 amps) of peak demand load would be connected to the other end of the new double-ended switchgear (SWGR-B), for a total of 4,342 kVA (3,473 kW or 5,222 amps) connected to the 480-Volt double-ended switchgear. The two transformers (with total capacity of 3,360 kVA) that will be provided under the Electrical Distribution System Design Project appear to be undersized for the peak demand load identified in the preliminary investigation (total of 4,342 kVA) for operating the WRP during a peak demand condition. However, the actual maximum demand load for operating the WRP should be lower than the findings in our preliminary research since the seven-year PG&E electrical usage data (between June 28, 2007 and June 18, 2013) indicates the maximum demand was 1,427 kVA (1,142 kW or 1,717 amps). The maximum peak demand occurred on May 28, 2008. Therefore, the two 480-Volt transformers and the double-ended switchgear to be provided as part of the Electrical Distribution System Design Project will have adequate capacity to provide power to the existing loads under the peak load conditions.

– The 2012 Master Plan Update (see Phase III) identifies future projects with a total connected load of 615 kVA (493 kW or 740 amps) that may be added to the electrical distribution system. In addition, the Solids Expansion Project (see Phase IV) will require a new MCC-K with 303 kVA (365 amps) of additional load. Assuming the entire future load of 918 kVA identified in the 2012 Master Plan and the Solids Expansion Project will be required to operate the WRP during a peak demand condition, the maximum electrical demand at WRP in the future can be calculated in accordance with National Electrical Code (NEC) to be 2,700 kVA (i.e., (1,427 kVA x 1.25) + 615 kVA + 303 kVA). Since the two future transformers feeding the new 480-V switchgear will have a total capacity of 3,360 kVA, the 480-Volt transformers and the double-ended switchgear to be provided as of the Electrical Distribution System Design Project will have adequate capacity for additional electrical loads identified in the 2012 Master Plan Update under the peak load conditions. It should be noted that the future 480-Volt transformers and double-ended switchgear will have adequate capacity only if both transformers are online at the same time, which is the normal operating mode and will result in division of entire WRP loads between the two transformers. During a routine transformer maintenance condition or a transformer failure where one of the transformers is offline, only up to 1,680-kVA of loads in WRP can be operated.

- New ductbanks will be provided between the 21-kV switchgear, new substation transformers, new switchgear, and most new MCCs. Some of the existing ductbanks will be reused where feasible.

- New feeder cables will be provided between the new switchgear and all existing MCCs.

5.0 PHASE II - MCC REPLACEMENT PROJECT

This section includes the findings and recommendations for replacement of MCCs as outlined in TM1, dated October 2007. Information obtained during field visits for MCCs is summarized in Table 1. In addition, Table 1 shows the calculated short-circuit currents at each MCC. Refer to Appendix A for a copy of the short-circuit analysis report.

5.1 Replacement of Existing Motor Control Centers

TM1, dated October 2007 included the following evaluations:

- MCC-A, MCC-D, and MCC-E are older MCCs. However, they have a low calculated short-circuit current available at their buses and therefore are considered safe. It is estimated that these MCCs will last until the end of their useful life in approximately 5 to 10 years.

- MCC-B, MCC-C, and MCC-CE are outdated vintage MCCs. In addition, these MCCs have a higher calculated available short-circuit current at their buses than their rating and, therefore, are not considered safe. The replacement of these MCCs is recommended.

- MCC-G, MCC-PS, and MCC-R1 are older MCCs. However, they have a low calculated available short-circuit current at their buses and therefore are considered safe. It is estimated that these MCCs will last until the end of their useful life in approximately 15 to 25 years.

- MCC-H is newer and has a low calculated available short-circuit current at its bus, and therefore is considered safe. It is estimated that this MCC will last until the end of its useful life in approximately 25 to 30 years.

- The standby Panelboard B was approximately 40 years old and in extremely bad condition. This panelboard has been disconnected and removed from the system by City staff.

Based on MCCs condition assessment in TM1, the replacement of outdated vintage MCCs has a high priority, however, it was not as critical when compared to the modifications needed to the 21-kV switchgear and replacement of the unit substations and switchboards. Therefore, the vintage MCCs have been identified for replacement in Phase II.

The City staff have replaced the following MCCs since TM1 was prepared in October 2007:

- MCC-B has been replaced in-place with a new MCC-B.
- MCC-CE has been replaced with a new MCC-T.
- MCC-F has been replaced in-place with a new MCC-F.

5.2 Replacement of Existing Feeder Cables

In general, reuse of existing feeder cables is not recommended. Most of the feeder cables between existing MCCs and plant loads are between 30 and 45 years old. Therefore, as part of the replacement of vintage MCCs, the feeder cables between the MCCs and their connected loads should be replaced. It should be noted that the feeder cables between existing MCC-CE (new MCC-T), MCC-B, and MCC-F and their connected loads were not replaced by City staff when MCCs were replaced.

5.3 Recommended Improvements

- Provision of new feeder cables between the new MCCs and their connected loads are recommended.
- Since the feeder cables between MCC-CE (new MCC-T), MCC-B, and MCC-F and field equipment were not replaced by City staff during MCC replacement, the condition of all feeder cables between all MCCs and field equipment remain the same and their replacement is recommended.
- The estimated construction cost of feeder replacement associated with Phase II Improvements is approximately $4,165,500.

6.0 PHASE III - 2012 MASTER PLANT UPDATE

In the 2012 Master Plan Update, Tetra Tech identified the additional electrical loads (including any loads that will be deleted) due to each future project. Tetra Tech also identified the physical location of the future projects. Tetra Tech grouped the future projects into three phases; Phase 1, Phase 2, and Phase 3. Phase 1 was further divided in Phases 1a, 1b, and 1c. Phase 1 is to be completed from 2013 to 2017 and includes projects 1, 2, 3, 4, 6, 14, 15, 19, and 20. Phase 2 is to be completed from 2018 to 2022 and includes projects 5, 8, 11, 12, 13, and 16. Phase 3 is to be completed from 2022 to 2033 and includes projects 7, 9, 10, 18, and 21.

6.1 Analysis of Loads Due to Future Projects

This section analyzes the impact of the future projects indentified in the 2012 Master Plan Update on the electrical distribution system. Based on the information in the 2012 Master Plan Update, Table 2 summarizes the impact of these future projects on the WRP's electrical system. In addition to the information from the 2012 Master Plan Update, interviews and discussions with City's staff and Tetra Tech engineers, and field observations were used to analyze the impact of the additional electrical loads from the future projects.

6.1.1 Project No. 1 – Aeration Equipment Replacement

This project rehabilitates the existing aeration tank 1 to match the current configuration of aeration tank 2 as described in the 2012 Master Plan Update. Aeration tank 1 was in service previously and all associated equipment was powered from MCC-B. As part of this project, MCC-B will be reused to provide power to new aeration tank equipment. According to the 2012 Master Plan Update, this project will not add any new loads to the electrical system.

Necessary Electrical Improvements: Provide new breakers, starters, cables, and conduits as necessary. However, no MCC improvements are required.

6.1.2 Project No. 2 –Standby Power

This project provides a standby generator to power the critical processes and equipment if an outage of utility power occurs. These improvements do not add new loads to the system.

The standby power requirement is similar to the peak demand load requirement discussed above. As noted from the results of the initial investigation, total peak demand load for the WRP is 3,475 kW (4,342 kVA). However, since the actual maximum demand for WRP was 1,142 kW (1,427 kVA) based on seven years of data from PG&E's invoices, the standby generator can be sized for the actual maximum demand, for which a 1,500-kW generator is adequate.

However, the 1,500-kW standby generator will not be adequate if the entire future load of 880 kW identified in the 2012 Master Plan Update is required to operate in addition to the actual maximum peak demand of 1,142 kW identified in PG&E invoices.

Either a 2,000 kW generator should be provided or a load-shedding scheme may need to be implemented to shed the loads with lowest priority as needed to reduce the overall standby capacity requirement below 1,500 kW in the future. The decision should be based on the amount of future loads (i.e., 880 kW) that will need to operate from the generator during a power outage. If the amount of future load is approximately 300 kW, then a 1,500 kW generator will be adequate.

Table 2 Electrical Loads – 2012 Master Plan Update Projects
WRP Electrical Distribution System Analysis
City of Livermore, California

Project No.	Description	Project Timing	CIP Project Phase	Location	Closest MCC	Capacity at 480V (Amp)	Existing Operating 480V Loads (Amp)	Added or (Deleted) 480V Loads (Amp)
1	Aeration equipment replacement (no additional electrical loads)	2013	1a	Aeration Basin 1	MCC-B	1,200	777	N/A
2	Standby power	2014	1b	N/A	N/A	N/A	N/A	N/A
3	Finer mechanical screening equipment (2-hp drive motor)	2016	1c	Headworks	MCC-E	600	300	4
4	Process control improvements (Eight 5-hp mixers and one 2-hp gate actuator)	2013	1a	Aeration Basins	MCC-B	1,200	777	68
5	UV system replacement (Replaces existing 125-kW system with 100-kW system)	2018-2022	2	UV Bldg	MCC-G	600	350	150 (150)
6	Primary clarifier gate actuation and redundant grit classifier (Eight 2 hp gate actuators, one 10-hp grit pump, one 2-hp classifier)	2016	1c	Primary Treatment	MCC-E	600	300	45
7	Additional odor control (Two 50-hp fans, One 5-hp recirculation pump)	2022-2027	3	Solids Handling	MCC-F	800	200	138
8	Grit system improvements (One 2-hp mixer and two 10-hp grit transfer pumps)	2018-2022	2	Headworks	MCC-E	600	300	32 (162)
9	Dewatering improvements (Two Centrifuges each with 100-hp main drive and 20-hp back drive)	2022-2027	3	Solids Handling	MCC-F	800	200	352 (10)

Table 2 Electrical Loads – 2012 Master Plan Update Projects
WRP Electrical Distribution System Analysis
City of Livermore, California

Project No.	Description	Project Timing	CIP Project Phase	Location	Closest MCC	Capacity at 480V (Amp)	Existing Operating 480V Loads (Amp)	Added or (Deleted) 480V Loads (Amp)
10	P-Recovery (Two 5-hp filtrate pumps, two 3-hp chemical pumps, 20-kW for lighting and HVAC)	2022-2027	3	Solids Handling	MCC-F	800	200	56
11	Cogeneration (Three 200-kW microturbines)	2018-2022	2	N/A	N/A	N/A	N/A	N/A
12	Gravity thickener (Two 5-hp pumps)	2018-2022	2	Solids Handling	MCC-F	800	200	16
13	BNR upgrades (Two 250-hp blowers, Two 30-hp RAS pumps, two 2-hp gate actuators)	2018-2022	2	Aeration Basins	MCC-B	1,200	777	691
14	Arc flash study (no additional electrical loads)	2014	1b	N/A	N/A	N/A	N/A	N/A
15	Miscellaneous structural improvements (no additional electrical loads)	2016	1c	N/A	N/A	N/A	N/A	N/A
16	Add new raw sewage screw pump - (One 25-hp pump)	2019	2	Headworks	MCC-E	600	300	34
17	Secondary clarifier #2 mechanism (insignificant increase in electrical loads)	Unknown	Unknown	N/A	MCC-PS (FUT) MCC-A	600 800	N/A 635	5.5 (5.5)
18	Upsize basin return pumps (Two 60-hp and one 20-hp pump) *hps are assumed. Tetra Tech to provide final pump hps	2023	3	Basin Return Pump Station	MCC-PS (FUT) MCC-T	600 1,600	N/A 1,603	181 (118)

Table 2 Electrical Loads – 2012 Master Plan Update Projects
WRP Electrical Distribution System Analysis
City of Livermore, California

Project No.	Description	Project Timing	CIP Project Phase	Location	Closest MCC	Capacity at 480V (Amp)	Existing Operating 480V Loads (Amp)	Added or (Deleted) 480V Loads (Amp)
19	Miscellaneous improvements (no additional electrical loads)	2016	1c	N/A	N/A	N/A	N/A	N/A
20	Electrical distribution system upgrades	2016	1c	N/A	N/A	N/A	N/A	N/A
21	MCC replacement	2023	3	N/A	N/A	N/A	N/A	N/A

Diesel engine-driven generator sets are available in a wide range of kW capacity. The type of engine being considered will have a sub-base diesel storage tank in a weatherproof walk-in enclosure, thus reducing the capital cost of the enclosure building. With the sub-base diesel storage tank located under the foundation of the diesel-generator set, there are savings of valuable space, piping costs and any environmental problem that may result due to accidental rupture of the storage tank. The sub-base diesel tank will provide enough diesel fuel for approximately 12 hours of operation. A separate diesel fuel storage tank will be required if extended operation of the generator is desired.

We recommend a detailed investigation and research to revisit and review the list of the demand/duty loads to clarify the reason for the large discrepancy between the investigated maximum peak demand loads and actual maximum peak demand loads shown on the utility invoices.

Necessary Electrical Improvements: Provide double-ended switchgear, two new transformers, new cables, conduits, and ductbanks as designed in the Electrical Distribution System Design Project. Include provisions in the new electrical distribution system to accommodate a 1,500-kW standby generator (already included in the Electrical Distribution System Design Project).

6.1.3 Project No. 3 – Finer Mechanical Screening Equipment

This project modifies the plant's influent screening facility as described in the 2012 Master Plan Update. As shown in Figure 1, the closest MCC to this process area is MCC-E. According to Table 1, this project will result in additional electrical load requirements of 2 hp. MCC-E has spare capacity for the additional load.

Necessary Electrical Improvements: Provide new breakers, starters, cables, and conduits as necessary. No new MCCs or additions are required.

6.1.4 Project No. 4 – Process Control Improvements

This project modifies the existing aeration basin controls as described in the 2012 Master Plan Update. As shown in Figure 1, the closest MCC to this process area is MCC-B. According to Table 1, this project will result in additional electrical load requirements of eight 5-hp mixers and one 2-hp gate actuator, or a total of 68 amps. MCC-B has spare capacity for the additional loads.

Necessary Electrical Improvements: Provide new breakers, starters, cables, and conduits as necessary. No new MCCs or additions are required.

6.1.5 Project No. 5 – UV System Replacement

This project replaces the existing 150-kVA (125-kW) UV System with a new 100-kW UV system as described in the 2012 Master Plan Update. This project does not increase the load on the system. The current UV system is powered from a 300-amp disconnect in MCC-G. MCC-G has a 600-amp rated bus. The main disconnect in MCC-G is rated for 400 amps. Therefore, even though there are plenty of spare buckets in MCC-G, the 400-amp main disconnect limits the spare capacity.

Necessary Electrical Improvements: Provide new breakers, starters, cables, and conduits as necessary. No new MCCs sections are required. A new feeder breaker and conductors between MCC-G and new UV system will be required.

6.1.6 Project No. 6 – Primary Clarifier Gate Actuation and Redundant Grit Classifier

This project modifies the plant's primary treatment system as described in the 2012 Master Plan Update. As shown in Figure 1, the closest MCC to this process area is MCC-E. According to Table 1, this project will result in additional electrical load requirements of eight 2-hp gate actuators, one 10-hp grit pump, and one 2-hp classifier, or a total of 45 amps. MCC-E has spare capacity for the additional load.

Necessary Electrical Improvements: Provide new breakers, starters, cables, and conduits as necessary. No new MCCs or additions are required.

6.1.7 Project No. 7 – Additional Odor Control

This project adds an additional odor control system as described in the 2012 Master Plan Update. As shown in Figure 1, the closest MCC to this process area is MCC-F. According to Table 1, this project will result in additional electrical load requirements of two 50-hp fans and one 5-hp recirculation pump, or a total of 138 amps. MCC-F has spare electrical capacity for the additional loads. However, MCC-F has limited physical space for adding breakers or VFDs.

Necessary Electrical Improvements: Provide new breakers, starters, cables, and conduits as necessary. Provide additional MCC sections as an extension of existing MCC-F. Feed the new MCC-F sections from a new feeder breaker inside existing MCC-F.

6.1.8 Project No. 8 – Grit System Improvements

This project modifies the plant headworks as described in the 2012 Master Plan Update. As indicated in Figure 1, the closest MCC to this process area is MCC-E. According to Table 1, this project will result in additional electrical load requirements of one 2-hp mixer and two 10-hp grit transfer pumps, or a total of approximately 32 amps. This project will remove one 1-hp mixer, two 10-hp grit transfer pumps, and two 25-hp preaeration blowers, or approximately 98 amps. This project decreases the total electrical load by 51 hp, or approximately 66 amps.

Necessary Electrical Improvements: Provide new breakers, starters, cables, and conduits as necessary. No new MCCs or additions are required.

6.1.9 Project No. 9 – Dewatering Improvements

This project replaces the existing belt press dewatering system as described in the 2012 Master Plan Update. As shown in Figure 1, the closest MCC to this process area is MCC-F. According to Table 1, this project will result in electrical load requirements of two 100-hp VFDs and two 20-hp VFDs, or a total of approximately 352 amps, replacing the existing loads of approximately 10 amps. MCC-F has spare electrical capacity for the additional loads. However, MCC-F has limited physical space for adding breakers or VFDs.

Necessary Electrical Improvements: Provide new breakers, starters, cables, and conduits as necessary. Provide additional MCC sections as an extension of existing MCC-F. Feed the new MCC-F sections from a new feeder breaker inside existing MCC-F.

6.1.10 Project No. 10 – P-Recovery

This project includes a new Struvite Mitigation and Phosphorus Recovery System as described in the 2012 Master Plan Update. As indicated in Figure 1, the closest MCC to this process area is MCC-F. According to Table 1, this project will result in electrical load requirements of two 5-hp filtrate pumps, two 3-hp feed pumps, and 20-kW of lighting and HVAC load, or a total of approximately 56 amps. MCC-F has spare electrical capacity for the additional loads. However, MCC-F has limited physical space for adding breakers or VFDs.

Necessary Electrical Improvements: Provide new breakers, starters, cables, and conduits as necessary. Provide additional MCC sections as an extension of existing MCC-F. Feed the new MCC-F sections from a new feeder breaker inside existing MCC-F.

6.1.11 Project No. 11 – Cogeneration

This project provides a new cogeneration facility as described in the 2012 Master Plan Update. The cogeneration system will result in electrical generation of approximately 600 kW. The cogeneration facilities are normally provided as packaged systems including the electrical equipment and PLC controls for connection to the plant’s electrical distribution system. The cogeneration system will be connected to the plant’s main 480-V switchgear.

Necessary Electrical Improvements: Provide a dedicated breaker in the main 480-V switchgear reserved for connection to the future cogeneration system (this is already included in the Electrical Distribution System Upgrade Project). The cogeneration system must be provided with the required electrical equipment and controls to disconnect from the main plant’s power distribution system upon loss of power and to comply with utility interconnection requirements.

6.1.12 Project No. 12 – Gravity Thickener

This project provides a new gravity thickening system as described in the 2012 Master Plan Update. As indicated in Figure 1, the closest MCC to this process area is MCC-F.

According to Table 1, this project will result in electrical load requirements of two 5-hp pumps, or approximately 16 amps. MCC-F has spare electrical capacity for the additional loads. However, MCC-F has limited physical space for adding breakers or VFDs.

Necessary Electrical Improvements: Provide new breakers, starters, cables, and conduits as necessary. Provide additional MCC sections as an extension of existing MCC-F. Feed the new MCC-F sections from a new feeder breaker inside existing MCC-F.

6.1.13 Project No. 13 – BNR Upgrade

This project converts the existing activated sludge process to a Biological Nutrient Removal (BNR) process to reduce the total phosphorus (TP) and total nitrogen (TN) as described in the 2012 Master Plan Update. As indicated in Figure 1, the closest MCC to this process area is MCC-B. According to Table 1, this project will result in additional electrical load requirements of two 250-hp blowers, two 30-hp RAS pumps, and two 2-hp gate actuators, or approximately 691 amps. MCC-B does not have enough spare capacity for the new loads.

Necessary Electrical Improvements: Provide a new MCC in the aeration basin area, new ductbank from switchgear to the new MCC for the main feed cables and new breaker in the switchgear to support the BNR Upgrades. Provide new breakers, starters, cables, and conduits as necessary.

6.1.14 Project No. 14 – Arc Flash Study

National Electrical Code (NEC) and National Fire Protection Association (NFPA) standard for electrical safety in the workplace (NFPA 70E) provide guidelines and standards for a practical safe working area for employees relative to the hazards arising from the use of electricity. These improvements do not add new loads to the system.

Necessary Electrical Improvements: Perform an arc flash study and analysis in accordance with NFPA 70E to determine safe work practices, arc flash boundary, and the appropriate levels of personal protective equipment (PPE).

6.1.15 Project No. 15 – Miscellaneous Structural Improvements

This project provides miscellaneous structural improvements throughout the plant as described in the 2012 Master Plan Update. These improvements do not add new loads to the system.

Necessary Electrical Improvements: None.

6.1.16 Project No. 16 – Add Fourth Raw Sewage Screw Pump

This project provides a fourth raw sewage screw pump as described in the 2012 Master Plan Update. As indicated in Figure 1, the closest MCC to this process area is MCC-E. According to Table 1, this project will result in additional electrical load requirements of one

25-hp pump, or approximately 34 amps. MCC-E has the spare capacity for the additional loads required by this project.

Necessary Electrical Improvements: Provide new breakers, starters, cables, and conduits as necessary. No new MCCs or additions are required.

6.1.17 Project No. 17 – Replace Secondary Clarifier #2 Mechanism

This project replaces the mechanism in Secondary Clarifier #2 and automates the gates in the Secondary Distribution Box. The mechanism in Secondary Clarifier #2 is currently powered from existing MCC-A. However, the City is planning to install a new MCC-PS in the existing RAS/WAS building. The replaced mechanism will be powered from the new MCC-PS in the future. This project will result in an insignificant increase in electrical loads.

Necessary Electrical Improvements: Provide new breakers in MCC-PS in RAS/WAS building to feed the new gates. Provide ductbank and cables between MCC-PS and PLC in RAS/WAS building and the Secondary Distribution Box for power and automation required for the gates.

6.1.18 Project No. 18 – Basin Return Pumps Upgrades

This project replaces 3 existing basin return pumps with new larger pumps as described in the 2012 Master Plan Update. The pumps are currently powered from existing MCC-T in the tertiary building. However, the City is planning to install a new MCC-PS in the existing RAS/WAS building. The plant staff desires to power the new basin return pumps from the new MCC-PS in the future. According to Table 1, this project will result in electrical load requirements of two 60-hp VFDs and one 20-hp VFD, or a total of approximately 181 amps, replacing the existing loads of approximately 118 amps.

Necessary Electrical Improvements: Provide new MCC-PS in RAS/WAS building to support the basin return pumps upgrades. It should be noted that the existing RAS/WAS building is very small and extremely congested. Therefore, the installation of a new MCC in this building should be further evaluated in detail. Provide new breakers, starters, cables, and conduits as necessary.

6.1.19 Project No. 19 – Plant Wide Improvements

This project includes miscellaneous improvements that are required throughout the plant. These improvements do not add new electrical loads to the system.

Necessary Electrical Improvements: None.

6.1.20 Project No. 20 – Electrical Distribution System Upgrades

This project includes various electrical distribution system upgrades such as replacing transformers TC-1 and TC-2, replacing main switchboards MSBD-A and MSBD-B, installing new feeder cables, and installing a new ductbank. Refer to Section 4.0 for additional information.

Necessary Electrical Improvements: Refer to Section 4.0 for additional information.

6.1.21 Project No. 21 – MCC Replacement

This project replaces the older MCCs (MCC-A, -B, -C, -CE, -D, -E, and –F) with new MCCs. It also replaces the feeders from the older vintage MCCs and field equipment with new feeders. Refer to Section 5.0 for additional information.

Necessary Electrical Improvements: Refer to Section 5.0 for additional information.

6.2 Recommended Improvements

Table 3 shows the additional loads to be added to the various electrical equipment according to 2012 Master Plan update Projects.

The following improvements are necessary to the electrical distribution system for the future projects identified in the 2012 Master Plan Update:

- General Improvements:
  - With the exception of the miscellaneous structural improvements project No. 15 and Project No. 19, all other projects will require general electrical improvements including: addition of new breakers in MCCs, new conduits, new ductbanks, new cables, new controls, etc.
- Major Improvements:
  - Add new sections to MCC-F. This is required by Projects 7, 9, 10, and 12.
  - Add a new breaker, ductbank, and conductors between the main switchgear and cogeneration facility.
  - Add new MCC-B1 in the aeration basin area to support the BNR Upgrades (Project 13). This new MCC will require a new ductbank from switchgear for the main feeder cables and a new feeder breaker in the switchgear.
  - Add new MCC-PS to the RAS/WAS building to replace Panel PS. This is required by Project 18. The conduits for the feeders to this new MCC shall be installed in the Electrical Distribution System Design Project to be cost-effective.

Table 3	Impact of Additional Loads from 2012 Master Plan Update WRP Electrical Distribution System Analysis City of Livermore, California			
Component Name	**Continuous Rating (A)**	**Existing Demand Load (A)**	**Load Addition or (Deletion) (A)**	**Final Demand Load (A)**
MCC-B	1,200	777	759	1,536
MCC-E	600	300	(47)	253
MCC-F	600	199	552	751
MCC-G	600	350	(150)+150=0	350
PANEL-PS (1)	600	213	(213)	0
(NEW) MCC-PS	600	0	213+118	331
MCC-T (2)	1,600	1,603	(118)	1,485

Notes:

(1) PANEL-PS will be demolished and replaced by MCC-PS

(2) Existing Basin Return Pumps will be removed from MCC-T and fed from future MCC-PS.

7.0 PHASE IV - SOLIDS EXPANSION PROJECT

TM No. 5 of the Phase VI Expansion Solids Project indicated that approximately 259 Amps will be added to the Digester Control Building due to additional digesters and appurtenances and approximately 106 Amps will be added to the Solids Handling Building due to the Gravity Belt Thickener Project.

The Gravity Belt Thickener Project has been constructed in 2011. As mentioned above, the Digestion Capacity Expansion Project will add approximately 259 Amps. TM No. 5 of the Phase VI Expansion Solids Project recommended adding a new motor control center, MCC-K, in the Digester Control Building. The main sections of the ductbank from this future MCC to the main switchgear has been installed in the Ductbank Improvements Project in 2012. The remaining ductbank sections and work required in the Digester Control Building to complete the conduit routing and connections for this MCC is included in the Electrical Distribution System Design Project. The MCC-K sections in the Digester Control Building may be installed in the future under the Digestion Capacity Expansion Project.

APPENDIX A – ELECTRICAL STUDIES REPORTS

Sep 19, 2013   10:39:33

SKM POWER*TOOLS FOR WINDOWS
A_FAULT SHORT CIRCUIT ANALYSIS REPORT

T H R E E   P H A S E   F A U L T   R E P O R T
(FOR APPLICATION OF LOW VOLTAGE BREAKERS)
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

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=========================================================================
=====

  MCC LUVWMA1    3P Duty: 27.360 KA AT  -81.44 DEG (  22.75 MVA)  X/R:
7.12
                 VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0015 + J  0.0100
OHMS
                 LOW VOLTAGE POWER CIRCUIT BREAKER   27.741 KA
                 MOLDED CASE CIRCUIT BREAKER > 20KA  29.453 KA
                 CONTRIBUTIONS:  P-103I             3.093 KA      ANG:
-84.29
                                 P-102I             3.093 KA      ANG:
-84.29
                                 P-101I             3.093 KA      ANG:
-84.29
                 MCC LUVWMA FDR  TC-5I SECONDAR    18.099 KA      ANG:
-79.98

  MCC-A          3P Duty: 17.019 KA AT  -65.37 DEG (  14.15 MVA)  X/R:
2.59
                 VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0068 + J  0.0148
OHMS
                 LOW VOLTAGE POWER CIRCUIT BREAKER   17.019 KA
                 MOLDED CASE CIRCUIT BREAKER < 20KA  17.019 KA
                 MOLDED CASE CIRCUIT BREAKER > 20KA  17.019 KA
                 CONTRIBUTIONS:  MISC. MOTORS-A     0.181 KA      ANG:
-84.29
                 MCC-H FDR       MCC-H              0.660 KA      ANG:
97.05
                 SWBD-HDS (E) F  SWBD-HDS           0.886 KA      ANG:
96.80
                 MCC-A FDR       MSBD-B            15.384 KA      ANG:
-63.40

  MCC-B          3P Duty: 22.953 KA AT  -69.59 DEG (  19.08 MVA)  X/R:
3.58
                 VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0042 + J  0.0113
OHMS
                 LOW VOLTAGE POWER CIRCUIT BREAKER   22.953 KA
                 MOLDED CASE CIRCUIT BREAKER > 20KA  22.953 KA
                 CONTRIBUTIONS:  AER TNK BLR #1     1.681 KA      ANG:
-84.29
```

AER TNK BLR #2   1.681 KA   ANG:
-84.29
MISC. MTRS   0.767 KA   ANG:
-84.29
MCC-B FDR   MSBD-B   18.988 KA   ANG:
-66.42

MCC-D   3P Duty: 12.846 KA AT -48.88 DEG (10.68 MVA) X/R:
1.75
VOLTAGE: 480.   EQUIV. IMPEDANCE= 0.0142 + J 0.0163
OHMS
LOW VOLTAGE POWER CIRCUIT BREAKER   12.846 KA
MOLDED CASE CIRCUIT BREAKER < 20KA 12.846 KA
MOLDED CASE CIRCUIT BREAKER > 20KA 12.846 KA
CONTRIBUTIONS: MISC. MOTORS-D   1.526 KA   ANG:
-84.29
MCC-D FDR   MSBD-B   11.636 KA   ANG:
-44.53

MCC-E   3P Duty: 15.486 KA AT -60.33 DEG (12.87 MVA) X/R:
2.27
VOLTAGE: 480.   EQUIV. IMPEDANCE= 0.0089 + J 0.0155
OHMS
LOW VOLTAGE POWER CIRCUIT BREAKER   15.486 KA
MOLDED CASE CIRCUIT BREAKER < 20KA 15.486 KA
MOLDED CASE CIRCUIT BREAKER > 20KA 15.486 KA
CONTRIBUTIONS: MISC. MOTORS-E   1.437 KA   ANG:
-84.29
MCC-E FDR   MSBD-B   14.185 KA   ANG:
-57.97

```
                 T H R E E   P H A S E   F A U L T   R E P O R T
                    (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                          PRE FAULT VOLTAGE: 1.0000
                          MODEL TRANSFORMER TAPS: NO

=============================================================================
=====

  MCC-F          3P Duty: 15.097 KA AT  -59.51 DEG (  12.55 MVA)  X/R:
2.05
                 VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0093 + J  0.0158
OHMS
                 LOW VOLTAGE POWER CIRCUIT BREAKER   15.097 KA
                 MOLDED CASE CIRCUIT BREAKER < 20KA  15.097 KA
                 MOLDED CASE CIRCUIT BREAKER > 20KA  15.097 KA
                 CONTRIBUTIONS:  MISC. MOTORS-F     0.957 KA      ANG:
-84.29
                 MCC-F FDR       MSBD-B            14.234 KA      ANG:
-57.89

  MCC-G          3P Duty: 11.650 KA AT  -57.71 DEG (   9.69 MVA)  X/R:
1.88
                 VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0127 + J  0.0201
OHMS
                 LOW VOLTAGE POWER CIRCUIT BREAKER   11.650 KA
                 MOLDED CASE CIRCUIT BREAKER < 20KA  11.650 KA
                 MOLDED CASE CIRCUIT BREAKER > 20KA  11.650 KA
                 CONTRIBUTIONS:  MISC. MOTORS-G     0.289 KA      ANG:
-84.29
                 MCC-G FDR       MCC-T             11.392 KA      ANG:
-57.06

  MCC-H          3P Duty: 10.388 KA AT  -52.98 DEG (   8.64 MVA)  X/R:
1.73
                 VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0161 + J  0.0213
OHMS
                 LOW VOLTAGE POWER CIRCUIT BREAKER   10.388 KA
                 MOLDED CASE CIRCUIT BREAKER < 20KA  10.388 KA
                 MOLDED CASE CIRCUIT BREAKER > 20KA  10.388 KA
                 CONTRIBUTIONS:  MTR-MCC-H          0.672 KA      ANG:
-84.29
                 MCC-H FDR       MCC-A              9.819 KA      ANG:
-50.95

  MCC-R1         3P Duty:  8.023 KA AT  -59.79 DEG (   6.67 MVA)  X/R:
1.74
                 VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0174 + J  0.0299
OHMS
```

LOW VOLTAGE POWER CIRCUIT BREAKER 8.023 KA
MOLDED CASE CIRCUIT BREAKER < 10KA 8.027 KA
MOLDED CASE CIRCUIT BREAKER < 20KA 8.023 KA
MOLDED CASE CIRCUIT BREAKER > 20KA 8.023 KA
MCC-R1 FDR SWBD SB-R1 8.023 KA ANG:
-59.79

MCC-T 3P Duty: 24.735 KA AT -69.34 DEG (20.56 MVA) X/R:
4.06
VOLTAGE: 480. EQUIV. IMPEDANCE= 0.0040 + J 0.0105
OHMS
LOW VOLTAGE POWER CIRCUIT BREAKER 24.735 KA
MOLDED CASE CIRCUIT BREAKER > 20KA 24.735 KA
CONTRIBUTIONS: RW PMP #5 1.237 KA ANG:
-84.29
RW PMP #3 1.237 KA ANG:
-84.29
RW PMP #2 1.237 KA ANG:
-84.29
RW PMP #1 1.237 KA ANG:
-84.29
MISC. MOTORS-T 1.715 KA ANG:
-84.29
MCC-G FDR MCC-G 0.285 KA ANG:
96.19
MCC-T FDR BUS MSBD-A 18.109 KA ANG:
-63.67

```
                 T H R E E   P H A S E   F A U L T   R E P O R T
                    (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                          PRE FAULT VOLTAGE: 1.0000
                          MODEL TRANSFORMER TAPS: NO

==========================================================================
=====

  MSBD-A         3P Duty: 31.825 KA AT  -79.65 DEG (  26.46 MVA)  X/R:
5.50
                 VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0016 + J  0.0086
OHMS
                 LOW VOLTAGE POWER CIRCUIT BREAKER   31.825 KA
                 MOLDED CASE CIRCUIT BREAKER > 20KA  32.625 KA
                 MCC-T FDR BUS   MCC-T              6.357 KA      ANG:  -
258.24
                 MSBD-A FDR      BUS-TC1 SEC       25.471 KA      ANG:
-80.01

  MSBD-B         3P Duty: 41.890 KA AT  -80.29 DEG (  34.83 MVA)  X/R:
5.88
                 VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0011 + J  0.0065
OHMS
                 LOW VOLTAGE POWER CIRCUIT BREAKER   41.890 KA
                 MOLDED CASE CIRCUIT BREAKER > 20KA  43.522 KA
                 MCC-F FDR       MCC-F              0.922 KA      ANG:
97.27
                 MCC-D FDR       MCC-D              1.431 KA      ANG:  -
259.92
                 MCC-E FDR       MCC-E              1.360 KA      ANG:
98.01
                 MCC-PS FDR      PNL-PS             0.995 KA      ANG:
98.75
                 MCC-B FDR       MCC-B              3.752 KA      ANG:
98.78
                 MSBD-B FDR      BUS-TC2 SEC       31.808 KA      ANG:
-79.97
                 MCC-A FDR       MCC-A              1.624 KA      ANG:
98.71

  Main 21kV Swit 3P Duty:  3.517 KA AT  -82.42 DEG ( 127.92 MVA)  X/R:
7.60
                 VOLTAGE:  21000.   EQUIV. IMPEDANCE=  0.4548 + J  3.4174
OHMS
                 21KV SWGR FDR   BUS-UTILITY        3.006 KA      ANG:
97.29
                 TC-5I FDR       TC-5I PRIMARY      0.146 KA      ANG:
97.15
```

(E) TC-3 FDR   BUS-TC3 PRI   0.060 KA   ANG: -
259.45
TC-3 FDR   BUS-TC1-PRI   0.305 KA   ANG: -
259.92

PANEL-PB   3P Duty: 1.053 KA AT   -9.97 DEG (0.88 MVA) X/R:
0.18
VOLTAGE: 480.   EQUIV. IMPEDANCE= 0.2592 + J 0.0456
OHMS
LOW VOLTAGE POWER CIRCUIT BREAKER   1.053 KA
MOLDED CASE CIRCUIT BREAKER < 10KA   1.053 KA
MOLDED CASE CIRCUIT BREAKER < 20KA   1.053 KA
MOLDED CASE CIRCUIT BREAKER > 20KA   1.053 KA
PANEL-PB FDR   MCC-B   1.053 KA   ANG:
-9.97

PNL-PM   3P Duty: 15.777 KA AT -63.98 DEG (13.12 MVA) X/R:
2.38
VOLTAGE: 480.   EQUIV. IMPEDANCE= 0.0077 + J 0.0158
OHMS
LOW VOLTAGE POWER CIRCUIT BREAKER   15.777 KA
MOLDED CASE CIRCUIT BREAKER < 20KA 15.777 KA
MOLDED CASE CIRCUIT BREAKER > 20KA 15.777 KA
MCC-PM FDR   MCC-A   15.777 KA   ANG:
-63.98

PNL-PS   3P Duty: 12.479 KA AT -47.48 DEG (10.37 MVA) X/R:
1.51
VOLTAGE: 480.   EQUIV. IMPEDANCE= 0.0150 + J 0.0164
OHMS

THREE PHASE FAULT REPORT
(FOR APPLICATION OF LOW VOLTAGE BREAKERS)
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

```
==========================================================================
            LOW VOLTAGE POWER CIRCUIT BREAKER   12.479 KA
            MOLDED CASE CIRCUIT BREAKER < 20KA  12.479 KA
            MOLDED CASE CIRCUIT BREAKER > 20KA  12.479 KA
            CONTRIBUTIONS:  MISC. MOTORS-P     1.039 KA      ANG: -84.29
            MCC-PS FDR      MSBD-B            11.664 KA      ANG: -44.42

 SWBD SB-R1 3P Duty: 23.567 KA AT  -72.29 DEG (  19.59 MVA)  X/R: 3.30
            VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0036 + J  0.0112 OHMS
            LOW VOLTAGE POWER CIRCUIT BREAKER   23.567 KA
            MOLDED CASE CIRCUIT BREAKER > 20KA  23.567 KA
            AFD-R1 FDR      BUS-AFD R1         1.465 KA      ANG: 99.31
            AFD-2 FDR       BUS-AFD R2         1.465 KA      ANG: 99.31
            SWBD SB-R1 FDR  BUS-SWBD SB-R1    20.672 KA      ANG: -251.10

 SWBD-HDS   3P Duty: 10.529 KA AT  -62.06 DEG (   8.75 MVA)  X/R: 2.44
            VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0123 + J  0.0233 OHMS
            LOW VOLTAGE POWER CIRCUIT BREAKER   10.529 KA
            MOLDED CASE CIRCUIT BREAKER < 20KA  10.529 KA
            MOLDED CASE CIRCUIT BREAKER > 20KA  10.529 KA
            CONTRIBUTIONS:  MISC. MOTORS-H     0.206 KA      ANG: -84.29
                            CHILLER            0.709 KA      ANG: -84.29
            SWBD-HDS (E) F  MCC-A              9.688 KA      ANG: -60.01
```

```
                    U N B A L A N C E D   F A U L T   R E P O R T
                      (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                            PRE FAULT VOLTAGE: 1.0000
                            MODEL TRANSFORMER TAPS: NO

=========================================================================
=====
   LOCATION     FAULT      KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5
CYCLES
   VOLTAGE      DUTIES    (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG.
RMS *

=========================================================================
=====

 MCC LUVWMA1    3P Duty:  27.360    7. Z1=   4.3962        36.992
32.370
               SLG DUTY:  24.481    6. Z2=   4.3962        32.104
    480. VOLTS    LN/LN:  23.695       Z0=   5.9510
              LN/LN/GND: 26.474 ( 22.144 GND RETURN KA)

 MCC-A          3P Duty:  17.019    3. Z1=   7.0676        18.462
17.748
               SLG DUTY:  12.449    3. Z2=   7.0676        13.493
    480. VOLTS    LN/LN:  14.739       Z0=  14.8630
              LN/LN/GND: 15.313 (  9.810 GND RETURN KA)

 MCC-B          3P Duty:  22.953    4. Z1=   5.2403        26.628
24.826
               SLG DUTY:  16.860    3. Z2=   5.2403        18.895
    480. VOLTS    LN/LN:  19.878       Z0=  10.9223
              LN/LN/GND: 20.966 ( 13.323 GND RETURN KA)

 MCC-D          3P Duty:  12.846    2. Z1=   9.3635        13.193
13.020
               SLG DUTY:   9.787    1. Z2=   9.3635         9.904
    480. VOLTS    LN/LN:  11.125       Z0=  18.1476
              LN/LN/GND: 11.726 (  7.904 GND RETURN KA)

 MCC-E          3P Duty:  15.486    2. Z1=   7.7672        16.426
15.959
               SLG DUTY:  11.626    2. Z2=   7.7672        12.204
    480. VOLTS    LN/LN:  13.411       Z0=  15.5134
              LN/LN/GND: 14.017 (  9.303 GND RETURN KA)

 MCC-F          3P Duty:  15.097    2. Z1=   7.9671        15.785
15.443
               SLG DUTY:  11.480    2. Z2=   7.9671        11.977
```

```
    480. VOLTS    LN/LN:  13.075       Z0=  15.5134
              LN/LN/GND: 13.643 (  9.257 GND RETURN KA)

 MCC-G          3P Duty:  11.650    2. Z1=  10.3250        12.055
11.853
               SLG DUTY:   7.237    1. Z2=  10.3250         7.305
    480. VOLTS    LN/LN:  10.089       Z0=  29.3949
              LN/LN/GND: 10.791 (  5.231 GND RETURN KA)

 MCC-H          3P Duty:  10.388    2. Z1=  11.5794        10.659
10.523
               SLG DUTY:   7.555    2. Z2=  11.5794         7.739
    480. VOLTS    LN/LN:   8.996       Z0=  24.6730
              LN/LN/GND:  9.225 (  5.928 GND RETURN KA)
```

```
                  U N B A L A N C E D   F A U L T   R E P O R T
                    (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                          PRE FAULT VOLTAGE: 1.0000
                          MODEL TRANSFORMER TAPS: NO

=========================================================================
=====
   LOCATION     FAULT      KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5
CYCLES
   VOLTAGE      DUTIES    (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG.
RMS *

=========================================================================
=====

 MCC-R1         3P Duty:   8.023    2. Z1=  14.9920         8.235
8.129
               SLG DUTY:   5.904    2. Z2=  14.9920         6.127
    480. VOLTS    LN/LN:   6.948       Z0=  31.1947
             LN/LN/GND:  7.166 (  4.666 GND RETURN KA)

 MCC-T          3P Duty:  24.735    4. Z1=   4.8628        29.536
27.191
               SLG DUTY:  13.792    1. Z2=   4.8628        13.887
    480. VOLTS    LN/LN:  21.421       Z0=  17.3029
             LN/LN/GND: 23.868 (  9.281 GND RETURN KA)

 MSBD-A         3P Duty:  31.825    6. Z1=   3.7794        40.737
36.426
               SLG DUTY:  31.126    5. Z2=   3.7794        39.456
    480. VOLTS    LN/LN:  27.561       Z0=   4.0348
             LN/LN/GND: 31.684 ( 30.455 GND RETURN KA)

 MSBD-B         3P Duty:  41.890    6. Z1=   2.8713        54.409
48.366
               SLG DUTY:  40.921    5. Z2=   2.8713        52.155
    480. VOLTS    LN/LN:  36.278       Z0=   3.0770
             LN/LN/GND: 41.911 ( 39.989 GND RETURN KA)

 Main 21kV Swit 3P Duty:   3.517    8. Z1=   0.7818         4.815
4.193
               SLG DUTY:   0.000    1. Z2=   0.7818         0.000
  21000. VOLTS    LN/LN:   3.046       Z0= INFINITE
             LN/LN/GND:  3.046 (  0.000 GND RETURN KA)

 PANEL-PB       3P Duty:   1.053    0. Z1= 114.2297         1.053
1.053
               SLG DUTY:   0.618    0. Z2= 114.2297         0.618
```

```
    480. VOLTS    LN/LN:   0.912       Z0= 355.6950
             LN/LN/GND:  0.945 (  0.437 GND RETURN KA)

 PNL-PM         3P Duty:  15.777    2. Z1=   7.6239        16.862
16.324
              SLG DUTY:  11.516    2. Z2=   7.6239        12.352
    480. VOLTS    LN/LN:  13.663       Z0=  16.1046
             LN/LN/GND: 14.148 (  9.062 GND RETURN KA)

 PNL-PS         3P Duty:  12.479    2. Z1=   9.6388        12.673
12.576
              SLG DUTY:   9.645    1. Z2=   9.6388         9.734
    480. VOLTS    LN/LN:  10.807       Z0=  18.1476
             LN/LN/GND: 11.347 (  7.857 GND RETURN KA)
```

U N B A L A N C E D   F A U L T   R E P O R T
(FOR APPLICATION OF LOW VOLTAGE BREAKERS)
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

```
==================================================================================
   LOCATION     FAULT      KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
   VOLTAGE      DUTIES    (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
==================================================================================

 SWBD SB-R1     3P Duty:  23.567    3. Z1=   5.1038        26.853     25.238
               SLG DUTY:  20.421    2. Z2=   5.1038        21.956
    480. VOLTS    LN/LN:  20.410       Z0=   7.5489
              LN/LN/GND: 23.481 ( 17.929 GND RETURN KA)

 SWBD-HDS       3P Duty:  10.529    2. Z1=  11.4236        11.302     10.919
               SLG DUTY:   7.292    2. Z2=  11.4236         7.826
    480. VOLTS    LN/LN:   9.119       Z0=  26.6932
              LN/LN/GND:  9.318 (  5.572 GND RETURN KA)
```

F A U L T   S T U D Y   S U M M A R Y
(FOR APPLICATION OF LOW VOLTAGE BREAKERS)
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

BUS RECORD	VOLTAGE	A V A I L A B L E	F A U L T	D U T I E S (KA)	
NO NAME	L-L	3 PHASE	X/R	LINE/GRND	X/R
MCC LUVWMA1	480.	27.360	7.12	24.481	6.15
MCC-A	480.	17.019	2.59	12.449	2.58
MCC-B	480.	22.953	3.58	16.860	3.06
MCC-D	480.	12.846	1.75	9.787	1.42
MCC-E	480.	15.486	2.27	11.626	2.11
MCC-F	480.	15.097	2.05	11.480	2.01
MCC-G	480.	11.650	1.88	7.237	1.34
MCC-H	480.	10.388	1.73	7.555	1.70
MCC-R1	480.	8.023	1.74	5.904	1.93
MCC-T	480.	24.735	4.06	13.792	1.26
MSBD-A	480.	31.825	5.50	31.126	5.27
MSBD-B	480.	41.890	5.88	40.921	5.40
Main 21kV Swit	21000.	3.517	7.60	0.000	1.00
PANEL-PB	480.	1.053	0.18	0.618	0.15
PNL-PM	480.	15.777	2.38	11.516	2.43
PNL-PS	480.	12.479	1.51	9.645	1.34
SWBD SB-R1	480.	23.567	3.30	20.421	2.46
SWBD-HDS	480.	10.529	2.44	7.292	2.44

31 FAULTED BUSES, 53 BRANCHES, 23 CONTRIBUTIONS
UNBALANCED FAULTS REQUESTED

*** SHORT CIRCUIT STUDY COMPLETE ***

```
      T H R E E   P H A S E   M O M E N T A R Y   D U T Y   R E P O R T
                          PRE FAULT VOLTAGE: 1.0000
                          MODEL TRANSFORMER TAPS: NO

=========================================================================
=====

  MCC LUVWMA1    VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-A          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-B          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-D          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-E          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-F          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-G          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-H          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-R1         VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-T          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MSBD-A         VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MSBD-B         VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  Main 21kV Swit E/Z:      3.333 KA AT  -82.62 DEG ( 121.23 MVA)  X/R:
7.74
                 SYM*1.6:    5.333 KA       MOMENTARY BASED ON X/R:
4.580 KA
                 SYM*2.7:    8.999 KA           CREST BASED ON X/R:
7.855 KA
                 VOLTAGE:  21000.   EQUIV. IMPEDANCE=  0.4675 + J  3.6074
OHMS
                 21KV SWGR FDR   BUS-UTILITY        3.006 KA      ANG:
97.29
                 TC-5I FDR       TC-5I PRIMARY      0.129 KA      ANG:
96.98
                 (E) TC-3 FDR    BUS-TC3 PRI        0.052 KA      ANG:  -
260.11
                 TC-3 FDR        BUS-TC1-PRI        0.147 KA      ANG:  -
261.19
```

PANEL-PB	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
PNL-PM	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)

T H R E E   P H A S E   M O M E N T A R Y   D U T Y   R E P O R T
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

===
=====

PNL-PS   VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

SWBD SB-R1   VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

SWBD-HDS   VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

```
       U N B A L A N C E D   M O M E N T A R Y   D U T Y   R E P O R T
                          PRE FAULT VOLTAGE: 1.0000
                          MODEL TRANSFORMER TAPS: NO

=========================================================================
=====
   LOCATION     FAULT       E/Z    X/R  EQUIVALENT       MOMENTARY FAULT
DUTIES
   VOLTAGE      TYPE        KA          IMPEDANCE (PU)   E/Z * 1.6  @ 0.5
CYCLE

=========================================================================
=====

                 3P Duty:   3.33    7.7 Z1=   0.8248        5.33
4.58
 Main 21kV Swit SLG DUTY:   0.00    1.0 Z2=   0.8248        0.00
0.00
  21000.     VOLTS LN/LN:  2.887       Z0= INFINITE
               LN/LN/GND:   2.89 (    0.00 GND RETURN KA)
```

M O M E N T A R Y D U T Y S U M M A R Y R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO
SOLUTION METHOD : E/Z

BUS RECORD NO NAME	VOLTAGE L-L	* 3 PHASE * KA	X/R	* * * SLG * * * KA	X/R
Main 21kV Swit	21000.	4.580	7.74	0.000	1.00

6 FAULTED BUSES, 53 BRANCHES, 23 CONTRIBUTIONS
UNBALANCED FAULTS REQUESTED

*** SHORT CIRCUIT STUDY COMPLETE ***

T H R E E P H A S E I N T E R R U P U T I N G D U T Y R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

```
==========================================================================

  MCC LUVWMA1    VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-A          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-B          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-D          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-E          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-F          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-G          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-H          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-R1         VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-T          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MSBD-A         VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MSBD-B         VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  Main 21kV Swit E/Z:      3.155 KA AT  -82.73 DEG ( 114.76 MVA)  X/R: 7.85
                 VOLTAGE:  21000.   EQUIV. IMPEDANCE=  0.4861 + J  3.8121 OHMS
                 21KV SWGR FDR   BUS-UTILITY        3.006 KA      ANG:  -262.71
                 TC-5I FDR       TC-5I PRIMARY      0.061 KA      ANG:   96.32
                 (E) TC-3 FDR    BUS-TC3 PRI        0.023 KA      ANG:  -262.42
                 TC-3 FDR        BUS-TC1-PRI        0.064 KA      ANG:   97.08

                 GENERATOR NAME -- AT BUS --   KA    VOLTS PU   LOCAL/REMOTE
             UTIL-0001                       3.006     0.01         R
```

TOTAL REMOTE: 3.006 KA NACD RATIO: 0.9528

	SYM2	SYM3	SYM5	SYM8
MULT. FACT:	1.000	1.000	1.000	1.001
DUTY (KA) :	3.155	3.155	3.155	3.157

	TOT2	TOT3	TOT5	TOT8
MULT. FACT:	1.142	1.021	1.000	1.000
DUTY (KA) :	3.603	3.220	3.155	3.155

PANEL-PB VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

T H R E E P H A S E I N T E R R U P U T I N G D U T Y R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

==

PNL-PM	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
PNL-PS	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
SWBD SB-R1	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
SWBD-HDS	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)

```
    U N B A L A N C E D   I N T E R R U P T I N G   D U T Y   R E P O R T
                          PRE FAULT VOLTAGE: 1.0000
                          MODEL TRANSFORMER TAPS: NO
                          NACD OPTION:  INTERPOLATED

==========================================================================
=====
   LOCATION        FAULT    E/Z    X/R       ANSI AC/DC
INTERRUPTING
                   TYPE     KA               DECREMENT FACT.   DUTIES
(KA)
                                             3 PHASE    SLG    3 PHASE
SLG

==========================================================================
=====

  Main 21kV Swit 3P Duty:   3.15    7.8 SYM2:    1.00           3.15
   VOLTS: 21000.0    SLG:               SYM3:    1.00           3.15
    NACD:  0.953   LN/LN:   2.73        SYM5:    1.00           3.15
               LN/LN/GND:   2.73        SYM8:    1.00           3.16
              GND RETURN:               TOT2:    1.14           3.60
                  Z1(PU):       0.87142 TOT3:    1.02           3.22
                  Z2(PU):       0.87142 TOT5:    1.00           3.15
                  Z0(PU):               TOT8:    1.00           3.15
```

```
      I N T E R R U P T I N G   D U T Y   S U M M A R Y   R E P O R T
                          PRE FAULT VOLTAGE: 1.0000
                          MODEL TRANSFORMER TAPS: NO
                          NACD OPTION:  INTERPOLATED

=========================================================================
=====
   BUS RECORD      VOLTAGE  NACD     * 3  P H A S E *      * * * S L G *
* *
    NO NAME          L-L    RATIO    E/Z KA       X/R      E/Z KA
X/R

=========================================================================
=====

 Main 21kV Swit    21000. 0.953      3.155      7.85

    6 FAULTED BUSES,   53 BRANCHES,   23 CONTRIBUTIONS
 UNBALANCED FAULTS REQUESTED

 *** SHORT CIRCUIT STUDY COMPLETE ***
```

Sep 19, 2013 10:39:32

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SKM POWER*TOOLS FOR WINDOWS
DEMAND LOAD ANALYSIS REPORT

*** SOLUTION COMMENTS ***
========================

LOAD ANALYSIS INCLUDES ALL LOADS.

EXISTING LOAD SUMMARY

****

LOAD SCHEDULE FOR BUS-AFD R1   480. VOLTS LINE TO LINE
SOURCE OF PWR   SWBD SB-R1

ITEM DESCRIPTION	CONNECTED KVA	MAX PH AMPS	DEMAND KVA	MAX PH AMPS	DESIGN KVA	MAX PH AMPS	% P F
END USE LOADS							
LARGEST KVA MTR	233.1	280.4	233.1	280.4	291.4	350.5	80.00 LAG
BRANCH LOADS							
TOTALS	233.1	280.4	233.1	280.4	291.4	350.5	80.00 LAG

LOAD SCHEDULE FOR BUS-AFD R2   480. VOLTS LINE TO LINE
SOURCE OF PWR   SWBD SB-R1

ITEM DESCRIPTION	CONNECTED KVA	MAX PH AMPS	DEMAND KVA	MAX PH AMPS	DESIGN KVA	MAX PH AMPS	% P F
END USE LOADS							
LARGEST KVA MTR	233.1	280.4	233.1	280.4	291.4	350.5	80.00 LAG
BRANCH LOADS							

```
==========================================================================
==========
      TOTALS        233.1    280.4     233.1    280.4     291.4    350.5
80.00 LAG


 LOAD SCHEDULE FOR  BUS-SWBD SB-R1                      480. VOLTS LINE
TO LINE
 SOURCE OF PWR      BUS-TC3 SEC

==========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

==========================================================================
==========
 END USE LOADS
 BRANCH LOADS
  BUS-SWBD SB-R1    491.3    590.9     491.3    590.9     549.5    661.0
80.00 LAG

==========================================================================
==========
      TOTALS        491.3    590.9     491.3    590.9     549.5    661.0
80.00 LAG


 LOAD SCHEDULE FOR  BUS-SWBD SB-R1                      480. VOLTS LINE
TO LINE
 SOURCE OF PWR      BUS-SWBD SB-R1

==========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

==========================================================================
==========
 END USE LOADS
 BRANCH LOADS
  SWBD SB-R1        491.3    590.9     491.3    590.9     549.5    661.0
80.00 LAG

==========================================================================
==========
      TOTALS        491.3    590.9     491.3    590.9     549.5    661.0
80.00 LAG
```

LOAD SUMMARY

****

LOAD SCHEDULE FOR BUS-TC1-PRI 21000. VOLTS LINE TO LINE
SOURCE OF PWR Main 21kV Swit

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS	* DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							
BRANCH LOADS							
BUS-TC1 SEC	1332.6	36.6	1332.6	36.6	1480.7	40.7	80.00 LAG
BUS-TC2 PRI	2107.7	57.9	2055.2	56.5	2206.1	60.7	80.00 LAG
TOTALS	3440.3	94.6	3387.8	93.1	3627.1	99.7	80.00 LAG

LOAD SCHEDULE FOR BUS-TC1 SEC 480. VOLTS LINE TO LINE
SOURCE OF PWR BUS-TC1-PRI

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS	* DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							
BRANCH LOADS							

```
  MSBD-A           1332.6   1602.9    1332.6   1602.9    1480.7   1781.0
80.00 LAG

==========================================================================
==========
      TOTALS       1332.6   1602.9    1332.6   1602.9    1480.7   1781.0
80.00 LAG


 LOAD SCHEDULE FOR  BUS-TC2 PRI                      21000. VOLTS LINE
TO LINE
 SOURCE OF PWR      BUS-TC1-PRI

==========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

==========================================================================
==========
 END USE LOADS
 BRANCH LOADS
  BUS-TC2 SEC      2107.7     57.9    2055.2     56.5    2206.1     60.7
80.00 LAG

==========================================================================
==========
      TOTALS       2107.7     57.9    2055.2     56.5    2206.1     60.7
80.00 LAG


 LOAD SCHEDULE FOR  BUS-TC2 SEC                        480. VOLTS LINE
TO LINE
 SOURCE OF PWR      BUS-TC2 PRI

==========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

==========================================================================
==========
 END USE LOADS
 BRANCH LOADS
  MSBD-B           2107.7   2535.1    2055.2   2472.0    2206.1   2653.5
80.00 LAG

==========================================================================
==========
```

TOTALS	2107.7	2535.1	2055.2	2472.0	2206.1	2653.5

80.00 LAG

LOAD SUMMARY

****

LOAD SCHEDULE FOR BUS-TC3 PRI 21000. VOLTS LINE TO LINE
SOURCE OF PWR Main 21kV Swit

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS	* DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							
BRANCH LOADS							
BUS-TC3 SEC	491.3	13.5	491.3	13.5	549.5	15.1	80.00 LAG
TOTALS	491.3	13.5	491.3	13.5	549.5	15.1	80.00 LAG

LOAD SCHEDULE FOR BUS-TC3 SEC 480. VOLTS LINE TO LINE
SOURCE OF PWR BUS-TC3 PRI

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS	* DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							
BRANCH LOADS							
BUS-SWBD SB-R1	491.3	590.9	491.3	590.9	549.5	661.0	80.00 LAG

==
==========
     TOTALS   491.3   590.9   491.3   590.9   549.5   661.0
80.00 LAG

LOAD SCHEDULE FOR BUS-UTILITY   21000. VOLTS LINE
TO LINE
SOURCE OF PWR   SOURCE BUS

==
==========

ITEM DESCRIPTION *	CONNECTED KVA	MAX PH * AMPS	DEMAND KVA	MAX PH * AMPS	DESIGN KVA	MAX PH * AMPS	% P F
END USE LOADS							
BRANCH LOADS							
Main 21kV Swit	5292.9	145.5	5227.9	143.7	5515.9	151.6	80.00 LAG
TOTALS	5292.9	145.5	5227.9	143.7	5515.9	151.6	80.00 LAG

LOAD SCHEDULE FOR Main 21kV Swit   21000. VOLTS LINE
TO LINE
SOURCE OF PWR   BUS-UTILITY

==
==========

ITEM DESCRIPTION *	CONNECTED KVA	MAX PH * AMPS	DEMAND KVA	MAX PH * AMPS	DESIGN KVA	MAX PH * AMPS	% P F
END USE LOADS							
BRANCH LOADS							
BUS-TC3 PRI	491.3	13.5	491.3	13.5	549.5	15.1	80.00 LAG
BUS-TC1-PRI	3440.3	94.6	3387.8	93.1	3627.1	99.7	80.00 LAG
TC-5I PRIMARY	1361.3	37.4	1361.3	37.4	1470.6	40.4	80.00 LAG

==
==========
      TOTALS   5292.9   145.5   5227.9   143.7   5515.9   151.6
80.00 LAG

LOAD SUMMARY

****

LOAD SCHEDULE FOR MCC-A 480. VOLTS LINE TO LINE
SOURCE OF PWR MSBD-B

ITEM DESCRIPTION	CONNECTED KVA	MAX PH AMPS	DEMAND KVA	MAX PH AMPS	DESIGN KVA	MAX PH AMPS	% P F
END USE LOADS							
LARGEST KVA MTR	25.6	30.8	25.6	30.8	32.1	38.6	80.00 LAG
GENERAL LOADS	105.0	126.3	102.5	123.3	102.5	123.3	80.00 LAG
BRANCH LOADS							
MCC-H	145.0	174.4	145.0	174.4	181.2	218.0	80.00 LAG
PNL-PM	100.0	120.3	100.0	120.3	100.0	120.3	80.00 LAG
SWBD-HDS	204.4	245.9	204.4	245.9	248.2	298.6	80.00 LAG
TOTALS	580.1	697.7	527.6	634.5	583.9	702.3	80.00 LAG

LOAD SCHEDULE FOR MCC-B 480. VOLTS LINE TO LINE
SOURCE OF PWR MSBD-B

ITEM DESCRIPTION	CONNECTED KVA	MAX PH AMPS	DEMAND KVA	MAX PH AMPS	DESIGN KVA	MAX PH AMPS	% P F

```
==========================================================================
==========
 END USE LOADS
 LARGEST KVA MTR    238.8    287.2     238.8    287.2     298.4    359.0
80.00 LAG
 KVA TYPE MTR       347.2    417.6     347.2    417.6     347.2    417.6
80.00 LAG
 LIGHTING            60.0     72.2      60.0     72.2      75.0     90.2
80.00 LAG
 BRANCH LOADS
  PANEL-PB            0.0      0.0       0.0      0.0     WARNING: LOAD
IS ZERO

==========================================================================
==========
      TOTALS        645.9    776.9     645.9    776.9     720.6    866.7
80.00 LAG


 LOAD SCHEDULE FOR  MCC-D                               480. VOLTS LINE
TO LINE
 SOURCE OF PWR      MSBD-B

==========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

==========================================================================
==========
 END USE LOADS
 LARGEST KVA MTR    215.6    259.4     215.6    259.4     269.6    324.2
80.00 LAG
 LIGHTING            75.0     90.2      75.0     90.2      93.8    112.8
80.00 LAG
 BRANCH LOADS

==========================================================================
==========
      TOTALS        290.6    349.6     290.6    349.6     363.3    437.0
80.00 LAG
```

LOAD SUMMARY

****
*****

LOAD SCHEDULE FOR MCC-E 480. VOLTS LINE TO LINE
SOURCE OF PWR MSBD-B

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS	* DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							
LARGEST KVA MTR	204.0	245.4	204.0	245.4	255.0	306.7	80.00 LAG
LIGHTING	45.0	54.1	45.0	54.1	56.3	67.7	80.00 LAG
BRANCH LOADS							
TOTALS	249.0	299.5	249.0	299.5	311.2	374.4	80.00 LAG

LOAD SCHEDULE FOR MCC-F 480. VOLTS LINE TO LINE
SOURCE OF PWR MSBD-B

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS	* DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							
LARGEST KVA MTR	135.2	162.6	135.2	162.6	169.0	203.3	80.00 LAG

LIGHTING	30.0	36.1	30.0	36.1	37.5	45.1	80.00 LAG
BRANCH LOADS							
TOTALS	165.2	198.7	165.2	198.7	206.5	248.4	80.00 LAG

LOAD SCHEDULE FOR MCC-G 480. VOLTS LINE TO LINE
SOURCE OF PWR MCC-T

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS	* DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							
LARGEST KVA MTR	40.8	49.1	40.8	49.1	51.0	61.3	80.00 LAG
LIGHTING	250.0	300.7	250.0	300.7	312.5	375.9	80.00 LAG
BRANCH LOADS							
TOTALS	290.8	349.8	290.8	349.8	363.5	437.2	80.00 LAG

LOAD SCHEDULE FOR MCC-H 480. VOLTS LINE TO LINE
SOURCE OF PWR MCC-A

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS	* DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							
LARGEST KVA MTR	95.0	114.3	95.0	114.3	118.7	142.8	80.00 LAG
LIGHTING	50.0	60.1	50.0	60.1	62.5	75.2	80.00 LAG

BRANCH LOADS

===
==========

```
      TOTALS         145.0    174.4     145.0    174.4     181.2    218.0
80.00 LAG
```

LOAD SUMMARY

****

LOAD SCHEDULE FOR MCC LUVWMA1 480. VOLTS LINE TO LINE
SOURCE OF PWR TC-5I SECONDAR

ITEM DESCRIPTION	CONNECTED KVA	MAX PH AMPS	DEMAND KVA	MAX PH AMPS	DESIGN KVA	MAX PH AMPS	% P F
END USE LOADS							
LARGEST KVA MTR	437.1	525.8	437.1	525.8	546.4	657.2	80.00 LAG
KVA TYPE MTR	874.2	1051.5	874.2	1051.5	874.2	1051.5	80.00 LAG
ENERGY AUDIT KVA	50.0	60.1	50.0	60.1	50.0	60.1	80.00 LAG
BRANCH LOADS							
TOTALS	1361.3	1637.4	1361.3	1637.4	1470.6	1768.9	80.00 LAG

LOAD SCHEDULE FOR MCC-R1 480. VOLTS LINE TO LINE
SOURCE OF PWR SWBD SB-R1

ITEM DESCRIPTION	CONNECTED KVA	MAX PH AMPS	DEMAND KVA	MAX PH AMPS	DESIGN KVA	MAX PH AMPS	% P F
END USE LOADS							

```
 GENERAL LOADS       25.0     30.1      25.0     30.1      25.0     30.1
80.00 LAG
 BRANCH LOADS

==========================================================================
==========
      TOTALS         25.0     30.1      25.0     30.1      25.0     30.1
80.00 LAG


 LOAD SCHEDULE FOR  MCC-T                              480. VOLTS LINE
TO LINE
 SOURCE OF PWR      MSBD-A

==========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

==========================================================================
==========
 END USE LOADS
 KVA TYPE MTR       699.4    841.2     699.4    841.2     699.4    841.2
80.00 LAG
 LIGHTING           100.0    120.3     100.0    120.3     125.0    150.4
80.00 LAG
 LARGEST KVA MTR    242.4    291.6     242.4    291.6     303.1    364.5
80.00 LAG
 BRANCH LOADS
  MCC-G             290.8    349.8     290.8    349.8     363.5    437.2
80.00 LAG

==========================================================================
==========
      TOTALS       1332.6   1602.9    1332.6   1602.9    1480.7   1781.0
80.00 LAG


 LOAD SCHEDULE FOR  MSBD-A                             480. VOLTS LINE
TO LINE
 SOURCE OF PWR      BUS-TC1 SEC

==========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

==========================================================================
==========
 END USE LOADS
```

BRANCH LOADS

MCC-T	1332.6	1602.9	1332.6	1602.9	1480.7	1781.0	80.00 LAG
TOTALS	1332.6	1602.9	1332.6	1602.9	1480.7	1781.0	80.00 LAG

LOAD SUMMARY

****

LOAD SCHEDULE FOR MSBD-B   480. VOLTS LINE TO LINE
SOURCE OF PWR   BUS-TC2 SEC

ITEM DESCRIPTION	CONNECTED KVA	MAX PH AMPS	DEMAND KVA	MAX PH AMPS	DESIGN KVA	MAX PH AMPS	% P F
END USE LOADS							
BRANCH LOADS							
MCC-A	580.1	697.7	527.6	634.5	583.9	702.3	80.00 LAG
MCC-B	645.9	776.9	645.9	776.9	720.6	866.7	80.00 LAG
MCC-D	290.6	349.6	290.6	349.6	363.3	437.0	80.00 LAG
MCC-E	249.0	299.5	249.0	299.5	311.2	374.4	80.00 LAG
MCC-F	165.2	198.7	165.2	198.7	206.5	248.4	80.00 LAG
PNL-PS	176.9	212.7	176.9	212.7	221.1	265.9	80.00 LAG
TOTALS	2107.7	2535.1	2055.2	2472.0	2206.1	2653.5	80.00 LAG

LOAD SCHEDULE FOR PANEL-PB   480. VOLTS LINE TO LINE
SOURCE OF PWR   MCC-B

===

ITEM DESCRIPTION * CONNECTED MAX PH * DEMAND MAX PH * DESIGN MAX PH * %

```
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

==========================================================================
==========
 END USE LOADS
 BRANCH LOADS

==========================================================================
==========
 ***  WARNING  ***  DESIGN LOAD IS ZERO KVA


 LOAD SCHEDULE FOR  PNL-PM                                    480. VOLTS LINE
TO LINE
 SOURCE OF PWR      MCC-A

==========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

==========================================================================
==========
 END USE LOADS
 GENERAL LOADS      100.0    120.3     100.0    120.3     100.0    120.3
80.00 LAG
 BRANCH LOADS

==========================================================================
==========
      TOTALS        100.0    120.3     100.0    120.3     100.0    120.3
80.00 LAG


 LOAD SCHEDULE FOR  PNL-PS                                    480. VOLTS LINE
TO LINE
 SOURCE OF PWR      MSBD-B

==========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

==========================================================================
==========
 END USE LOADS
 LARGEST KVA MTR    146.9    176.7     146.9    176.7     183.6    220.8
80.00 LAG
```

LIGHTING	30.0	36.1	30.0	36.1	37.5	45.1
80.00 LAG						
BRANCH LOADS						

==
==========

TOTALS	176.9	212.7	176.9	212.7	221.1	265.9
80.00 LAG						

LOAD SUMMARY

****

LOAD SCHEDULE FOR SWBD-HDS 480. VOLTS LINE TO LINE
SOURCE OF PWR MCC-A

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS *	DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							
LIGHTING	75.0	90.2	75.0	90.2	93.8	112.8	80.00 LAG
LARGEST KVA MTR	100.3	120.6	100.3	120.6	125.3	150.8	80.00 LAG
KVA TYPE MTR	29.1	35.1	29.1	35.1	29.1	35.1	80.00 LAG
BRANCH LOADS							
TOTALS	204.4	245.9	204.4	245.9	248.2	298.6	80.00 LAG

LOAD SCHEDULE FOR SWBD SB-R1 480. VOLTS LINE TO LINE
SOURCE OF PWR BUS-SWBD SB-R1

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS *	DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							

```
 BRANCH LOADS
  BUS-AFD R1        233.1    280.4     233.1    280.4     291.4    350.5
80.00 LAG
  BUS-AFD R2        233.1    280.4     233.1    280.4     291.4    350.5
80.00 LAG
  MCC-R1             25.0     30.1      25.0     30.1      25.0     30.1
80.00 LAG

=========================================================================
==========
      TOTALS        491.3    590.9     491.3    590.9     549.5    661.0
80.00 LAG


 LOAD SCHEDULE FOR  TC-5I PRIMARY                    21000. VOLTS LINE
TO LINE
 SOURCE OF PWR      Main 21kV Swit

=========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

=========================================================================
==========
 END USE LOADS
 BRANCH LOADS
  TC-5I SECONDAR   1361.3     37.4    1361.3     37.4    1470.6     40.4
80.00 LAG

=========================================================================
==========
      TOTALS       1361.3     37.4    1361.3     37.4    1470.6     40.4
80.00 LAG


 LOAD SCHEDULE FOR  TC-5I SECONDAR                     480. VOLTS LINE
TO LINE
 SOURCE OF PWR      TC-5I PRIMARY

=========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

=========================================================================
==========
 END USE LOADS
 BRANCH LOADS
```

MCC LUVWMA1	1361.3	1637.4	1361.3	1637.4	1470.6	1768.9	80.00 LAG
TOTALS	1361.3	1637.4	1361.3	1637.4	1470.6	1768.9	80.00 LAG

LOAD SUMMARY

****
*****

TOTAL SOURCE LOAD SUMMARY

****

LOAD DESCRIPTION TYPE	UNITS	CONNECTED LOAD	DEMAND LOAD	DESIGN LOAD	POWER FACTOR %
ENERGY AUDIT KVA	KW	40.0	40.0	40.0	
	KVAR	30.0	30.0	30.0	
	KVA	50.0	50.0	50.0	80.00 LAGGING
LARGEST KVA MTR	KW	349.7	349.7	437.1	
	KVAR	262.3	262.3	327.8	
	KVA	437.1	437.1	546.4	80.00 LAGGING
KVA TYPE MTR	KW	3088.6	3088.6	3088.6	
	KVAR	2316.5	2316.5	2316.5	
	KVA	3860.8	3860.8	3860.8	80.00 LAGGING
GENERAL LOADS	KW	184.0	132.0	132.0	
	KVAR	138.0	99.0	99.0	
	KVA	230.0	165.0	165.0	80.00 LAGGING
LIGHTING	KW	572.0	572.0	715.0	
	KVAR	429.0	429.0	536.2	
	KVA	715.0	715.0	893.8	80.00 LAGGING
TOTAL LOADS	KW	4234.3	4182.3	4412.7	
	KVAR	3175.7	3136.7	3309.5	
	KVA	5292.9	5227.9	5515.9	
	% PF	80.0 LAGGING	80.0 LAGGING	80.0 LAGGING	

LOAD DEMAND TABLE

LOAD DESCRIPTION	LOAD TYPE	FIRST DEMAND KVA	%	SECOND DEMAND KVA	%	THIRD DEMAND KVA	%	DESIGN FACT
GEN	K	100	100	ALL	50	ALL	100	1.00
LTS	K	ALL	100	ALL	100	ALL	100	1.25
REC	Z	10	100	ALL	50	ALL	100	1.00
OFF EQ	K	ALL	100	ALL	100	ALL	100	1.00
HEAT	Z	ALL	100	ALL	100	ALL	100	1.25
CAP	Z	ALL	100	ALL	100	ALL	100	1.35
SPARE	K	ALL	100	ALL	100	ALL	100	1.00
GENERAL LOADS	K	100	100	ALL	50	ALL	100	1.00
LIGHTING	K	ALL	100	ALL	100	ALL	100	1.25
RECEPTACLES	Z	10	100	ALL	50	ALL	100	1.00
OFFICE EQUIPMENT	K	ALL	100	ALL	100	ALL	100	1.00
HEATING	Z	ALL	100	ALL	100	ALL	100	1.25
CAPACITORS	Z	ALL	100	ALL	100	ALL	100	1.35
SPACE	K	ALL	100	ALL	100	ALL	100	1.00
SPARE	K	ALL	100	ALL	100	ALL	100	1.00
SPARE	K	ALL	100	ALL	100	ALL	100	1.00
SPARE	K	ALL	100	ALL	100	ALL	100	1.00

SPARE	K	ALL 100	ALL 100	ALL 100
1.00				
SPARE	K	ALL 100	ALL 100	ALL 100
1.00				
SPARE	K	ALL 100	ALL 100	ALL 100
1.00				

NOTES:

1) LARGEST MOTOR CIRCUIT IDENTIFIED AND USED TO CALCULATE DESIGN LOAD BASED ON NEC ART 430.

2) MULTI-LEVEL DEMAND AND DESIGN FACTORS APPLIED AT EACH LOAD BUS.

3) LOAD TOTALS CALCULATED USING COMPLEX ADDITION BASED ON POWER FACTOR.

Sep 19, 2013   10:39:33

SKM POWER*TOOLS FOR WINDOWS
A_FAULT SHORT CIRCUIT ANALYSIS REPORT

```
                 T H R E E   P H A S E   F A U L T   R E P O R T
                    (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                          PRE FAULT VOLTAGE: 1.0000
                          MODEL TRANSFORMER TAPS: NO

==========================================================================
=====

  MCC LUVWMA1    3P Duty: 27.360 KA AT  -81.44 DEG (  22.75 MVA)  X/R:
7.12
                 VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0015 + J  0.0100
OHMS
                 LOW VOLTAGE POWER CIRCUIT BREAKER   27.741 KA
                 MOLDED CASE CIRCUIT BREAKER > 20KA  29.453 KA
                 CONTRIBUTIONS:  P-103I             3.093 KA      ANG:
-84.29
                                 P-102I             3.093 KA      ANG:
-84.29
                                 P-101I             3.093 KA      ANG:
-84.29
                 MCC LUVWMA FDR  TC-5I SECONDAR    18.099 KA      ANG:
-79.98

  MCC-A          3P Duty: 17.019 KA AT  -65.37 DEG (  14.15 MVA)  X/R:
2.59
                 VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0068 + J  0.0148
OHMS
                 LOW VOLTAGE POWER CIRCUIT BREAKER   17.019 KA
                 MOLDED CASE CIRCUIT BREAKER < 20KA  17.019 KA
                 MOLDED CASE CIRCUIT BREAKER > 20KA  17.019 KA
                 CONTRIBUTIONS:  MISC. MOTORS-A     0.181 KA      ANG:
-84.29
                 MCC-H FDR       MCC-H              0.660 KA      ANG:
97.05
                 SWBD-HDS (E) F  SWBD-HDS           0.886 KA      ANG:
96.80
                 MCC-A FDR       MSBD-B            15.384 KA      ANG:
-63.40

  MCC-B          3P Duty: 22.953 KA AT  -69.59 DEG (  19.08 MVA)  X/R:
3.58
                 VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0042 + J  0.0113
OHMS
                 LOW VOLTAGE POWER CIRCUIT BREAKER   22.953 KA
                 MOLDED CASE CIRCUIT BREAKER > 20KA  22.953 KA
                 CONTRIBUTIONS:  AER TNK BLR #1     1.681 KA      ANG:
-84.29
```

AER TNK BLR #2 1.681 KA ANG:
-84.29
MISC. MTRS 0.767 KA ANG:
-84.29
MCC-B FDR MSBD-B 18.988 KA ANG:
-66.42

MCC-D 3P Duty: 12.846 KA AT -48.88 DEG (10.68 MVA) X/R:
1.75
VOLTAGE: 480. EQUIV. IMPEDANCE= 0.0142 + J 0.0163
OHMS
LOW VOLTAGE POWER CIRCUIT BREAKER 12.846 KA
MOLDED CASE CIRCUIT BREAKER < 20KA 12.846 KA
MOLDED CASE CIRCUIT BREAKER > 20KA 12.846 KA
CONTRIBUTIONS: MISC. MOTORS-D 1.526 KA ANG:
-84.29
MCC-D FDR MSBD-B 11.636 KA ANG:
-44.53

MCC-E 3P Duty: 15.486 KA AT -60.33 DEG (12.87 MVA) X/R:
2.27
VOLTAGE: 480. EQUIV. IMPEDANCE= 0.0089 + J 0.0155
OHMS
LOW VOLTAGE POWER CIRCUIT BREAKER 15.486 KA
MOLDED CASE CIRCUIT BREAKER < 20KA 15.486 KA
MOLDED CASE CIRCUIT BREAKER > 20KA 15.486 KA
CONTRIBUTIONS: MISC. MOTORS-E 1.437 KA ANG:
-84.29
MCC-E FDR MSBD-B 14.185 KA ANG:
-57.97

```
                  T H R E E   P H A S E   F A U L T   R E P O R T
                     (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                           PRE FAULT VOLTAGE: 1.0000
                           MODEL TRANSFORMER TAPS: NO

============================================================================

  MCC-F           3P Duty: 15.097 KA AT  -59.51 DEG (  12.55 MVA)  X/R: 2.05
                  VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0093 + J  0.0158 OHMS
                  LOW VOLTAGE POWER CIRCUIT BREAKER   15.097 KA
                  MOLDED CASE CIRCUIT BREAKER < 20KA  15.097 KA
                  MOLDED CASE CIRCUIT BREAKER > 20KA  15.097 KA
                  CONTRIBUTIONS:  MISC. MOTORS-F     0.957 KA      ANG: -84.29
                  MCC-F FDR       MSBD-B            14.234 KA      ANG: -57.89

  MCC-G           3P Duty: 11.650 KA AT  -57.71 DEG (   9.69 MVA)  X/R: 1.88
                  VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0127 + J  0.0201 OHMS
                  LOW VOLTAGE POWER CIRCUIT BREAKER   11.650 KA
                  MOLDED CASE CIRCUIT BREAKER < 20KA  11.650 KA
                  MOLDED CASE CIRCUIT BREAKER > 20KA  11.650 KA
                  CONTRIBUTIONS:  MISC. MOTORS-G     0.289 KA      ANG: -84.29
                  MCC-G FDR       MCC-T             11.392 KA      ANG: -57.06

  MCC-H           3P Duty: 10.388 KA AT  -52.98 DEG (   8.64 MVA)  X/R: 1.73
                  VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0161 + J  0.0213 OHMS
                  LOW VOLTAGE POWER CIRCUIT BREAKER   10.388 KA
                  MOLDED CASE CIRCUIT BREAKER < 20KA  10.388 KA
                  MOLDED CASE CIRCUIT BREAKER > 20KA  10.388 KA
                  CONTRIBUTIONS:  MTR-MCC-H          0.672 KA      ANG: -84.29
                  MCC-H FDR       MCC-A              9.819 KA      ANG: -50.95

  MCC-R1          3P Duty:  8.023 KA AT  -59.79 DEG (   6.67 MVA)  X/R: 1.74
                  VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0174 + J  0.0299 OHMS
```

LOW VOLTAGE POWER CIRCUIT BREAKER 8.023 KA
MOLDED CASE CIRCUIT BREAKER < 10KA 8.027 KA
MOLDED CASE CIRCUIT BREAKER < 20KA 8.023 KA
MOLDED CASE CIRCUIT BREAKER > 20KA 8.023 KA
MCC-R1 FDR SWBD SB-R1 8.023 KA ANG:
-59.79

MCC-T 3P Duty: 24.735 KA AT -69.34 DEG (20.56 MVA) X/R:
4.06
VOLTAGE: 480. EQUIV. IMPEDANCE= 0.0040 + J 0.0105
OHMS
LOW VOLTAGE POWER CIRCUIT BREAKER 24.735 KA
MOLDED CASE CIRCUIT BREAKER > 20KA 24.735 KA
CONTRIBUTIONS: RW PMP #5 1.237 KA ANG:
-84.29
RW PMP #3 1.237 KA ANG:
-84.29
RW PMP #2 1.237 KA ANG:
-84.29
RW PMP #1 1.237 KA ANG:
-84.29
MISC. MOTORS-T 1.715 KA ANG:
-84.29
MCC-G FDR MCC-G 0.285 KA ANG:
96.19
MCC-T FDR BUS MSBD-A 18.109 KA ANG:
-63.67

```
               T H R E E   P H A S E   F A U L T   R E P O R T
                  (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                        PRE FAULT VOLTAGE: 1.0000
                        MODEL TRANSFORMER TAPS: NO

=============================================================================

  MSBD-A         3P Duty: 31.825 KA AT  -79.65 DEG (  26.46 MVA)  X/R: 5.50
                 VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0016 + J  0.0086 OHMS
                 LOW VOLTAGE POWER CIRCUIT BREAKER   31.825 KA
                 MOLDED CASE CIRCUIT BREAKER > 20KA  32.625 KA
                 MCC-T FDR BUS   MCC-T              6.357 KA      ANG:  -258.24
                 MSBD-A FDR      BUS-TC1 SEC       25.471 KA      ANG: -80.01

  MSBD-B         3P Duty: 41.890 KA AT  -80.29 DEG (  34.83 MVA)  X/R: 5.88
                 VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0011 + J  0.0065 OHMS
                 LOW VOLTAGE POWER CIRCUIT BREAKER   41.890 KA
                 MOLDED CASE CIRCUIT BREAKER > 20KA  43.522 KA
                 MCC-F FDR       MCC-F              0.922 KA      ANG: 97.27
                 MCC-D FDR       MCC-D              1.431 KA      ANG:  -259.92
                 MCC-E FDR       MCC-E              1.360 KA      ANG: 98.01
                 MCC-PS FDR      PNL-PS             0.995 KA      ANG: 98.75
                 MCC-B FDR       MCC-B              3.752 KA      ANG: 98.78
                 MSBD-B FDR      BUS-TC2 SEC       31.808 KA      ANG: -79.97
                 MCC-A FDR       MCC-A              1.624 KA      ANG: 98.71

  Main 21kV Swit 3P Duty:  3.517 KA AT  -82.42 DEG ( 127.92 MVA)  X/R: 7.60
                 VOLTAGE:  21000.   EQUIV. IMPEDANCE=  0.4548 + J  3.4174 OHMS
                 21KV SWGR FDR   BUS-UTILITY        3.006 KA      ANG: 97.29
                 TC-5I FDR       TC-5I PRIMARY      0.146 KA      ANG: 97.15
```

```
                  (E) TC-3 FDR    BUS-TC3 PRI        0.060 KA      ANG:  -
259.45
                  TC-3 FDR        BUS-TC1-PRI        0.305 KA      ANG:  -
259.92

  PANEL-PB        3P Duty:  1.053 KA AT   -9.97 DEG (   0.88 MVA)  X/R:
0.18
                  VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.2592 + J  0.0456
OHMS
                  LOW VOLTAGE POWER CIRCUIT BREAKER    1.053 KA
                  MOLDED CASE CIRCUIT BREAKER < 10KA   1.053 KA
                  MOLDED CASE CIRCUIT BREAKER < 20KA   1.053 KA
                  MOLDED CASE CIRCUIT BREAKER > 20KA   1.053 KA
                  PANEL-PB FDR    MCC-B              1.053 KA      ANG:
-9.97

  PNL-PM          3P Duty: 15.777 KA AT  -63.98 DEG (  13.12 MVA)  X/R:
2.38
                  VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0077 + J  0.0158
OHMS
                  LOW VOLTAGE POWER CIRCUIT BREAKER   15.777 KA
                  MOLDED CASE CIRCUIT BREAKER < 20KA  15.777 KA
                  MOLDED CASE CIRCUIT BREAKER > 20KA  15.777 KA
                  MCC-PM FDR      MCC-A             15.777 KA      ANG:
-63.98

  PNL-PS          3P Duty: 12.479 KA AT  -47.48 DEG (  10.37 MVA)  X/R:
1.51
                  VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0150 + J  0.0164
OHMS
```

```
                 T H R E E   P H A S E   F A U L T   R E P O R T
                    (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                          PRE FAULT VOLTAGE: 1.0000
                          MODEL TRANSFORMER TAPS: NO

==========================================================================
=====
                 LOW VOLTAGE POWER CIRCUIT BREAKER   12.479 KA
                 MOLDED CASE CIRCUIT BREAKER < 20KA  12.479 KA
                 MOLDED CASE CIRCUIT BREAKER > 20KA  12.479 KA
                 CONTRIBUTIONS:  MISC. MOTORS-P     1.039 KA      ANG:
-84.29
                 MCC-PS FDR      MSBD-B            11.664 KA      ANG:
-44.42

  SWBD SB-R1     3P Duty: 23.567 KA AT  -72.29 DEG (  19.59 MVA)  X/R:
3.30
                 VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0036 + J  0.0112
OHMS
                 LOW VOLTAGE POWER CIRCUIT BREAKER   23.567 KA
                 MOLDED CASE CIRCUIT BREAKER > 20KA  23.567 KA
                 AFD-R1 FDR      BUS-AFD R1         1.465 KA      ANG:
99.31
                 AFD-2 FDR       BUS-AFD R2         1.465 KA      ANG:
99.31
                 SWBD SB-R1 FDR  BUS-SWBD SB-R1    20.672 KA      ANG:  -
251.10

  SWBD-HDS       3P Duty: 10.529 KA AT  -62.06 DEG (   8.75 MVA)  X/R:
2.44
                 VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0123 + J  0.0233
OHMS
                 LOW VOLTAGE POWER CIRCUIT BREAKER   10.529 KA
                 MOLDED CASE CIRCUIT BREAKER < 20KA  10.529 KA
                 MOLDED CASE CIRCUIT BREAKER > 20KA  10.529 KA
                 CONTRIBUTIONS:  MISC. MOTORS-H     0.206 KA      ANG:
-84.29
                                 CHILLER            0.709 KA      ANG:
-84.29
                 SWBD-HDS (E) F  MCC-A              9.688 KA      ANG:
-60.01
```

```
                  U N B A L A N C E D   F A U L T   R E P O R T
                    (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                          PRE FAULT VOLTAGE: 1.0000
                          MODEL TRANSFORMER TAPS: NO

=========================================================================
=====
   LOCATION     FAULT      KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5
CYCLES
   VOLTAGE      DUTIES    (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG.
RMS *

=========================================================================
=====

 MCC LUVWMA1    3P Duty:  27.360    7. Z1=   4.3962        36.992
32.370
               SLG DUTY:  24.481    6. Z2=   4.3962        32.104
    480. VOLTS    LN/LN:  23.695       Z0=   5.9510
              LN/LN/GND: 26.474 ( 22.144 GND RETURN KA)

 MCC-A          3P Duty:  17.019    3. Z1=   7.0676        18.462
17.748
               SLG DUTY:  12.449    3. Z2=   7.0676        13.493
    480. VOLTS    LN/LN:  14.739       Z0=  14.8630
              LN/LN/GND: 15.313 (  9.810 GND RETURN KA)

 MCC-B          3P Duty:  22.953    4. Z1=   5.2403        26.628
24.826
               SLG DUTY:  16.860    3. Z2=   5.2403        18.895
    480. VOLTS    LN/LN:  19.878       Z0=  10.9223
              LN/LN/GND: 20.966 ( 13.323 GND RETURN KA)

 MCC-D          3P Duty:  12.846    2. Z1=   9.3635        13.193
13.020
               SLG DUTY:   9.787    1. Z2=   9.3635         9.904
    480. VOLTS    LN/LN:  11.125       Z0=  18.1476
              LN/LN/GND: 11.726 (  7.904 GND RETURN KA)

 MCC-E          3P Duty:  15.486    2. Z1=   7.7672        16.426
15.959
               SLG DUTY:  11.626    2. Z2=   7.7672        12.204
    480. VOLTS    LN/LN:  13.411       Z0=  15.5134
              LN/LN/GND: 14.017 (  9.303 GND RETURN KA)

 MCC-F          3P Duty:  15.097    2. Z1=   7.9671        15.785
15.443
               SLG DUTY:  11.480    2. Z2=   7.9671        11.977
```

```
    480. VOLTS    LN/LN:  13.075       Z0=  15.5134
              LN/LN/GND: 13.643 (  9.257 GND RETURN KA)

 MCC-G          3P Duty:  11.650    2. Z1=  10.3250        12.055
11.853
               SLG DUTY:   7.237    1. Z2=  10.3250         7.305
    480. VOLTS    LN/LN:  10.089       Z0=  29.3949
              LN/LN/GND: 10.791 (  5.231 GND RETURN KA)

 MCC-H          3P Duty:  10.388    2. Z1=  11.5794        10.659
10.523
               SLG DUTY:   7.555    2. Z2=  11.5794         7.739
    480. VOLTS    LN/LN:   8.996       Z0=  24.6730
              LN/LN/GND:  9.225 (  5.928 GND RETURN KA)
```

```
                  U N B A L A N C E D   F A U L T   R E P O R T
                    (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
                          PRE FAULT VOLTAGE: 1.0000
                          MODEL TRANSFORMER TAPS: NO

==========================================================================
=====
   LOCATION     FAULT      KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5
CYCLES
   VOLTAGE      DUTIES    (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG.
RMS *

==========================================================================
=====

 MCC-R1         3P Duty:   8.023    2. Z1=  14.9920         8.235
8.129
               SLG DUTY:   5.904    2. Z2=  14.9920         6.127
    480. VOLTS    LN/LN:   6.948       Z0=  31.1947
             LN/LN/GND:  7.166 (  4.666 GND RETURN KA)

 MCC-T          3P Duty:  24.735    4. Z1=   4.8628        29.536
27.191
               SLG DUTY:  13.792    1. Z2=   4.8628        13.887
    480. VOLTS    LN/LN:  21.421       Z0=  17.3029
             LN/LN/GND: 23.868 (  9.281 GND RETURN KA)

 MSBD-A         3P Duty:  31.825    6. Z1=   3.7794        40.737
36.426
               SLG DUTY:  31.126    5. Z2=   3.7794        39.456
    480. VOLTS    LN/LN:  27.561       Z0=   4.0348
             LN/LN/GND: 31.684 ( 30.455 GND RETURN KA)

 MSBD-B         3P Duty:  41.890    6. Z1=   2.8713        54.409
48.366
               SLG DUTY:  40.921    5. Z2=   2.8713        52.155
    480. VOLTS    LN/LN:  36.278       Z0=   3.0770
             LN/LN/GND: 41.911 ( 39.989 GND RETURN KA)

 Main 21kV Swit 3P Duty:   3.517    8. Z1=   0.7818         4.815
4.193
               SLG DUTY:   0.000    1. Z2=   0.7818         0.000
  21000. VOLTS    LN/LN:   3.046       Z0= INFINITE
             LN/LN/GND:  3.046 (  0.000 GND RETURN KA)

 PANEL-PB       3P Duty:   1.053    0. Z1= 114.2297         1.053
1.053
               SLG DUTY:   0.618    0. Z2= 114.2297         0.618
```

```
    480. VOLTS    LN/LN:   0.912       Z0= 355.6950
             LN/LN/GND:  0.945 (  0.437 GND RETURN KA)

 PNL-PM         3P Duty:  15.777    2. Z1=   7.6239        16.862
16.324
              SLG DUTY:  11.516    2. Z2=   7.6239        12.352
    480. VOLTS    LN/LN:  13.663       Z0=  16.1046
             LN/LN/GND: 14.148 (  9.062 GND RETURN KA)

 PNL-PS         3P Duty:  12.479    2. Z1=   9.6388        12.673
12.576
              SLG DUTY:   9.645    1. Z2=   9.6388         9.734
    480. VOLTS    LN/LN:  10.807       Z0=  18.1476
             LN/LN/GND: 11.347 (  7.857 GND RETURN KA)
```

U N B A L A N C E D F A U L T R E P O R T
(FOR APPLICATION OF LOW VOLTAGE BREAKERS)
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

```
===============================================================================
   LOCATION     FAULT      KA     X/R  EQUIVALENT (PU)  ASYM. KA AT 0.5 CYCLES
   VOLTAGE      DUTIES    (RMS)        FAULT IMPEDANCE  * MAX. RMS  AVG. RMS *
===============================================================================

 SWBD SB-R1     3P Duty:  23.567    3. Z1=   5.1038        26.853     25.238
               SLG DUTY:  20.421    2. Z2=   5.1038        21.956
    480. VOLTS    LN/LN:  20.410       Z0=   7.5489
              LN/LN/GND: 23.481 ( 17.929 GND RETURN KA)

 SWBD-HDS       3P Duty:  10.529    2. Z1=  11.4236        11.302     10.919
               SLG DUTY:   7.292    2. Z2=  11.4236         7.826
    480. VOLTS    LN/LN:   9.119       Z0=  26.6932
              LN/LN/GND:  9.318 (  5.572 GND RETURN KA)
```

F A U L T   S T U D Y   S U M M A R Y
(FOR APPLICATION OF LOW VOLTAGE BREAKERS)
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

BUS RECORD NO NAME	VOLTAGE L-L	AVAILABLE FAULT DUTIES (KA) 3 PHASE	X/R	LINE/GRND	X/R
MCC LUVWMA1	480.	27.360	7.12	24.481	6.15
MCC-A	480.	17.019	2.59	12.449	2.58
MCC-B	480.	22.953	3.58	16.860	3.06
MCC-D	480.	12.846	1.75	9.787	1.42
MCC-E	480.	15.486	2.27	11.626	2.11
MCC-F	480.	15.097	2.05	11.480	2.01
MCC-G	480.	11.650	1.88	7.237	1.34
MCC-H	480.	10.388	1.73	7.555	1.70
MCC-R1	480.	8.023	1.74	5.904	1.93
MCC-T	480.	24.735	4.06	13.792	1.26
MSBD-A	480.	31.825	5.50	31.126	5.27
MSBD-B	480.	41.890	5.88	40.921	5.40
Main 21kV Swit	21000.	3.517	7.60	0.000	1.00
PANEL-PB	480.	1.053	0.18	0.618	0.15
PNL-PM	480.	15.777	2.38	11.516	2.43
PNL-PS	480.	12.479	1.51	9.645	1.34
SWBD SB-R1	480.	23.567	3.30	20.421	2.46
SWBD-HDS	480.	10.529	2.44	7.292	2.44

31 FAULTED BUSES, 53 BRANCHES, 23 CONTRIBUTIONS
UNBALANCED FAULTS REQUESTED

*** SHORT CIRCUIT STUDY COMPLETE ***

T H R E E   P H A S E   M O M E N T A R Y   D U T Y   R E P O R T
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

===

```
  MCC LUVWMA1    VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-A          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-B          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-D          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-E          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-F          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-G          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-H          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-R1         VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MCC-T          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MSBD-A         VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  MSBD-B         VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

  Main 21kV Swit E/Z:      3.333 KA AT  -82.62 DEG ( 121.23 MVA)  X/R:
7.74
                 SYM*1.6:    5.333 KA       MOMENTARY BASED ON X/R:
4.580 KA
                 SYM*2.7:    8.999 KA           CREST BASED ON X/R:
7.855 KA
                 VOLTAGE:  21000.   EQUIV. IMPEDANCE=  0.4675 + J  3.6074
OHMS
                 21KV SWGR FDR   BUS-UTILITY        3.006 KA      ANG:
97.29
                 TC-5I FDR       TC-5I PRIMARY      0.129 KA      ANG:
96.98
                 (E) TC-3 FDR    BUS-TC3 PRI        0.052 KA      ANG:  -
260.11
                 TC-3 FDR        BUS-TC1-PRI        0.147 KA      ANG:  -
261.19
```

```
PANEL-PB        VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )

PNL-PM          VOLTAGE:    480.  ( SEE LOW VOLTAGE REPORT )
```

T H R E E   P H A S E   M O M E N T A R Y   D U T Y   R E P O R T
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

===

PNL-PS	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
SWBD SB-R1	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
SWBD-HDS	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)

```
       U N B A L A N C E D   M O M E N T A R Y   D U T Y   R E P O R T
                          PRE FAULT VOLTAGE: 1.0000
                          MODEL TRANSFORMER TAPS: NO

=========================================================================
=====
   LOCATION     FAULT       E/Z    X/R  EQUIVALENT       MOMENTARY FAULT
DUTIES
   VOLTAGE      TYPE        KA          IMPEDANCE (PU)   E/Z * 1.6  @ 0.5
CYCLE

=========================================================================
=====

                 3P Duty:   3.33    7.7 Z1=   0.8248        5.33
4.58
 Main 21kV Swit SLG DUTY:   0.00    1.0 Z2=   0.8248        0.00
0.00
  21000.     VOLTS LN/LN:  2.887       Z0= INFINITE
               LN/LN/GND:   2.89 (    0.00 GND RETURN KA)
```

M O M E N T A R Y   D U T Y   S U M M A R Y   R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO
SOLUTION METHOD   : E/Z

BUS RECORD NO NAME	VOLTAGE L-L	* 3 P H A S E * KA	X/R	* * * SLG * * * KA	X/R
Main 21kV Swit	21000.	4.580	7.74	0.000	1.00

6 FAULTED BUSES,   53 BRANCHES,   23 CONTRIBUTIONS
UNBALANCED FAULTS REQUESTED

*** SHORT CIRCUIT STUDY COMPLETE ***

T H R E E   P H A S E   I N T E R R U P U T I N G   D U T Y   R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

==

MCC LUVWMA1 VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

MCC-A VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

MCC-B VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

MCC-D VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

MCC-E VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

MCC-F VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

MCC-G VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

MCC-H VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

MCC-R1 VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

MCC-T VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

MSBD-A VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

MSBD-B VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

Main 21kV Swit E/Z: 3.155 KA AT -82.73 DEG (114.76 MVA) X/R: 7.85
VOLTAGE: 21000. EQUIV. IMPEDANCE= 0.4861 + J 3.8121 OHMS

21KV SWGR FDR	BUS-UTILITY	3.006 KA	ANG: -262.71
TC-5I FDR	TC-5I PRIMARY	0.061 KA	ANG: 96.32
(E) TC-3 FDR	BUS-TC3 PRI	0.023 KA	ANG: -262.42
TC-3 FDR	BUS-TC1-PRI	0.064 KA	ANG: 97.08

GENERATOR NAME -- AT BUS --	KA	VOLTS PU	LOCAL/REMOTE
UTIL-0001	3.006	0.01	R

TOTAL REMOTE: 3.006 KA NACD RATIO: 0.9528

	SYM2	SYM3	SYM5	SYM8
MULT. FACT:	1.000	1.000	1.000	1.001
DUTY (KA) :	3.155	3.155	3.155	3.157

	TOT2	TOT3	TOT5	TOT8
MULT. FACT:	1.142	1.021	1.000	1.000
DUTY (KA) :	3.603	3.220	3.155	3.155

PANEL-PB VOLTAGE: 480. (SEE LOW VOLTAGE REPORT)

T H R E E P H A S E I N T E R R U P U T I N G D U T Y R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

===

PNL-PM	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
PNL-PS	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
SWBD SB-R1	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)
SWBD-HDS	VOLTAGE:	480.	(SEE LOW VOLTAGE REPORT)

U N B A L A N C E D   I N T E R R U P T I N G   D U T Y   R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO
NACD OPTION: INTERPOLATED

```
================================================================================
=====
   LOCATION        FAULT    E/Z    X/R       ANSI AC/DC                INTERRUPTING
                   TYPE     KA               DECREMENT FACT.    DUTIES (KA)
                                             3 PHASE    SLG    3 PHASE    SLG
================================================================================
=====

  Main 21kV Swit 3P Duty:   3.15    7.8 SYM2:    1.00           3.15
   VOLTS: 21000.0    SLG:               SYM3:    1.00           3.15
    NACD:  0.953   LN/LN:   2.73        SYM5:    1.00           3.15
               LN/LN/GND:   2.73        SYM8:    1.00           3.16
              GND RETURN:               TOT2:    1.14           3.60
                  Z1(PU):       0.87142 TOT3:    1.02           3.22
                  Z2(PU):       0.87142 TOT5:    1.00           3.15
                  Z0(PU):               TOT8:    1.00           3.15
```

I N T E R R U P T I N G D U T Y S U M M A R Y R E P O R T

PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO
NACD OPTION: INTERPOLATED

BUS RECORD NO NAME	VOLTAGE L-L	NACD RATIO	* 3 P H A S E * E/Z KA	X/R	* * * S L G * * * E/Z KA	X/R
Main 21kV Swit	21000.	0.953	3.155	7.85		

6 FAULTED BUSES, 53 BRANCHES, 23 CONTRIBUTIONS
UNBALANCED FAULTS REQUESTED

*** SHORT CIRCUIT STUDY COMPLETE ***

Sep 19, 2013 10:39:32

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SKM POWER*TOOLS FOR WINDOWS
DEMAND LOAD ANALYSIS REPORT

*** SOLUTION COMMENTS ***
=========================

LOAD ANALYSIS INCLUDES ALL LOADS.

EXISTING LOAD SUMMARY

****

LOAD SCHEDULE FOR BUS-AFD R1 480. VOLTS LINE TO LINE
SOURCE OF PWR SWBD SB-R1

ITEM DESCRIPTION	CONNECTED KVA	MAX PH AMPS	DEMAND KVA	MAX PH AMPS	DESIGN KVA	MAX PH AMPS	% P F
END USE LOADS							
LARGEST KVA MTR	233.1	280.4	233.1	280.4	291.4	350.5	80.00 LAG
BRANCH LOADS							
TOTALS	233.1	280.4	233.1	280.4	291.4	350.5	80.00 LAG

LOAD SCHEDULE FOR BUS-AFD R2 480. VOLTS LINE TO LINE
SOURCE OF PWR SWBD SB-R1

ITEM DESCRIPTION	CONNECTED KVA	MAX PH AMPS	DEMAND KVA	MAX PH AMPS	DESIGN KVA	MAX PH AMPS	% P F
END USE LOADS							
LARGEST KVA MTR	233.1	280.4	233.1	280.4	291.4	350.5	80.00 LAG
BRANCH LOADS							

==
==========
      TOTALS   233.1   280.4   233.1   280.4   291.4   350.5
80.00 LAG

 LOAD SCHEDULE FOR BUS-SWBD SB-R1   480. VOLTS LINE
TO LINE
 SOURCE OF PWR   BUS-TC3 SEC

==
==========
 ITEM DESCRIPTION * CONNECTED MAX PH * DEMAND MAX PH * DESIGN MAX PH
* %
                      KVA   AMPS   KVA   AMPS   KVA   AMPS
P F

==
==========
 END USE LOADS
 BRANCH LOADS
  BUS-SWBD SB-R1   491.3   590.9   491.3   590.9   549.5   661.0
80.00 LAG

==
==========
      TOTALS   491.3   590.9   491.3   590.9   549.5   661.0
80.00 LAG

 LOAD SCHEDULE FOR BUS-SWBD SB-R1   480. VOLTS LINE
TO LINE
 SOURCE OF PWR   BUS-SWBD SB-R1

==
==========
 ITEM DESCRIPTION * CONNECTED MAX PH * DEMAND MAX PH * DESIGN MAX PH
* %
                      KVA   AMPS   KVA   AMPS   KVA   AMPS
P F

==
==========
 END USE LOADS
 BRANCH LOADS
  SWBD SB-R1   491.3   590.9   491.3   590.9   549.5   661.0
80.00 LAG

==
==========
      TOTALS   491.3   590.9   491.3   590.9   549.5   661.0
80.00 LAG

LOAD SUMMARY

LOAD SCHEDULE FOR BUS-TC1-PRI 21000. VOLTS LINE TO LINE
SOURCE OF PWR Main 21kV Swit

ITEM DESCRIPTION	CONNECTED KVA	MAX PH AMPS	DEMAND KVA	MAX PH AMPS	DESIGN KVA	MAX PH AMPS	% P F
END USE LOADS							
BRANCH LOADS							
BUS-TC1 SEC	1332.6	36.6	1332.6	36.6	1480.7	40.7	80.00 LAG
BUS-TC2 PRI	2107.7	57.9	2055.2	56.5	2206.1	60.7	80.00 LAG
TOTALS	3440.3	94.6	3387.8	93.1	3627.1	99.7	80.00 LAG

LOAD SCHEDULE FOR BUS-TC1 SEC 480. VOLTS LINE TO LINE
SOURCE OF PWR BUS-TC1-PRI

ITEM DESCRIPTION	CONNECTED KVA	MAX PH AMPS	DEMAND KVA	MAX PH AMPS	DESIGN KVA	MAX PH AMPS	% P F
END USE LOADS							
BRANCH LOADS							

MSBD-A 1332.6 1602.9 1332.6 1602.9 1480.7 1781.0
80.00 LAG

==
==========
TOTALS 1332.6 1602.9 1332.6 1602.9 1480.7 1781.0
80.00 LAG

LOAD SCHEDULE FOR BUS-TC2 PRI 21000. VOLTS LINE
TO LINE
SOURCE OF PWR BUS-TC1-PRI

==
==========

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH * AMPS	DEMAND KVA	MAX PH * AMPS	DESIGN KVA	MAX PH * AMPS	% P F
END USE LOADS							
BRANCH LOADS							
BUS-TC2 SEC	2107.7	57.9	2055.2	56.5	2206.1	60.7	80.00 LAG
TOTALS	2107.7	57.9	2055.2	56.5	2206.1	60.7	80.00 LAG

LOAD SCHEDULE FOR BUS-TC2 SEC 480. VOLTS LINE
TO LINE
SOURCE OF PWR BUS-TC2 PRI

==
==========

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH * AMPS	DEMAND KVA	MAX PH * AMPS	DESIGN KVA	MAX PH * AMPS	% P F
END USE LOADS							
BRANCH LOADS							
MSBD-B	2107.7	2535.1	2055.2	2472.0	2206.1	2653.5	80.00 LAG

==
==========

TOTALS	2107.7	2535.1	2055.2	2472.0	2206.1	2653.5

80.00 LAG

LOAD SUMMARY

****

LOAD SCHEDULE FOR BUS-TC3 PRI 21000. VOLTS LINE TO LINE
SOURCE OF PWR Main 21kV Swit

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS	* DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							
BRANCH LOADS							
BUS-TC3 SEC	491.3	13.5	491.3	13.5	549.5	15.1	80.00 LAG
TOTALS	491.3	13.5	491.3	13.5	549.5	15.1	80.00 LAG

LOAD SCHEDULE FOR BUS-TC3 SEC 480. VOLTS LINE TO LINE
SOURCE OF PWR BUS-TC3 PRI

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS	* DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							
BRANCH LOADS							
BUS-SWBD SB-R1	491.3	590.9	491.3	590.9	549.5	661.0	80.00 LAG

```
==========================================================================
==========
      TOTALS        491.3    590.9     491.3    590.9     549.5    661.0
80.00 LAG


 LOAD SCHEDULE FOR  BUS-UTILITY                       21000. VOLTS LINE
TO LINE
 SOURCE OF PWR      SOURCE BUS

==========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

==========================================================================
==========
 END USE LOADS
 BRANCH LOADS
  Main 21kV Swit   5292.9    145.5    5227.9    143.7    5515.9    151.6
80.00 LAG

==========================================================================
==========
      TOTALS       5292.9    145.5    5227.9    143.7    5515.9    151.6
80.00 LAG


 LOAD SCHEDULE FOR  Main 21kV Swit                    21000. VOLTS LINE
TO LINE
 SOURCE OF PWR      BUS-UTILITY

==========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

==========================================================================
==========
 END USE LOADS
 BRANCH LOADS
  BUS-TC3 PRI       491.3     13.5     491.3     13.5     549.5     15.1
80.00 LAG
  BUS-TC1-PRI      3440.3     94.6    3387.8     93.1    3627.1     99.7
80.00 LAG
  TC-5I PRIMARY    1361.3     37.4    1361.3     37.4    1470.6     40.4
80.00 LAG
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==
==========

TOTALS	5292.9	145.5	5227.9	143.7	5515.9	151.6

80.00 LAG

LOAD SUMMARY

****

LOAD SCHEDULE FOR MCC-A 480. VOLTS LINE TO LINE
SOURCE OF PWR MSBD-B

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS	* DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							
LARGEST KVA MTR	25.6	30.8	25.6	30.8	32.1	38.6	80.00 LAG
GENERAL LOADS	105.0	126.3	102.5	123.3	102.5	123.3	80.00 LAG
BRANCH LOADS							
MCC-H	145.0	174.4	145.0	174.4	181.2	218.0	80.00 LAG
PNL-PM	100.0	120.3	100.0	120.3	100.0	120.3	80.00 LAG
SWBD-HDS	204.4	245.9	204.4	245.9	248.2	298.6	80.00 LAG
TOTALS	580.1	697.7	527.6	634.5	583.9	702.3	80.00 LAG

LOAD SCHEDULE FOR MCC-B 480. VOLTS LINE TO LINE
SOURCE OF PWR MSBD-B

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS	* DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F

```
==========================================================================
==========
 END USE LOADS
 LARGEST KVA MTR    238.8    287.2     238.8    287.2     298.4    359.0
80.00 LAG
 KVA TYPE MTR       347.2    417.6     347.2    417.6     347.2    417.6
80.00 LAG
 LIGHTING            60.0     72.2      60.0     72.2      75.0     90.2
80.00 LAG
 BRANCH LOADS
  PANEL-PB            0.0      0.0       0.0      0.0     WARNING: LOAD
IS ZERO

==========================================================================
==========
      TOTALS        645.9    776.9     645.9    776.9     720.6    866.7
80.00 LAG


 LOAD SCHEDULE FOR  MCC-D                               480. VOLTS LINE
TO LINE
 SOURCE OF PWR      MSBD-B

==========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

==========================================================================
==========
 END USE LOADS
 LARGEST KVA MTR    215.6    259.4     215.6    259.4     269.6    324.2
80.00 LAG
 LIGHTING            75.0     90.2      75.0     90.2      93.8    112.8
80.00 LAG
 BRANCH LOADS

==========================================================================
==========
      TOTALS        290.6    349.6     290.6    349.6     363.3    437.0
80.00 LAG
```

LOAD SUMMARY

****

LOAD SCHEDULE FOR MCC-E 480. VOLTS LINE TO LINE
SOURCE OF PWR MSBD-B

ITEM DESCRIPTION	CONNECTED KVA	MAX PH AMPS	DEMAND KVA	MAX PH AMPS	DESIGN KVA	MAX PH AMPS	% P F
END USE LOADS							
LARGEST KVA MTR	204.0	245.4	204.0	245.4	255.0	306.7	80.00 LAG
LIGHTING	45.0	54.1	45.0	54.1	56.3	67.7	80.00 LAG
BRANCH LOADS							
TOTALS	249.0	299.5	249.0	299.5	311.2	374.4	80.00 LAG

LOAD SCHEDULE FOR MCC-F 480. VOLTS LINE TO LINE
SOURCE OF PWR MSBD-B

ITEM DESCRIPTION	CONNECTED KVA	MAX PH AMPS	DEMAND KVA	MAX PH AMPS	DESIGN KVA	MAX PH AMPS	% P F
END USE LOADS							
LARGEST KVA MTR	135.2	162.6	135.2	162.6	169.0	203.3	80.00 LAG

LIGHTING	30.0	36.1	30.0	36.1	37.5	45.1	80.00 LAG
BRANCH LOADS							
TOTALS	165.2	198.7	165.2	198.7	206.5	248.4	80.00 LAG

LOAD SCHEDULE FOR MCC-G 480. VOLTS LINE TO LINE
SOURCE OF PWR MCC-T

ITEM DESCRIPTION *	CONNECTED KVA	MAX PH * AMPS	DEMAND KVA	MAX PH * AMPS	DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							
LARGEST KVA MTR	40.8	49.1	40.8	49.1	51.0	61.3	80.00 LAG
LIGHTING	250.0	300.7	250.0	300.7	312.5	375.9	80.00 LAG
BRANCH LOADS							
TOTALS	290.8	349.8	290.8	349.8	363.5	437.2	80.00 LAG

LOAD SCHEDULE FOR MCC-H 480. VOLTS LINE TO LINE
SOURCE OF PWR MCC-A

ITEM DESCRIPTION *	CONNECTED KVA	MAX PH * AMPS	DEMAND KVA	MAX PH * AMPS	DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							
LARGEST KVA MTR	95.0	114.3	95.0	114.3	118.7	142.8	80.00 LAG
LIGHTING	50.0	60.1	50.0	60.1	62.5	75.2	80.00 LAG

BRANCH LOADS

```
==============================================================================
==========
      TOTALS         145.0    174.4     145.0    174.4     181.2    218.0
80.00 LAG
```

LOAD SUMMARY

****

LOAD SCHEDULE FOR MCC LUVWMA1 480. VOLTS LINE TO LINE
SOURCE OF PWR TC-5I SECONDAR

ITEM DESCRIPTION	CONNECTED KVA	MAX PH AMPS	DEMAND KVA	MAX PH AMPS	DESIGN KVA	MAX PH AMPS	% P F
END USE LOADS							
LARGEST KVA MTR	437.1	525.8	437.1	525.8	546.4	657.2	80.00 LAG
KVA TYPE MTR	874.2	1051.5	874.2	1051.5	874.2	1051.5	80.00 LAG
ENERGY AUDIT KVA	50.0	60.1	50.0	60.1	50.0	60.1	80.00 LAG
BRANCH LOADS							
TOTALS	1361.3	1637.4	1361.3	1637.4	1470.6	1768.9	80.00 LAG

LOAD SCHEDULE FOR MCC-R1 480. VOLTS LINE TO LINE
SOURCE OF PWR SWBD SB-R1

ITEM DESCRIPTION	CONNECTED KVA	MAX PH AMPS	DEMAND KVA	MAX PH AMPS	DESIGN KVA	MAX PH AMPS	% P F
END USE LOADS							

```
 GENERAL LOADS       25.0     30.1      25.0     30.1      25.0     30.1
80.00 LAG
 BRANCH LOADS

========================================================================
==========
      TOTALS         25.0     30.1      25.0     30.1      25.0     30.1
80.00 LAG


 LOAD SCHEDULE FOR  MCC-T                              480. VOLTS LINE
TO LINE
 SOURCE OF PWR      MSBD-A

========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

========================================================================
==========
 END USE LOADS
 KVA TYPE MTR       699.4    841.2     699.4    841.2     699.4    841.2
80.00 LAG
 LIGHTING           100.0    120.3     100.0    120.3     125.0    150.4
80.00 LAG
 LARGEST KVA MTR    242.4    291.6     242.4    291.6     303.1    364.5
80.00 LAG
 BRANCH LOADS
  MCC-G             290.8    349.8     290.8    349.8     363.5    437.2
80.00 LAG

========================================================================
==========
      TOTALS       1332.6   1602.9    1332.6   1602.9    1480.7   1781.0
80.00 LAG


 LOAD SCHEDULE FOR  MSBD-A                             480. VOLTS LINE
TO LINE
 SOURCE OF PWR      BUS-TC1 SEC

========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

========================================================================
==========
 END USE LOADS
```

BRANCH LOADS

MCC-T	1332.6	1602.9	1332.6	1602.9	1480.7	1781.0
80.00 LAG						

==
==========

TOTALS	1332.6	1602.9	1332.6	1602.9	1480.7	1781.0
80.00 LAG						

LOAD SUMMARY

****

LOAD SCHEDULE FOR MSBD-B 480. VOLTS LINE TO LINE
SOURCE OF PWR BUS-TC2 SEC

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS	* DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							
BRANCH LOADS							
MCC-A	580.1	697.7	527.6	634.5	583.9	702.3	80.00 LAG
MCC-B	645.9	776.9	645.9	776.9	720.6	866.7	80.00 LAG
MCC-D	290.6	349.6	290.6	349.6	363.3	437.0	80.00 LAG
MCC-E	249.0	299.5	249.0	299.5	311.2	374.4	80.00 LAG
MCC-F	165.2	198.7	165.2	198.7	206.5	248.4	80.00 LAG
PNL-PS	176.9	212.7	176.9	212.7	221.1	265.9	80.00 LAG
TOTALS	2107.7	2535.1	2055.2	2472.0	2206.1	2653.5	80.00 LAG

LOAD SCHEDULE FOR PANEL-PB 480. VOLTS LINE TO LINE
SOURCE OF PWR MCC-B

===

ITEM DESCRIPTION * CONNECTED MAX PH * DEMAND MAX PH * DESIGN MAX PH * %

```
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

=========================================================================
==========
 END USE LOADS
 BRANCH LOADS

=========================================================================
==========
 ***  WARNING  ***  DESIGN LOAD IS ZERO KVA


 LOAD SCHEDULE FOR  PNL-PM                                   480. VOLTS LINE
TO LINE
 SOURCE OF PWR      MCC-A

=========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

=========================================================================
==========
 END USE LOADS
 GENERAL LOADS      100.0    120.3     100.0    120.3     100.0    120.3
80.00 LAG
 BRANCH LOADS

=========================================================================
==========
      TOTALS        100.0    120.3     100.0    120.3     100.0    120.3
80.00 LAG


 LOAD SCHEDULE FOR  PNL-PS                                   480. VOLTS LINE
TO LINE
 SOURCE OF PWR      MSBD-B

=========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

=========================================================================
==========
 END USE LOADS
 LARGEST KVA MTR    146.9    176.7     146.9    176.7     183.6    220.8
80.00 LAG
```

```
 LIGHTING              30.0     36.1      30.0     36.1      37.5     45.1
80.00 LAG
 BRANCH LOADS

=========================================================================
==========
      TOTALS          176.9    212.7     176.9    212.7     221.1    265.9
80.00 LAG
```

LOAD SUMMARY

****

LOAD SCHEDULE FOR SWBD-HDS 480. VOLTS LINE TO LINE
SOURCE OF PWR MCC-A

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS	* DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							
LIGHTING	75.0	90.2	75.0	90.2	93.8	112.8	80.00 LAG
LARGEST KVA MTR	100.3	120.6	100.3	120.6	125.3	150.8	80.00 LAG
KVA TYPE MTR	29.1	35.1	29.1	35.1	29.1	35.1	80.00 LAG
BRANCH LOADS							
TOTALS	204.4	245.9	204.4	245.9	248.2	298.6	80.00 LAG

LOAD SCHEDULE FOR SWBD SB-R1 480. VOLTS LINE TO LINE
SOURCE OF PWR BUS-SWBD SB-R1

ITEM DESCRIPTION	* CONNECTED KVA	MAX PH AMPS	* DEMAND KVA	MAX PH AMPS	* DESIGN KVA	MAX PH AMPS	* % P F
END USE LOADS							

```
 BRANCH LOADS
  BUS-AFD R1        233.1    280.4     233.1    280.4     291.4    350.5
80.00 LAG
  BUS-AFD R2        233.1    280.4     233.1    280.4     291.4    350.5
80.00 LAG
  MCC-R1             25.0     30.1      25.0     30.1      25.0     30.1
80.00 LAG

=========================================================================
==========
      TOTALS        491.3    590.9     491.3    590.9     549.5    661.0
80.00 LAG


 LOAD SCHEDULE FOR  TC-5I PRIMARY                     21000. VOLTS LINE
TO LINE
 SOURCE OF PWR      Main 21kV Swit

=========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

=========================================================================
==========
 END USE LOADS
 BRANCH LOADS
  TC-5I SECONDAR   1361.3     37.4    1361.3     37.4    1470.6     40.4
80.00 LAG

=========================================================================
==========
      TOTALS       1361.3     37.4    1361.3     37.4    1470.6     40.4
80.00 LAG


 LOAD SCHEDULE FOR  TC-5I SECONDAR                      480. VOLTS LINE
TO LINE
 SOURCE OF PWR      TC-5I PRIMARY

=========================================================================
==========
 ITEM DESCRIPTION * CONNECTED MAX PH *  DEMAND  MAX PH  *  DESIGN  MAX PH
* %
                      KVA      AMPS      KVA     AMPS       KVA     AMPS
P F

=========================================================================
==========
 END USE LOADS
 BRANCH LOADS
```

MCC LUVWMA1	1361.3	1637.4	1361.3	1637.4	1470.6	1768.9	80.00 LAG
TOTALS	1361.3	1637.4	1361.3	1637.4	1470.6	1768.9	80.00 LAG

LOAD SUMMARY

****
*****

TOTAL SOURCE LOAD SUMMARY

****

LOAD DESCRIPTION TYPE	UNITS	CONNECTED LOAD	DEMAND LOAD	DESIGN LOAD	POWER FACTOR %
ENERGY AUDIT KVA	KW	40.0	40.0	40.0	
	KVAR	30.0	30.0	30.0	
	KVA	50.0	50.0	50.0	80.00 LAGGING
LARGEST KVA MTR	KW	349.7	349.7	437.1	
	KVAR	262.3	262.3	327.8	
	KVA	437.1	437.1	546.4	80.00 LAGGING
KVA TYPE MTR	KW	3088.6	3088.6	3088.6	
	KVAR	2316.5	2316.5	2316.5	
	KVA	3860.8	3860.8	3860.8	80.00 LAGGING
GENERAL LOADS	KW	184.0	132.0	132.0	
	KVAR	138.0	99.0	99.0	
	KVA	230.0	165.0	165.0	80.00 LAGGING
LIGHTING	KW	572.0	572.0	715.0	
	KVAR	429.0	429.0	536.2	
	KVA	715.0	715.0	893.8	80.00 LAGGING
TOTAL LOADS	KW	4234.3	4182.3	4412.7	
	KVAR	3175.7	3136.7	3309.5	
	KVA	5292.9	5227.9	5515.9	
	% PF	80.0 LAGGING	80.0 LAGGING	80.0 LAGGING	

LOAD DEMAND TABLE

LOAD DESCRIPTION	LOAD TYPE	FIRST DEMAND KVA	FIRST DEMAND %	SECOND DEMAND KVA	SECOND DEMAND %	THIRD DEMAND KVA	THIRD DEMAND %	DESIGN FACT
GEN	K	100	100	ALL	50	ALL	100	1.00
LTS	K	ALL	100	ALL	100	ALL	100	1.25
REC	Z	10	100	ALL	50	ALL	100	1.00
OFF EQ	K	ALL	100	ALL	100	ALL	100	1.00
HEAT	Z	ALL	100	ALL	100	ALL	100	1.25
CAP	Z	ALL	100	ALL	100	ALL	100	1.35
SPARE	K	ALL	100	ALL	100	ALL	100	1.00
GENERAL LOADS	K	100	100	ALL	50	ALL	100	1.00
LIGHTING	K	ALL	100	ALL	100	ALL	100	1.25
RECEPTACLES	Z	10	100	ALL	50	ALL	100	1.00
OFFICE EQUIPMENT	K	ALL	100	ALL	100	ALL	100	1.00
HEATING	Z	ALL	100	ALL	100	ALL	100	1.25
CAPACITORS	Z	ALL	100	ALL	100	ALL	100	1.35
SPACE	K	ALL	100	ALL	100	ALL	100	1.00
SPARE	K	ALL	100	ALL	100	ALL	100	1.00
SPARE	K	ALL	100	ALL	100	ALL	100	1.00
SPARE	K	ALL	100	ALL	100	ALL	100	1.00

SPARE	K	ALL 100	ALL 100	ALL 100
1.00				
SPARE	K	ALL 100	ALL 100	ALL 100
1.00				
SPARE	K	ALL 100	ALL 100	ALL 100
1.00				

NOTES:

1) LARGEST MOTOR CIRCUIT IDENTIFIED AND USED TO CALCULATE DESIGN LOAD BASED ON NEC ART 430.

2) MULTI-LEVEL DEMAND AND DESIGN FACTORS APPLIED AT EACH LOAD BUS.

3) LOAD TOTALS CALCULATED USING COMPLEX ADDITION BASED ON POWER FACTOR.

Technical Memorandum

APPENDIX B – PLANNING LEVEL CONSTRUCTION COST ESTIMATES

Engineers...Working Wonders With Water™

PROJECT :	CITY OF LIVERMORE MASTER PLAN TECHNICAL MEMORANDUM PLANNING LEVEL CONSTRUCTION COST ESTIMATE	**DATE :**	9/16/2013
JOB # :	8145D.00	**BY :**	JED
ELEMENT :	Phase I Improvements		

	DESCRIPTION	QTY.	UNIT	UNIT PRICE	INSTALL ADJ.	TOTAL
Project #20						
	Unit Substation Liquid Filled, Fan Cooled Transformers	2	EA	$75,000	1.05	$157,500
	Double-Ended, Drawout, NEMA 3R, Walkin Switchgear	1	EA	$850,000	1.05	$892,500
	25kV Cables	800	FT	$25	1.05	$21,000
	600V Cables	60,000	FT	$15	1.05	$945,000
	Electrical Demolition (transformers, switchgear, cables,…etc.)	2	EA	$40,000	1.05	$84,000
	Ductbank	750	FT	$600	1.05	$472,500
	Misc. (Lighting, Grounding, Pull Boxes, Exposed Conduits, …etc.)	1	EA	$200,000	1.05	$210,000
	SUBTOTAL 1					$2,783,000
	Civil/Sitework Allowance (% of Subtotal 1)	1	%			$28,000
	Instrumentation Allowance (% of Subtotal 1)	0	%			$0
	SUBTOTAL 2					$2,811,000
	Estimating Contingency	30	%			$843,000
	SUBTOTAL 3					$3,654,000
	Sales Tax (Applied to 50% of % Subtotal 3)	8.75	%			$160,000
	Contractor General Conditions and Overhead (% of Subtotal 3)	20	%			$731,000
ELEMENT :	**Phase I Improvements**				**PLANNING LEVEL CONSTRUCTION COST =**	$4,545,000

Engineers...Working Wonders With Water™

PROJECT : CITY OF LIVERMORE
MASTER PLAN
TECHNICAL MEMORANDUM
PLANNING LEVEL CONSTRUCTION COST ESTIMATE

DATE : 9/16/2013

JOB # : 8145D.00

BY : JED

ELEMENT : Phase II Improvements

	DESCRIPTION	QTY.	UNIT	UNIT PRICE	INSTALL ADJ.	TOTAL
Project #21						
	MCC-A Sections	10	EA	$5,000	1.00	$50,000
	MCC-C Sections	16	EA	$5,000	1.00	$80,000
	MCC-D Sections	7	EA	$5,000	1.00	$35,000
	MCC-E Sections	9	EA	$5,000	1.00	$45,000
	600V Cables	100,000	FT	$15	1.00	$1,500,000
	Conduits	30,000	FT	$15	1.00	$450,000
	Demolition of Existing Cables and Conduits	10,000	FT	$8	1.00	$80,000
	SUBTOTAL 1					$2,240,000
	Civil/Sitework Allowance (% of Subtotal 1)	10	%			$224,000
	Instrumentation Allowance (% of Subtotal 1)	5	%			$112,000
	SUBTOTAL 2					$2,576,000
	Estimating Contingency	30	%			$773,000
	SUBTOTAL 3					$3,349,000
	Sales Tax (Applied to 50% of % Subtotal 3)	8.75	%			$146,500
	Contractor General Conditions and Overhead (% of Subtotal 3)	20	%			$670,000
ELEMENT : Phase II Improvements					**PLANNING LEVEL CONSTRUCTION COST =**	$4,165,500

Engineers...Working Wonders With Water™

PROJECT : CITY OF LIVERMORE
MASTER PLAN
TECHNICAL MEMORANDUM
PLANNING LEVEL CONSTRUCTION COST ESTIMATE

DATE : 9/16/2013

JOB # : 8145D.00

BY : JED

ELEMENT : Phase III-2012 MP Projects&Phase IV-Solids Exp. Project

	DESCRIPTION	QTY.	UNIT	UNIT PRICE	INSTALL ADJ.	TOTAL
	Phase III - 2012 Master Plan Update Projects					
Project #1	Aeration Equipment Replacement	1	EA	$10,000	1.00	$10,000
Project #2	Standby Power	1	EA	$750,000	1.00	$750,000
Project #3	Finer Mechanical Screening Equipment	1	EA	$5,000	1.00	$5,000
Project #4	Process Control Improvements	1	EA	$50,000	1.00	$50,000
Project #5	UV System Replacement	1	EA	$20,000	1.00	$20,000
Project #6	Primary Clarifier Gate Actuation & Redundant Grit Classifier	1	EA	$50,000	1.00	$50,000
Project #7	Additional Odor Control	1	EA	$50,000	1.00	$50,000
Project #8	Grit System Improvements	1	EA	$20,000	1.00	$20,000
Project #9	Dewatering Improvement	1	EA	$75,000	1.00	$75,000
Project #10	P-Recovery	1	EA	$25,000	1.00	$25,000
Project #11	Cogeneration	1	EA	$50,000	1.00	$50,000
Project #12	Gravity Thickener	1	EA	$10,000	1.00	$10,000
Project #13	BNR Upgrades	1	EA	$250,000	1.00	$250,000
Project #14	Arc Flash Study	1	EA	$50,000	1.00	$50,000
Project #15	Miscellaneous Structural Improvements	1	EA	$0	1.00	$0
Project #16	Add New Raw Sewage Screw Pump	1	EA	$10,000	1.00	$10,000
Project #17	Secondary Clarifier #2 Mechanism	1	EA	$15,000	1.00	$15,000
Project #18	Upsize Basin Returen Pumps	1	EA	$100,000	1.00	$100,000
Project #19	Miscellaneous Improvements	1	EA	$0	1.00	$0
Project #20	Electrical Distribution System Upgrades (Phase I Estimate)	-	-	-	-	-
Project #21	MCC Replacement (Phase II Estimate)	-	-	-	-	-
	Phase IV - Solids Expansion Project					
	Addition of new MCC-K and loads	1	EA	$50,000	1.00	$50,000
	SUBTOTAL 1					$1,590,000
	Civil/Sitework Allowance (% of Subtotal 1)	15	%			$239,000
	Instrumentation Allowance (% of Subtotal 1)	20	%			$318,000
	SUBTOTAL 2					$2,147,000
	Estimating Contingency	30	%			$644,000
	SUBTOTAL 3					$2,791,000
	Sales Tax (Applied to 50% of % Subtotal 3)	8.75	%			$122,000
	Contractor General Conditions and Overhead (% of Subtotal 3)	20	%			$558,000
ELEMENT :	**Phase III-2012 MP Projects&Phase IV-Solids Exp. Project**	**PLANNING LEVEL CONSTRUCTION COST =**				$3,471,000

LIVERMORE
CALIFORNIA

APPENDIX E – Preliminary Project Costs

TETRA TECH

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APPENDIX E –
Preliminary Project Costs

Project 1 - Aeration Equipment Replacement
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
Membrane Diffuser Study	1	20,000	LS	20,000
Aeration Basin 1 Diffusers and Piping	2,000	100	EA	200,000
Aeration Basin 2 Diffusers and Piping - Basin 2	2,000	100	EA	200,000
Pipe Supports	1	15,000	LS	15,000
Concrete Wall for Anaerobic Selector -Basin 1	1	65,000	LS	65,000
Electrical and Instrumentation	1	13,500	LS	13,500
Demolition	1	10,000	LS	10,000
Mobilization and Demobilization	1	15,000	LS	15,000
Subtotal				$538,500
Insurance and Bonds @ 2%				$10,800
Contractor's Overhead and Profit @ 10%				$53,900
Subtotal Construction Cost				$603,200
Engineering, Legal, Administrative @ 20%				$120,600
Subtotal				$723,800
Contingency @ 30%				$217,100
Total Capital Cost				$940,900

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 2 - Electrical Upgrades and Standby Power
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
Standby Generator	1	1,000,000	LS	1,000,000
Electrical Switchgear and transfer switches	1	1,012,500	LS	1,012,500
Miscellaneous Concrete Pads	1	25,000	EA	25,000

Subtotal	$2,037,500
Insurance and Bonds @ 2%	$40,800
Contractor's Overhead and Profit @ 10%	$203,800
Subtotal Construction Cost	$2,282,100
Engineering, Legal, Administrative @ 20%	$456,400
Subtotal	$2,738,500
Contingency @ 30%	$821,600
Total Capital Cost	$3,560,100

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 3 - Finer Mechanical Screening Equipment
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
Mechanical Fine Bar Screen	1	270,000	LS	270,000
Concrete Channel Modifications	1	250,000	LS	250,000
Relocate Existing Screen	1	100,000	LS	100,000
Instrumentation and Controls	1	25,000	LS	25,000
Electrical	1	5,700	LS	5,700
Painting and Coatings	1	6,500	LS	6,500
Mobilization and Demobilization	1	20,000	LS	20,000

Subtotal	$677,200
Insurance and Bonds @ 2%	$13,500
Contractor's Overhead and Profit @ 10%	$67,700
Subtotal Construction Cost	$758,400
Engineering, Legal, Administrative @ 20%	$151,700
Subtotal	$910,100
Contingency @ 30%	$273,000
Total Capital Cost	$1,183,100

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 4 - Process Control Improvements
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
Floating mixers (4 per aeration basin)	8	15,000	EA	120,000
Instrumentation DO probes, valves, flowmeters	1	75,000	LS	75,000
Programming and Controls	1	35,000	LS	35,000
Gates and Actuators	1	100,000	LS	100,000
Electrical	1	67,500	LS	67,500
Mobilization and Demobilization	1	10,000	LS	10,000

Subtotal	$407,500
Insurance and Bonds @ 2%	$8,200
Contractor's Overhead and Profit @ 10%	$40,800
Subtotal Construction Cost	$456,500
Engineering, Legal, Administrative @ 20%	$91,300
Subtotal	$547,800
Contingency @ 30%	$164,300
Total Capital Cost	$712,100

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 5 - UV System Replacement
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
UV Equipment	1	2,000,000	LS	2,000,000
Channel Modifications	1	40,000	LS	40,000
Instrumentation and Controls	1	50,000	LS	50,000
Electrical	1	23,000	LS	23,000
Mobilization and Demobilization	1	10,000	LS	10,000

Subtotal	$2,123,000
Insurance and Bonds @ 2%	$42,500
Contractor's Overhead and Profit @ 10%	$212,300
Subtotal Construction Cost	$2,377,800
Engineering, Legal, Administrative @ 20%	$475,600
Subtotal	$2,853,400
Contingency @ 30%	$856,000
Total Capital Cost	$3,709,400

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 6 - Primary Clarifier Gate Actuation and Redundant Grit Classifier
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
Slide Gate Actuators	8	15,000	EA	120,000
Grit Classifier	1	120,000	EA	120,000
Miscellaneous Structural Concrete and Steel	1	40,000	LS	40,000
Electrical	1	57,500	LS	57,500
Instrumentation and Controls	1	30,000	LS	30,000
Painting and Coatings	1	5,000	LS	5,000
Mobilization and Demobilization	1	10,000	LS	10,000

Subtotal	$382,500
Insurance and Bonds @ 2%	$7,700
Contractor's Overhead and Profit @ 10%	$38,300
Subtotal Construction Cost	$428,500
Engineering, Legal, Administrative @ 20%	$85,700
Subtotal	$514,200
Contingency @ 30%	$154,300
Total Capital Cost	$668,500

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 7 - Additional Odor Control
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
Solids Handling Building Biotower fans	2	50,000	LS	100,000
Biotower	1	300,000	LF	300,000
Ducting	1	50,000	LF	50,000
Modification to headworks scrubber - ducting and fan	1	50,000	LS	50,000
Ferric Chloride Chemical Addition for Equalization Basi	1	110,000	LS	110,000
Miscellaneous Structural Concrete and Steel	1	30,000	LS	30,000
Electrical	1	57,500	LS	57,500
Instrumentation and Controls	1	50,000	LS	50,000
Painting and Coatings	1	10,000	LS	10,000
Mobilization and Demobilization	1	25,000	LS	25,000

Subtotal	$782,500
Insurance and Bonds @ 2%	$15,700
Contractor's Overhead and Profit @ 10%	$78,300
Subtotal Construction Cost	$876,500
Engineering, Legal, Administrative @ 20%	$175,300
Subtotal	$1,051,800
Contingency @ 30%	$315,500
Total Capital Cost	$1,367,300

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 8 - Grit System Improvements
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
Vortex or Headcell Grit Removal Equipment	1	400,000	LS	400,000
Miscellaneous Piping and Valves	1	15,000	LS	15,000
Demolition	1	25,000	LS	25,000
Structural Modifications to Channels	1	150,000	LS	150,000
Electrical	1	25,000	LS	25,000
Instrumentation and Controls	1	20,000	LS	20,000
Painting and Coatings	1	10,000	LS	10,000
Mobilization and Demobilization	1	15,000	LS	15,000

Subtotal	$660,000
Insurance and Bonds @ 2%	$13,200
Contractor's Overhead and Profit @ 10%	$66,000
Subtotal Construction Cost	$739,200
Engineering, Legal, Administrative @ 20%	$147,800
Subtotal	$887,000
Contingency @ 30%	$266,100
Total Capital Cost	$1,153,100

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 9 - Dewatering Improvements
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
Polymer Optimization Study	1	25,000	LS	25,000
Dewatering Technology Study	1	50,000	EA	50,000
Centrifuges	2	650,000	EA	1,300,000
New Conveyors	2	75,000	LS	150,000
Belt Press Building Modifications	1	100,000	LS	100,000
Electrical Upgrades	1	250,000	LS	250,000
Polymer System	2	50,000	LS	100,000
Demolition	1	20,000	LS	20,000
Instrumentation SCADA and Controls	1	120,000	LS	120,000
Subtotal				$2,115,000
Insurance and Bonds @ 2%				$42,300
Contractor's Overhead and Profit @ 10%				$211,500
Subtotal Construction Cost				$2,368,800
Engineering, Legal, Administrative @ 20%				$473,800
Subtotal				$2,842,600
Contingency @ 30%				$852,800
Total Capital Cost				$3,695,400

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 10 - Phosphorus Recovery
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
Phosphorus removal study	1	25,000	LS	25,000
Phosphorus removal equipment	1	2,000,000	EA	2,000,000
Miscellaneous Piping and Valves	1	50,000	EA	50,000
Miscellaneous Structural Concrete and Steel	1	40,000	LS	40,000
Electrical	1	60,000	LS	60,000
Instrumentation and Controls	1	30,000	LS	30,000
Painting and Coatings	1	15,000	LS	15,000
Mobilization and Demobilization	1	18,000	LS	18,000

Subtotal	$2,238,000
Insurance and Bonds @ 2%	$44,800
Contractor's Overhead and Profit @ 10%	$223,800
Subtotal Construction Cost	$2,506,600
Engineering, Legal, Administrative @ 20%	$501,300
Subtotal	$3,007,900
Contingency @ 30%	$902,400
Total Capital Cost	$3,910,300

Preliminary costs based on Ostera process but will be dependent on process equipment and whether the system is operated by the City or a contractor

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 11 - Cogeneration
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
Cogeneration Study	1	50,000	LS	50,000
Gas cleaning	1	900,000	LS	900,000
Additional heat exchangers	1	200,000	LS	200,000
Combustion generator	1	500,000	LS	500,000
Building and Structural	1	400,000	LS	400,000
Piping	1	100,000	LS	100,000
Electrical	1	600,000	LS	600,000
Instrumentation and Controls	1	150,000	LS	150,000
Painting and Coatings	1	35,000	LS	35,000
Mobilization and Demobilization	1	25,000	LS	25,000

Subtotal	$2,960,000
Insurance and Bonds @ 2%	$59,200
Contractor's Overhead and Profit @ 10%	$296,000
Subtotal Construction Cost	$3,315,200
Engineering, Legal, Administrative @ 20%	$663,000
Subtotal	$3,978,200
Contingency @ 30%	$1,193,500
Total Capital Cost	$5,171,700

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 12 - Gravity Thickener
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
DAF Tank conversion study	1	20,000	LS	20,000
Conversion of DAF Tank to Gravity Thickener	1	100,000	LS	100,000
New Gravity Thickener	1	350,000	LS	350,000
Pumps	2	35,000	LS	70,000
Piping and Valves	1	40,000	LS	40,000
Miscellaneous Structural Concrete and Steel	1	50,000	LS	50,000
Electrical	1	15,000	LS	15,000
Instrumentation and Controls	1	10,000	LS	10,000
Painting and Coatings	1	25,000	LS	25,000
Mobilization and Demobilization	1	10,000	LS	10,000

Subtotal	$690,000
Insurance and Bonds @ 2%	$13,800
Contractor's Overhead and Profit @ 10%	$69,000
Subtotal Construction Cost	$772,800
Engineering, Legal, Administrative @ 20%	$154,600
Subtotal	$927,400
Contingency @ 30%	$278,200
Total Capital Cost	$1,205,600

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 13 - BNR Upgrades
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
New Basins - Diffusers and Piping	4,000	100	EA	400,000
New Blower Building	1	300,000	LS	300,000
Earthwork	1	30,000	LS	30,000
Structural Concrete and Steel	2	3,500,000	LS	7,000,000
Gates and Actuators	2	120,000	LS	240,000
Piping and Valves	1	180,000	LS	180,000
Blowers	2	90,000	EA	180,000
Electrical	1	290,000	LS	290,000
Demolition of Trickling Filters	1	95,000	LS	95,000
Instrumentation and Controls	1	100,000	LS	100,000
Painting and Coatings	1	20,000	LS	20,000
Mobilization and Demobilization	1	25,000	LS	25,000

Subtotal	$8,860,000
Insurance and Bonds @ 2%	$177,200
Contractor's Overhead and Profit @ 10%	$886,000
Subtotal Construction Cost	$9,923,200
Engineering, Legal, Administrative @ 20%	$1,984,600
Subtotal	$11,907,800
Contingency @ 30%	$3,572,300
Total Capital Cost	$15,480,100

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 14 - Arc Flash Study
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
Electrical Study (Arc flash, short circuit, coordination)	1	50,000	LS	50,000
Subtotal				$50,000
Contingency @ 30%				$15,000
Total Capital Cost				$65,000

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 15 - Miscellaneous Structural Improvements
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
Miscellaneous Seismic Repair Upgrades	1	60,000	LS	60,000
Miscellaneous Concrete Repairs	1	100,000	LS	100,000
Miscellaneous Corrosion Repairs	1	60,000	LS	60,000
Mobilization and Demobilization	1	15,000	LS	15,000

Subtotal	$235,000
Insurance and Bonds @ 2%	$4,700
Contractor's Overhead and Profit @ 10%	$23,500
Subtotal Construction Cost	$263,200
Engineering, Legal, Administrative @ 20%	$52,600
Subtotal	$315,800
Contingency @ 30%	$94,700
Total Capital Cost	$410,500

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 16 - Additional Influent Screw Pump
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
Screw Pump	1	70,000	LS	70,000
Miscellaneous Piping and Valves	1	5,000	LS	5,000
Demolition	1	5,000	LS	5,000
Structural Modifications to Channels	1	30,000	LS	30,000
Electrical	1	11,500	LS	11,500
Instrumentation and Controls	1	3,000	LS	3,000
Painting and Coatings	1	2,500	LS	2,500
Mobilization and Demobilization	1	6,000	LS	6,000

Subtotal	$133,000
Insurance and Bonds @ 2%	$2,700
Contractor's Overhead and Profit @ 10%	$13,300
Subtotal Construction Cost	$149,000
Engineering, Legal, Administrative @ 20%	$29,800
Subtotal	$178,800
Contingency @ 30%	$53,600
Total Capital Cost	$232,400

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 17 - Secondary Clarifier # 2 Mechanism Replacement
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
Clarifier Mechanism	1	120,000	LS	120,000
Miscellaneous Piping and Valves	1	5,000	LS	5,000
Demolition	1	5,000	LS	5,000
Electrical	1	10,000	LS	10,000
Instrumentation and Controls	1	3,000	LS	3,000
Painting and Coatings	1	5,500	LS	5,500
Mobilization and Demobilization	1	6,000	LS	6,000

Subtotal	$154,500
Insurance and Bonds @ 2%	$3,100
Contractor's Overhead and Profit @ 10%	$15,500
Subtotal Construction Cost	$173,100
Engineering, Legal, Administrative @ 20%	$34,600
Subtotal	$207,700
Contingency @ 30%	$62,300
Total Capital Cost	$270,000

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 18 - Basin Return Pumps Upgrade
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
Basin Return Pumps	3	40,000	LS	120,000
Miscellaneous Piping and Valves	1	15,000	LS	15,000
Demolition	1	7,500	LS	7,500
Structural Modifications to Channels	1	30,000	LS	30,000
Electrical	1	57,500	LS	57,500
Instrumentation and Controls	1	10,000	LS	10,000
Painting and Coatings	1	3,000	LS	3,000
Mobilization and Demobilization	1	8,000	LS	8,000

Subtotal	$251,000
Insurance and Bonds @ 2%	$5,000
Contractor's Overhead and Profit @ 10%	$25,100
Subtotal Construction Cost	$281,100
Engineering, Legal, Administrative @ 20%	$56,200
Subtotal	$337,300
Contingency @ 30%	$101,200
Total Capital Cost	$438,500

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

Project 19 - Miscellaneous Improvements
Estimated Capital Cost

Item	Quantity	Unit Cost		Total
Miscellaneous Improvements	1	85,000	LS	85,000
Mobilization and Demobilization	1	1,000	LS	1,000

Subtotal	$86,000
Insurance and Bonds @ 2%	$1,700
Contractor's Overhead and Profit @ 10%	$8,600
Subtotal Construction Cost	$96,300
Engineering, Legal, Administrative @ 20%	$19,100
Subtotal	$115,400
Contingency @ 30%	$34,600
Total Capital Cost	$150,000

ENR Construction Cost Index is 10,360 (San Francisco area, October 2013)

LIVERMORE
CALIFORNIA

APPENDIX F – Calculations

TETRA TECH

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APPENDIX F – Calculations

Appendix F - Process Calculations

Influent Flows, Loadings, and Peaking Factors

Current Flow			
AAF	7.07	MGD	Average annual flow
ADWF	6.93	MGD	Average dry weather flow (average 2009 - 2011)
WWF	8.00	MGD	Wet weather flow (max month flow)
P2WF	8.41	MGD	peak 2 week flow (calculated based on Ultmate buildout of 12.4 MGD)
PDF	11.19	MGD	Peak day flow
PHF	18.98	MGD	Peak hour flow
Current BOD Loading			
AADL	14300	lb/day	Average annual daily load
MMDL	20700	lb/day	Maximum month daily load (maximum moving 30-day average)
PDL	40000	lb/day	Peak day load
Current TSS Loading			
AADL	17300	lb/day	Average annual daily load
MMDL	26200	lb/day	Maximum month daily load (maximum moving 30-day average)
PDL	70600	lb/day	Peak day load
Peaking Factors			
Flow			
AAF:ADWF	1.02		
WWF:ADWF	1.15		
P2WF:ADWF	1.31		
PDF:ADWF	1.61		
PHF:ADWF	2.74		
BOD Loading			
MMDL:AADL	1.45		
PDL:AADL	2.80		
TSS Loading			
MMDL:AADL	1.51		
PDL:AADL	4.08		
Ultimate Buildout Flow			
AAF	9.66	MGD	Ultimate Buildout Flow ADWF * AAF:ADWF
ADWF	9.47	MGD	Given B&C 2005 Effluent Disposal Master Plan
WWF	10.93	MGD	Ultimate Buildout Flow ADWF * WWF:ADWF
P2WF	12.40	MGD	Given B&C Wet Weather Flow Storage analysis 2013
PDF	15.29	MGD	Ultimate Buildout Flow ADWF * PDF:ADWF
PHF	25.93	MGD	Ultimate Buildout Flow ADWF * PHF:ADWF
Ultimate Buildout BOD Loading			
AADL	19500	lb/day	Ultimate Buildout Flow ADWF/Current Flow ADWF * Current BOD Loading AADL
MMDL	28200	lb/day	Ultimate Buildout BOD Loading AADL * BOD Loading MMDL:AADL
PDL	54500	lb/day	Ultimate Buildout BOD Loading AADL * BOD Loading PDL:AADL
Ultimate Buildout TSS Loading			
AADL	23600	lb/day	
MMDL	35700	lb/day	Ultimate Buildout TSS Loading AADL * TSS Loading MMDL:AADL
PDL	96300	lb/day	Ultimate Buildout TSS Loading AADL * TSS Loading PDL:AADL

Influent Pumps

- Design capacity based on peak two week wet weather flow

Number of pumps	4	
Capacity Each	5.7	MGD
Capacity Total	22.8	MGD
Capacity Firm	17.10	MGD
Volume of EHB	15	MG
EHB Fill Rate at P2Wk Flow	-65.8	MG
EHB Volume Remaining	80.8	MG

- Storage volume in EHB too low for diurnal flow equalization. Recommend 4th pump.

Mechanical Screens

- Design capacity based on peak two week wet weather flow
- Capacity of screen determined by screen manufacturer and was not verified independently

Number of Screens	1	
Screen opening	5/8	inch
Capacity	12.00	MGD

- Prior to a 4th pump being installed, additional screening capacity is required to handle potential pumped flow

Primary Clarifiers

- Capacity based on BOD and TSS removal efficiency at SORs. Determine SOR where removal efficiency decreases
- Capacity based on total surface area. Firm capacity is not required for primary clarifiers

Number of Clarifiers	4		
Surface Area Clarifier Each	2356	ft^2	
Surface Area Clarifiers Total	9424	ft^2	
Average BOD Removal %	45%		
Average TSS Removal %	66%		
Capacity Criteria SOR_{ADWF}	1050	$gal/ft^2/day$	
Capacity Criteria SOR_{WWF}	1200	$gal/ft^2/day$	
Capacity SOR_{ADWF}	9.90	MGD	= 9424 * 1050 * 1,000,000
Capacity SOR_{WWF}	11.31	MGD	= 9424 * 1200 * 1,000,000

Aeration Basins

Aeration Basin Capacity

Primary Effluent BOD_{AADL}	10725	lb/day	
Primary Effluent BOD_{MMDL}	15525	lb/day	
Primary Effluent TSS_{AADL}	8024	lb/day	
Primary Effluent TSS_{MMDL}	12138	lb/day	
MLSS	2400	mg/L	
MLVSS	2000	mg/L	
Total biomass in clarifier	18%		
Number of Basins	2		
Volume Each	1.04	MG	
Volume Total	2.08	MG	
Capacity Criteria HRT	4	hrs	- Time required to stablize BOD within cells
Capacity Criteria Space Load	58	lb BOD/1,000 ft^3/day	- Average current space load in basins.
Capacity Criteria F/M	0.4	lb BOD/lb MLVSS	- Emperical paramater based on past experience.
Capacity HRT	12.49	MGD	= Vtotal * 24 / Capacity Criteria HRT
Capacity Space Load Organic	16147	lb/day	= Capacity Criteria Space Load * Volume Total * 1,000,000/7.48/1,000
Capacity Space Load Flow	9.85	MGD	= (Capacity Space Load Organic/Primary Effluent BODMMDL) * Ultimate Buildout Flow ADWF
Capacity F/M Organic	16395	lb/day	= Capacity Criteria F/M * Volume Total * MLVSS * (1 + Total biomass in clarifier) * 8.34
Capacity F/M Flow	10.00	MGD	= (Capacity F/M Organic/Primary Effluent BODMMDL) * Ultimate Buildout Flow ADWF

- Space loading is limiting the capacity of the aeration basins at a ADWF of 9.85 MGD.

Blower Capacity
- Refer to report Section 3.1.4.7 for description of aeration calculation
- Refer to separate aeration calculation page

ᵖE BOD @ Max Month Blower Cap	18715	lb/day	
Max Month Blower Capacity	11.42	MGD	- Refer to separate aeration calculations
Current Peak Day PE BOD Load	13878	lb/day	- Peak day primary effluent BOD load based on historical data
Peak Day PE BOD Load @ Ult.	18961	lb/day	= 13878 * 9.47 / 6.93
PE BOD @ Peak Day Blower Cap.	30600	lb/day	- Refer to separate aeration calculations
Peak Day Blower Capacity	15.28	MGD	= 30600 / 18961 * 9.47

Secondary Clarifiers

- Capacity of the clarifiers is based on total capacity. Firm capacity is not required

Number of Clarifiers	3		
Surface Area Each	6362	ft^2	
Surface Area Total	19085	ft^2	
MLSS	2400	mg/L	
RAS Flow Rate	100%	% influent Q	
Capacity Criteria SOR_{WWF}	600	$gal/ft^2/day$	- SOR at peak WWF month
Capacity Criteria SOR_{P2WF}	900	$gal/ft^2/day$	- SOR at peak 2 week flow
Capacity Criteria SLR	25	$lb/ft^2/day$	- SLR based on ADWF
Capacity SOR_{WWF}	11.45	MGD	= Capacity Criteria SORWWF * Surface Area Total / 1,000,000
Capacity SOR_{P2WF}	17.18	MGD	= Capacity Criteria SORP2WF * Surface Area Total / 1,000,000
Capacity SLR	11.92	MGD	= Capacity Criteria SLR * Surface Area Total / MLSS / 8.34 / (1 + RAS Flow Rate)

Disinfection

- Capacity based on Peak 2-Week flow

Volume of Cl_2 contact Basin	19500	ft^3
Volume of Cl_2 contact Basin	0.15	MG
Capacity Criteria Cl_2 Contact Time	25	min
Contact Basin Capacity	8.40	MGD
Length of Livermore Interceptor	34000	ft
Volume of Livermore Interceptor	1.01	MG
Total Cl_2 Contact Volume	1.16	MG
Total Cl_2 Contact Capacity	66.65	MGD

- Cl_2 contact capacity including the Livermore Interceptor is greater than the flow passed in the interceptor therefore the capacity is hydraulically limited.

WAS Thickening

Number of GBTs	2		- Capacity based on one in operation 24 hour/day 7 days/week.
GBT belt size	1.5	m	
Capacity Criteria	150	gpm/m	
Current WAS Flow Rate	126	gpm	- Maximum day WAS flow rate based on historical data
GBT Capacity	12.38	MGD	= Current Flow ADWF / (Current WAS Flow Rate / (GBT belt size * Capacity Criteria))
			= 6.93 / (126 / (1.5 * 150))

Anaerobic Digestion without Gravity Thickener

Number of Small Digesters	2		
Number of Large Digesters	1		
Volume Small Digesters Each	0.327	MG	
Volume Large Digesters Each	0.5	MG	
Total Digester Volume	1.154	MG	
Total Digester Volume	154278	ft^3	
Capacity Criteria HRT	15	days	- minimum time to achieve stabilization
Capacity Criteria VS Loading	0.18	lb VS/ft^3/day	- maximum VS loading for stable digester operation
Total Sludge to Digester	20955	lb/day	- Current total sludge to digester max 30-day average
Total Volatile Sludge to Digester	17630	lb/day	- Current total volatile sludge to digester
Average Feed Solids	4.14%	% Solids	- Current average combined sludge concentration to digester
% Primary Sludge	63%	% total sludge	
% Primary Sludge Volatile	86%	% VS	
% Primary Sludge Total Solids	3.55%	% Solids	
% TWAS	37%	% total sludge	
% TWAS Volatile	81%	% VS	
% TWAS Total Solids	5.72%	% Solids	

Total Sludge in Digesters	398449	lb	= Average Feed Solids * 1,000,000 * 8.34 * Total Digester Volume
Max Sludge Digester @ Min HRT	26563	lb/day	= Total Sludge in Digesters / Capacity Criteria HRT
ADWF to Produce Max Sludge	8.79	MGD	= Max Sludge Digester @ Min HRT / Current Total Sludge to Digester * Current Flow ADWF
Max Volatile Sludge to Digesters	27770	lb/day	= Capacity Criteria VS Loading * Total Digester Volume
ADWF to Produce Max VS	10.92	MGD	= Max Volatile Sludge to Digesters / Current Total Volatile Sludge to Digester * Current Flow ADWF

- Note the capacity of the Digester is limited by HRT and indicates a capacity less than ultimate buildout.
- Increasing the % solids to the digester can increase HRT without adding digester capacity.

Gravity Thickener Sizing

Solids Loading Rate	25.00	lb/ft^2/day	
Existing DAF Surface Area	491	ft^2	
New Thickener Surface Area	491	ft^2	
Primary Solids @ max Loading	24544	lb/day	= (491 + 491) * 25
Equivalent ADWF Capacity	12.92	MGD	= (24544 * 6.93) / (20955 * 0.63)

Anaerobic Diestion with Gravity Thickener

%Gravity Thickened PS	4.50%	% Solids	- Assumed gravity thickener solids concentration. Conservative estimate, could be 5 to 6%.
% Solids to Digester Combined	4.95%	% Solids	= 0.045 * 0.63 + 0.0572 * 0.37
Total Sludge in Digesters	476727	lb	= Average Feed Solids * 1,000,000 * 8.34 * Total Digester Volume
Max Sludge Digester @ Min HRT	31782	lb/day	= Total Sludge in Digesters / Capacity Criteria HRT
ADWF to Produce Max Sludge	10.51	MGD	= Max Sludge Digester @ Min HRT / Current Total Sludge to Digester * Current Flow ADWF
Max Volatile Sludge to Digesters	27770	lb/day	= Capacity Criteria VS Loading * Total Digester Volume
ADWF to Produce Max VS	10.92	MGD	= Max Volatile Sludge to Digesters / Current Total Volatile Sludge to Digester * Current Flow ADWF

- With gravity thickener, the capacity of the existing digesters is sufficient for ultimate buildout. No need for digester expansion

Biosolids Dewatering

Number BFP Operating	1		- Capacity based on one unit operating.
Total Number of BFP	2		
BFP Belt Size	2	m	
BFP Capacity Criteria	600	lb/hr/m	
BFP Processing Time	14	hr/day	
BFP Processing Time	7	day/week	
TS to Digesters @ Ultimate	28630	lb/day	= 20955 * 9.47 / 6.93
VS to Digesters @ Ultimate	24087	lb/day	= 17630 * 9.47 / 6.93
% VS Reduction in Digesters	63%		
VS to BFP	8912	lb/day	= VS to Digesters @ Ultimate * (1 - % VS Reduction in Digesters)
TS to BFP	13455	lb/day	= TS to Digesters @ Ultimate - VS to Digesters @ Ultimate + VS to BFP
Maximum Biosolids Processed	117600	lb/week	= 2 * 600 * 14 * 7
Biosolids at Max Month Load	94185	lb/week	= 13455 * 7
Capacity	11.82	MGD	= 117600 / 94185 * 9.47

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