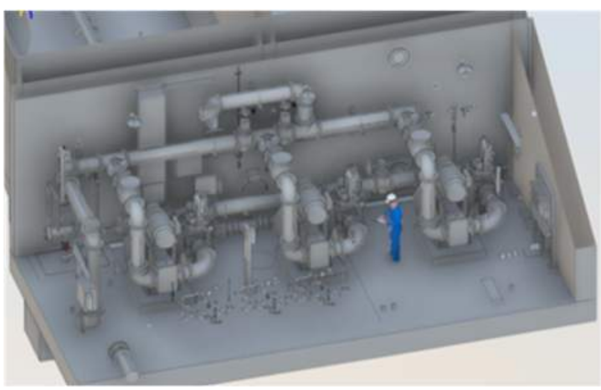
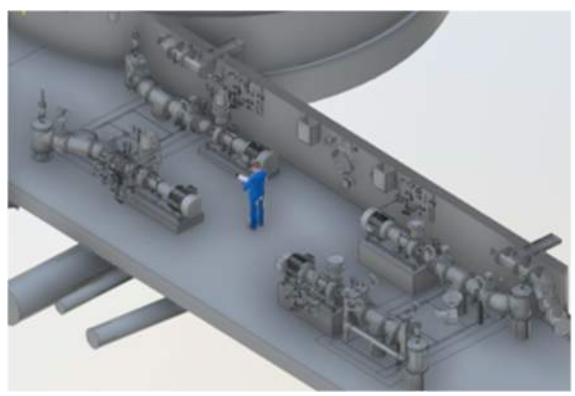
DRAFT STATE REVOLVING FUND
SRF PROJECT PLAN SUMMARY
MARCH 2025

Water Resource Recovery Facility (WRRF)
Improvements to the Sludge Feed System for Solids Processing – SRF Project Plan

Prepared for:

Michigan Department of Environment, Great Lakes, and Energy





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Acronyms and Abbreviations

%	percent
A	amperes
AHU	air handling unit
ANSI	American National Standards Institute
ATS	automatic transfer switch
BEP	best efficiency point
BFP	belt filter press
CFG	centrifuge
CFM	cubic feet per minute
cfs	cubic feet per second
CIP	Capital Improvement Plan
CWSRF	Clean Water State Revolving Fund
DCS	distributed control system
dtpd	dry tons per day
EGLE	Michigan Department of Environment, Great Lakes and Energy
EL	elevation
FEMA	Federal Emergency Management Agency
ft	foot/feet
ft^2	square feet
gal	gallon(s)
GIS	geographic information system
GLWA	Great Lakes Water Authority
gpm	gallon(s) per minute
GPS	Global Positioning System
HI	Hydraulic Institute
HIM	human interface module
hp	horsepower
HVAC	heating, ventilation, and air conditioning

I&C	instrumentation and control
in	inch(es)
kV	kilovolts(s)
kVA	kilovolt-ampere(s)
kW	kilowatt(s)
LPSC	low-pressure secondary water
mA	milliampere(s)
MAU	make-up air unit
MCC	motor control center
MDNR	Michigan Department of Natural Resources
MDOT	Michigan Department of Transportation
MG	million gallon(s)
MI	Michigan
mg/L	milligram(s) per liter
MGD	million gallons per day
mL	milliliter(s)
mm	millimeter(s)
MVA	megavolt-ampere(s)
N/A	not applicable
NPDES	National Pollution Discharge Elimination System
NPSH	net positive suction head
NPW	non-potable water
O&M	operation and maintenance
OIT	Operator Interface Terminal
PLC	programmable logic controller
POR	preferred operating range
SCADA	supervisory control and data acquisition
SCC	system control center
SEMCOG	Southeast Michigan Council of Governments
SFP	Sludge Feed Pump

SHPO	State Historic Preservation Office
SOP	standard operating procedures
SST	Sludge Storage Tank
THPO	Tribal Historic Preservation Officer
TM	Technical Memorandum
TPS	thickened primary sludge
TWAS	thickened waste activated sludge
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VFD	variable frequency drive
WRD	Water Resources Division
WRRF	Water Resource Recovery Facility
WSE	water surface elevation
WWMP	Wastewater Master Plan

Executive Summary

The Great Lakes Water Authority (GLWA) hired CDM Smith, the design and consulting engineer, to develop a Project Plan to apply for a Clean Water State Revolving Fund (CWSRF) loan through the Michigan Department of Environment, Great Lakes and Energy (EGLE). This Project Plan was prepared for in accordance with the CWSRF Project Planning Document Preparation Guidance (January 2023).

The intent of the CWSRF project is to implement a series of improvements to the sludge feed system at the Water Resource Recovery Facility (WRRF) which conveys sludge from six (6) sludge storage tanks (SSTs) to three (3) dewatering facilities: Biosolids Dryer Facility (BDF), Sludge Dewatering Complex I (C-I), and Sludge Dewatering Complex II (C-II). The sludge feed system is a critical step in the WRRF's ability to process solids and maintain the facility's solids throughput capacity. System failure could result in excessive solids buildup which could cause inefficiencies in the WRRF's treatment processes and potentially lead to poor effluent water quality, odor issues, and permit compliance issues.

The required improvements will replace aging pumping equipment and incorporate sludge feed conveyance loops to provide additional system flexibility, redundancy, and resiliency. Based on the analyses summarized in this project plan, the selected improvements include:

1) Replacement of sludge feed equipment including sludge feed pumps (SFPs), seal water booster pumps, sump pumps, and piping. Proposed equipment types, sizing, and piping configurations selected to improve system flexibility and redundancy.
2) Piping and instrumentation improvements associated with providing sludge conveyance loops from each sludge storage tank to the three (3) dewatering facilities. Conveyance loops will improve process control and reliability and include interconnection piping for system flexibility.
3) Associated civil/site, structural, architectural, process/mechanical, heating, ventilation, and air conditioning (HVAC), plumbing, electrical, and instrumentation and controls work.

1.0 Background

The Great Lakes Water Authority owns and operates the Water Resource Recovery Facility located at 9300 W. Jefferson Avenue, Detroit, MI 48209. The WRRF is a conventional activated sludge plant with a wet weather design capacity of 1,444 million gallons per day (MGD) and serves approximately one-third of the State of Michigan's population.

The WRRF generates solids through primary and secondary clarification. Solids handling processes include gravity thickening, blending, storage, dewatering, incineration, and drying treatment processes. Thickened primary sludge (TPS) and thickened waste activated sludge (TWAS) are blended prior to being discharged into six sludge storage tanks (SSTs). The sludge feed system, comprised of sludge feed pumps (SFPs) and piping, supplies thickened blended sludges from the SSTs to sludge dewatering equipment at three different dewatering facilities. These dewatering facilities include belt filter presses (BFPs) located in Sludge Dewatering Complex I (C-I); BFPs in Sludge Dewatering Complex II (C-II); and centrifuges (CFGs) in the Biosolids Drying Facility (BDF). Under normal operating conditions, the BDF CFGs process 60 to 70 percent of the WRRF's solids. BFPs in C-I and C-II are used to dewater the balance of sludge not processed by the BDF or when the BDF equipment is offline for maintenance. Dewatered sludge from C-I and C-II is incinerated onsite and dried sludge from the BDF is land-applied offsite.

The WRRF's National Pollutant Discharge Elimination System (NPDES) permit (Permit No. MI0022802 dated July 2019) requires the plant's solids handling processes to meet the following capacity requirements:

- Average capacity of 500 dry tons per day (dtpd), calculated as a calendar monthly average.
- Peak capacity of 850 dtpd, calculated as a 10-day average. NOTE – EGLE has indicated that this NPDES requirement is no longer valid and will be removed from future NPDES updates.

There are no specific requirements on the flow rates or percent solids of the feed sludge to the dewatering facilities. The NPDES permit requires WRRF to:

- Maintain a monthly average solids inventory of less than 750 dtpd, when there are less than 5 days of discharge from the Detroit River outfall (Point 049A) during the month and maintain a calendar quarterly average solids inventory not to exceed 1,000 dtpd. Solids inventory is defined as the total solids in the Complex A and B gravity thickeners, determined daily in dtpd.
- Notify EGLE within one business day if solids are recycled from the gravity thickeners to the head of the WRRF for more than 72 hours and provide an explanation for the recycled solids. Recycled solids are defined as a total suspended solids (TSS) overflow concentration of 1,000 mg/l or greater from the Complex A thickeners.
- At least 10 days in advance of scheduled maintenance and within 24 hours after initiation of diversion due to emergency conditions, the permittees shall notify EGLE of the reason for the diversion and the expected duration of the diversion.

Many of the existing SFPs and system components are oversized and approaching the end of their service lives. Additionally, sludge feed piping "dead ends" at each of the dewatering facilities resulting in sludge feed header pressures that are difficult to maintain within the operating range required for the sludge flow control equipment upstream of each piece of dewatering equipment. The end result of the aged pumping equipment, oversized sludge feed components, dewatering facility locations, and piping configurations is a sludge feed system that is challenging to operate and maintain with limited flexibility.

The primary focus of this project, WRRF Improvements to the Sludge Feed System for Solids Processing, is replacing aged and oversized sludge feed components, incorporating sludge feed loops into the conveyance systems, and providing associated improvements to improve system flexibility, redundancy, and resiliency.

1.1 Study and Service Areas

The WRRF study area is in the City of Detroit, located in Wayne County, servicing approximately 2.9 million residents in approximately 1.16 million households, some of which are located in overburdened communities. The service area is shown in **Figure 1.1** and an aerial map of the WRRF is shown in **Figure 1.2**.

Figure 1.1: WRRF Service Area

Figure 1.2: WRRF Aerial Map (9300 W. Jefferson Ave)

1.2 Population

Population projections were made for the 2020 wastewater master plan (*Great Lakes Water Authority Wastewater Master Plan, 2020)*. Population projections were based on the Southeast Michigan Council of Governments (SEMCOG) forecast for 2045 supplemented by GLWA Member surveys and extrapolation to the year 2060.

SEMCOG prepares annual analyses of population and households by local unit of government within its seven county planning region. The 2045 forecast was completed in June 2018. Population forecasting, and the associated economic and demographic projections that drive population growth, is an essential component of master planning. Population change directly impacts sanitary wastewater flows (including domestic, commercial, industrial, and institutional flows) and the increase in the size of the service area (infiltration/inflow).

Based on the Member survey and SEMCOG projections from the wastewater master plan, the GLWA regional service area population is forecast to grow up to nine percent by the year 2060:

- 2.75 million residents in 2018
- 2.77 million residents in 2025
- 2.90 million residents in 2045
- 3.06 million residents in 2060

1.3 Existing Environmental Evaluation

1.3.1 Cultural and Historic Resources

Proposed improvements are located within the existing WRRF and BDF sites. Cultural and historic impacts are being evaluated but are not anticipated.

A State Historic Preservation Office (SHPO) Section 106 application will be prepared and submitted to identify any historic properties in the project area. Project requirements and constraints will be added to mitigate project activities from affecting the historic properties, if found.

There are 12 federally recognized Indian tribes in Michigan, whose Tribal Historic Preservation Officers (THPO) assume the role of SHPO for projects on tribal lands. These tribes will be contacted to give them the opportunity to have their interests and concerns considered. The Tribes to be contacted include: Bay Mills, Grand Traverse Band of Ottawa and Chippewa Indians, Gun Lake Tribe, Hannahville, Keweenaw Bay Indian Community, Lac Vieux Desert Band of Lake Superior Chippewa Indians, Little River Band of Ottawa Indians, Little Traverse Bay Bands of Odawa Indians, Nottawaseppi Huron Band of the Potawatomi, Pokagon Band of the Potawatomi Indians, Saginaw Chippewa Indian Tribe of Michigan, and Sault Tribe of Chippewa Indians. If any tribe determines that historic properties with religious and/or cultural significance will be impacted by the project, mitigative measures recommended by the tribe will be implemented.

1.3.2 Air Quality

The most recent EGLE Air Quality Report (2022) has been reviewed to assess the air quality in the study area. Since EGLE began monitoring in the early 1970s, criteria pollutant levels have decreased, indicating that the air is much cleaner today than when the federal Clean Air Act began. The entire state of Michigan is in attainment for carbon monoxide, lead, nitrogen dioxide, and particulate matter. Portions of the state are in nonattainment, for sulfur dioxide and ozone, but the levels of these pollutants are continuing to decrease.

1.3.3 Wetlands

A wetland map for the WRRF was generated at the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory website. The map is included in **Appendix A**.

The Rouge River and two ponds are adjacent to the WRRF. The freshwater ponds and riverine system are not anticipated to be impacted by this project.

1.3.4 Great Lakes, Shorelands, Coastal Zones, and Coastal Management Areas

The proposed project is not expected to impact the Great Lakes, Shorelands, Coastal Zones, or Coastal Management Areas.

1.3.5 Natural or Wild and Scenic Rivers

Natural or Wild and Scenic Rivers, particularly the Rouge River, are not expected to be impacted by the construction of the proposed project.

1.3.6 Major Surface Waters

The main surface water body within the project area is the Rouge River. This river is intensively developed, with extensive urban, commercial, and industrial complexes. It is not expected to be negatively impacted by construction of the proposed project. Improvements at the WRRF will help to maintain the quality of the water being discharged into the river.

1.3.7 Topography

Existing topography USGS quadrangle maps are provided in **Appendix B**. The city of Detroit is relatively flat. The study area is part of the vast central lowlands of North America, consisting of plains and low hills.

1.3.8 Floodplains

The project work area lies outside of the 100-Year Floodplain. A FEMA issued Flood Hazard Map is shown in **Appendix C**. There are no special flood hazards near the WRRF. Consequently, the proposed project is not expected to impact floodplains.

1.3.9 Geology

There are no geological structures or formations in the vicinity of the proposed project study area.

1.3.10 Soil Types

At the WRRF project location, the soils consist of sandy topsoil (slightly organic), silty sand and clayey sand fill soils, and native soft gray silty clay.

1.3.11 Agricultural Resources

There is no agricultural land within the WRRF project location. Consequently, the proposed project is not expected to impact agricultural resources.

1.3.12 Fauna and Flora

A USFWS Section 7 review will be completed for this project. Because the proposed work is limited to existing facilities, no impacts to federally listed endangered or threatened species are anticipated.

1.4 Existing System

The WRRF sludge feed system is comprised of six sludge storage tanks (4 circular, 2 rectangular), six sludge feed pumps, piping, valves, instruments, and appurtenances. The system conveys sludge through pressurized sludge headers from the sludge storage tanks to flow control equipment upstream of dewatering equipment located in the three dewatering facilities.

1.4.1 Sludge Storage Tanks 1-4 (SSTs 1-4)

SSTs 1-4 are used to store blended thickened primary sludge (TPS) and thickened waste activated sludge (TWAS) prior to it being conveyed to the dewatering facilities for processing. The tanks were constructed in 1971 and were originally equipped with center supported sludge collection equipment that has since been removed. Coarse bubble mixing systems are provided in SSTs 1-4 to keep solids in suspense. The tanks are above/below grade, cylindrical, reinforced concrete structures with cone-shaped bottoms **(Figure 1.3)**. The dimensions of each tank and critical elevations are displayed in **Table 1.1.**

Figure 1.3: Sludge Storage Tank 3 (typical of SSTs 1-4)

Table 1.1: SSTs 1-4 Dimensions

Tank Name	Volume (gal)	Diameter (ft)	Maximum SWD/Elev. (ft)	Minimum SWD/Elev. (ft)	Top of Wall Elev. (ft)	Overflow Inv. Elev. (ft)	Outlet Pipe Inv. Elev. (ft)
SST-1	210,000	35	28/124	11/107[1]	126	124	90
SST-2	210,000	35	28/124	11/107[1]	126	124	90
SST-3	210,000	35	28/124	2/98[1]	126	124	90
SST-4	210,000	35	28/124	2/98[1]	126	124	90

[1] Based on operational data from 5/2020 - 5/2023

1.4.2 Sludge Storage Tanks 5/6

SSTs 5/6 are used to store blended TPS and TWAS prior to it being conveyed to the dewatering facilities for processing. Air mixing systems are provided to keep solids in suspense. The tanks are above/below grade, rectangular, reinforced concrete structures with a common central divider wall **(Figure 1.4)**. The dimensions of each tank and critical elevations are displayed in **Table 1.2.**

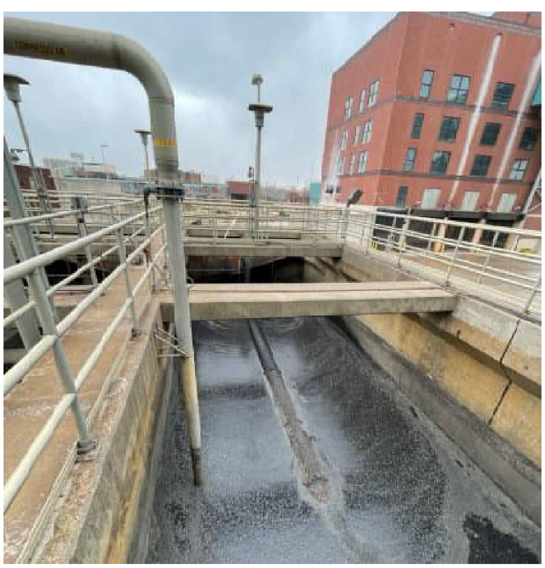


Figure 1.4: Sludge Storage Tank 6

Table 1.2: SSTs 5/6 Dimensions

Tank Name	Volume (gal)	Dimensions Length/Width (ft)	Maximum SWD/Elev. (ft)	Minimum SWD/Elev. (ft)	Top of Wall Elev. (ft)	Overflow Inv. Elev. (ft)	Outlet Pipe Inv. Elev. (ft)
SST-5	230,000	70.33/18.25	23/123	0/100[1]	126	123	97
SST-6	230,000	70.33/18.25	23/123	0/100[1]	126	123	97

[1] Based on operational data from 5/2020 - 5/2023

1.4.3 Sludge Feed Pumps 1-4

The SSTs 1-4 Pipe Gallery houses the pumps, piping, and appurtenances associated with SSTs 1-4 and is located below Pump Station Avenue (between SSTs 1-4). SFPs 1-4 convey blended TPS and TWAS from SSTs 1-4 to the Dewatering Complex II BFPs and Biosolids Dryer Facility centrifuges. Each pump is shown in **Figure 1.5** and pertinent data/information is displayed in **Table 1.3**. Two booster pumps located in the pipe gallery are provided to increase low-pressure secondary water (LPSW) pressure for each pump's seal water system/assembly.

Figure 1.5: SFP-1 (top left), SFP-2 (top right), SFP-3 (bottom left), and SFP-4 (bottom right)

Table 1.3: SFPs 1-4 Data/Information

Parameter	SFP-1	SFP-2	SFP-3	SFP-4
Status	Operational	Operational	Operational	Operational
Pump Type	Chopper	Chopper	Chopper	Chopper
Pump Model	Vaughan HE8P10B	Vaughan HE4V8TSEC2-155	Vaughan HES8P10TS-150	Vaughan HES8P10TS-150
Power (hp)	200	60	250	250
Flow (gpm)	2400	800	2400	2400
Head (ft)	185	125	190	190
Voltage (V)/ Phase/ Frequency (Hz)	460/3/60	460/3/60	460/3/60	460/3/60
Amps	230	69	285	285
VFD	Rockwell	Yes	Yes	Yes
VFD Location	SSTs 1-4 Pipe Gallery	Complex A Electrical Room	Basement of Complex A	Basement of Complex A
Pump Speed (RPM)	1785	1300	1785	1785
Installation Year	2013	2023	2015	2015
Seal Water	Yes	Yes	Yes	Yes
Motor Type	Induction	Induction	Induction	Induction
Enclosure Type	TEFC	TEFC	TEFC	TEFC
Upstream Tank	SSTs 1/2	SSTs 1/2	SSTs 3/4	SSTs 3/4
Downstream Dewatering Facility	C-II BFPs	C-II BFPs	BDF CFGs	BDF CFGs
Install Contract	N/A	2102646	PC-792	PC-792
Suction Size	10”	8”	10”	10”
Discharge Size	8”	4”	8”	8”

1.4.4 Sludge Feed Pumps 5/6

The SSTs 5/6 Pump Building houses the pumps, piping, and appurtenances associated with SSTs 5/6 and is connected to the east side of the SSTs. SFPs 5 and 6 convey blended TPS and TWAS from SSTs 5 and 6 to the Dewatering Complex I BFPs. Each pump is shown in **Figure 1.6** and pertinent data/information is displayed in **Table 1.4**. Low-pressure secondary water (LPSW) piping is routed to each pump’s seal water system/assembly. A seal water booster pump is provided but is no longer operable.

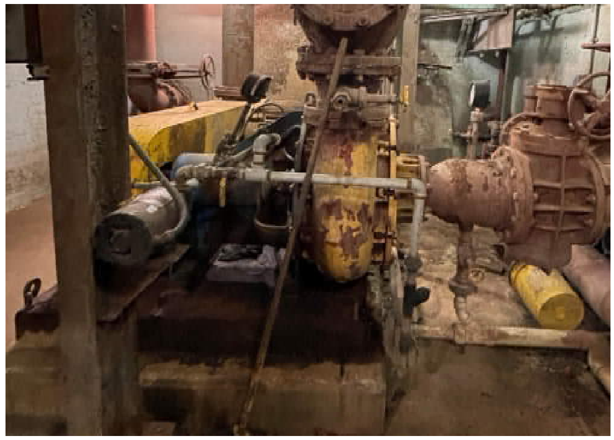



Figure 1.6: SFP-5 (left), SFP-6 (right)

Table 1.4: SFPs 5/6 Data/Information

Parameter	SFP-5	SFP-6
Status	Out of Operation	Operational
Pump Type	Recessed Impeller	Chopper
Pump Model	Wemco Torque Flow type C	Vaughan HE8P10C
Power (hp)	150	150
Flow (gpm)	2400	2400
Head (ft)	130	145
Voltage (V)/ Phase/ Frequency (Hz)	460/3/60	460/3/60
Amps	281	175
VFD	ASI Robicon 454 GT	Rockwell
VFD Location	SSTs 5/6 Pump Building (upper level)	SSTs 5/6 Pump Building (upper level)
Pump Speed (RPM)	1170	1785
Installation Year	2005	Unknown
Seal Water	Yes	Yes
Motor Type	Induction	Induction
Enclosure Type	TEFC	TEFC
Upstream Tank	SSTs 5/6	SSTs 5/6
Downstream Dewatering Facility	C-I BFPs	C-I BFPs
Install Contract	PC-744 (DWP-1016)	N/A
Suction Size	10”	8”
Discharge Size	8”	N/A

1.4.5 Sludge Piping

The existing piping systems are used to convey sludge from the six sludge storage tanks to the three dewatering facilities. Each header is a pressurized pipeline that “dead ends” at the dewatering equipment (no return lines). The BDF feed header in the SSTs 1-4 Pipe Gallery is equipped with a sludge recirculation/blowoff line to maintain proper pressure to the BDF. **Table 1.5** provides a summary of information for each sludge pipe segment.

Table 1.5: Sludge Piping Information

Pipe Function	Pipe Section Start Location	Pipe Section End Location	Exposed /Buried	Project Installed	Year Installed	Material	Pipe Lining	Remarks
C-II BFP Feed	SFPs 1/2 Suction	SFPs 1/2 Discharge	Exposed	PC-744 (DWP-1016)	2006	DI	Unknown	-
	SSTs 1-4 Pipe Gallery	C-II Basement	Buried	PC-241	1971	DI[1]	Unknown	In Yard
	C-II Basement	C-II Basement	Exposed	PC-792	2016	DI 53	PROTECTO 401 ceramic epoxy	-
	C-II Basement	C-II 5th Floor	Exposed	PC-691[1]	1998[1]	DI	Unknown	-
	C-II 5th Floor	C-II BFPs	Exposed	PC-787	2012	STL XS	Liquid Epoxy (Tnemec N140 Pota-pox	-
BDF Feed	SFPs 3/4 Suction	SFPs 3/4 Discharge	Exposed	PC-792	2016	DI 53	PROTECTO 401 ceramic epoxy	-
	SSTs 1-4 Pipe Gallery	BDF Storage Room	Buried	PC-792	2016	DI PC350	PROTECTO 401	In Yard
	BDF Storage Room	BDF Centrifuge Mezzanine	Exposed	PC-792	2016	DI 53	PROTECTO 401 ceramic epoxy[1]	-
C-I BFP Feed	SFPs 5/6 Suction	SFPs 5/6 Discharge	Exposed	PC-616, PC-744 (DWP-1016)	1987 & 2006	DI	Unknown	-
	SFPs 5/6 Discharge	C-I Basement	Buried	PC-246	1971	DI[1]	Unknown	In Yard
	C-I Basement	C-I BFPs	Exposed	PC-787	2012	STL XS	Liquid Epoxy (Tnemec N140 Pota-pox	-

[1]Estimated/Most Probable

1.4.6 HVAC and Plumbing

Major HVAC equipment for the SSTs 1-4 Pipe Gallery and SSTs 5/6 Pump Building are summarized in **Table 1.6**.

Plumbing systems in the SSTs 1-4 Pipe Gallery consist of non-potable water (low pressure-secondary), sanitary drainage, compressed air, and natural gas piping. Systems in the SSTs 5/6 Pump Building consist of storm water drainage, building sump pumps, natural gas, and non-potable water (low pressure-secondary).

Table 1.6 – HVAC Equipment Details

Location	Unit No.	Description	Capacity
SSTs 1-4 Pipe Gallery	MA-A4	Makeup Air Unit	4,000 CFM
	EF-EG-A4	Exhaust Fan	4,000 CFM
SSTs 5/6 Pump Building	MA-A5	Makeup Air Unit	1,600 CFM
	EF-GE-A7	Exhaust Fan	1,600 CFM

1.4.7 Electrical

The primary power source for the SFPs and the associated systems is provided through a 480-volt substation, ST-1. ST-1 is a double-ended substation with two (2) – 2000kVA transformers and a main-tie-main configuration. Main Bus A feeds MCC-A1, MCC-A3, and MCC-A5. Main Bus B feeds MCC-2A, MCC-4A, and MCC-A6.

The variable frequency drive (VFD) for SFP-1 (SFP-1 VFD) and associated control stations and disconnect switches for SFP-2, SFP-3 and SFP-4 are located in the SSTs 1-4 Pipe Gallery. SFP-2 VFD is located in the Complex A Electrical Room. SFP-3 VFD and SFP-4 VFD are in located in the Complex A Gallery. The VFDs are standalone units in stainless steel enclosures. The VFDs are fed from MCC-A3 and MCC-A4 in the Electrical Room above the gallery.

The SSTs 5/6 Pump Building is powered by two (2) motor control centers (MCC), MCC-A5 and MCC-A6. The MCCs and VFDs are located on the ground floor level. Each MCC contains starters for ancillary equipment to the SFPs and feeder breakers to the VFDs for SFP-5 (SFP-5 VFD) and SFP-6 (SFP-6 VFD).

1.4.8 Instrumentation and Controls

The SSTs 1-4 Pipe Gallery contains process instrumentation (pressure indicators, pressure switches, and flowmeters) associated with SFPs 1-4. Signals from the process instrumentation and VFDs are connected to Ovation cabinets located in the Complex A Telecom Room.

The process instrumentation and equipment for SFPs 5 and 6 are split between the upper and lower levels of the SSTs 5/6 Pump Building. The pumps and associated process instrumentation are located in the basement, while the VFDs and control panels are located upstairs. The I/O signals from the SFPs are integrated into the Ovation Controller and Network Cabinet located in Complex A Telecom Room.

1.5 Need for Project

The sludge feed system is a critical step in the WRRF's ability to process solids and maintain the facility's solids throughput capacity. System failure could result in excessive solids buildup which could cause inefficiencies in the WRRF's treatment processes and potentially lead to poor effluent water quality, odor issues, and permit compliance issues. This project is focused on improving system reliability, flexibility, operational ease, and maintenance. Numerous components of the sludge feed system assets are approaching the end of their expected useful lives. The sludge feed pumps are oversized for the feed rates required at each dewatering facility based on the current mode of operation. In addition, the sludge feed piping "dead ends" at each of the dewatering facilities, resulting in sludge header pressures that are difficult to maintain within the operating range required for the sludge flow control equipment upstream of the dewatering equipment.

1.5.1 Sludge Feed System Needs

The sludge feed system needs and issues were identified from meetings with operation and maintenance (O&M) staff and site visits and investigations by CDM Smith. The following issues were identified related to each of the components making up the sludge feed system. Refer to **Appendix D**, TM-3 Existing Conditions, for the complete investigation and additional information on project needs.

1.5.1.1 Sludge Storage Tanks

The following needs and issues were identified for the sludge storage tanks:

- Ultrasonic level sensors are inaccurate and difficult to access.
- Current process of draining and cleaning tanks is laborious.
- Excess grit and rags accumulate on in-tank air piping.

1.5.1.2 Sludge Feed Pumps

The following needs and issues were identified for the sludge feed pumps:

- Pump types and sizing result in inefficient operation and limits operational flexibility.
- Excessive rags in tanks can clog pumps.
- SSTs 1-4 Pipe Gallery has been prone to process flooding events.
- Tight clearances, difficult access, and minimal equipment lifting provisions for maintenance activities.
- Limited washdown stations for process areas.
- Poor lighting in pump process areas.
- Equipment is approaching the end of expected useful life.

1.5.1.3 Sludge Piping

The following needs and issues were identified for the sludge piping systems:

- Sludge feed piping “dead ends” at each of the dewatering facilities, resulting in sludge header pressures that are difficult to maintain within the operating range requirements.
- Excessive wear/frequent replacement of the BDF sludge feed header recirculation line pinch valve that is used to maintain system pressure. Results in frequent replacements and system downtime.
- Limited and aging instruments results in challenges associated with monitoring pumping system performance and troubleshooting issues.
- Limited flushing locations.
- Limited interconnections between feed headers to allow for sludge feed system operational flexibility.

1.5.1.4 HVAC Needs

The HVAC equipment serving the sludge feed system process areas is approaching the end of its expected useful life and requires replacement. Refer to **Appendix D**, TM-3 Existing Conditions, for the complete investigation and additional information.

1.6 Project Future Needs

This project will provide the necessary capacity for sludge conveyance to the dewatering facilities for the entire project life cycle. A detailed analysis of the dewatering system sludge demands at each dewatering facility was performed during the conceptual design phase to establish the sludge feed system design requirements. This analysis is detailed in **Appendix E**, TM-4 Dewatering System Sludge Demands. NPDES Permit requirements, BDF Contract requirements, Dewatering Facility capacities, and historic operational data were all considered in the analysis. Significant WRRF service area growth during this project's life cycle is not anticipated as discussed in Section 1.2. Expected sludge flow increases during the project life cycle are negligible.

2.0 Analysis of Alternatives

Alternatives analyses were performed during the project's conceptual design phase. Alternative development, evaluations, and recommendations are documented in the technical memorandums listed below which are included in **Appendix F**.

- TM-5A Pumping Technology Evaluation and Shortlisting
- TM-5B Pumping Systems Evaluation
- TM-5C Additional Pumping Systems Evaluation
- TM-6 SSTs 1-4 Drainage and SSTs 1-4 Pipe Gallery Flooding Mitigation

2.1 Alternatives

2.1.1 No Action Alternative

The No Action alternative involves maintaining current system operations. Aging equipment will eventually fail and leave the WRRF at risk of achieving inadequate treatment, operation and maintenance issues, NPDES permit non-compliance, and degraded water quality in receiving water bodies (the Rouge River). The objectives of the project are not met under the No Action alternative and are not in accordance with the recommendations of the conceptual design evaluations performed by CDM Smith.

2.1.2 Enhancing Existing System to Improve Performance Alternative

Enhancing the existing system considers operational changes, replacement of existing equipment, addition of new equipment, and/or training of operating personnel to achieve the goals of the project.

The improvements recommended for this project are based on the enhancements needed to overcome challenges with the existing system, including:

- Aging equipment that is approaching end of useful life.
- Limited system flexibility due to existing equipment sizing and configuration.
- Operation challenges associated with sludge feed piping "dead ends" at each of the dewatering facilities.

Replacement of existing equipment with in-kind or alternative equipment, modifications to the system configurations and layouts, and modifications to standard operating procedures were all considered as part of this alternative.

2.1.3 Regionalization Alternative

Great Lakes Water Authority is a regional water authority which owns and operates the WRRF. Additional regionalization as an alternative is not applicable to this project.

2.2 Monetary Evaluation

Monetary evaluations of the alternatives considered for this project were performed during the conceptual design phase. These evaluations were used in conjunction with non-cost criteria to rank and recommend alternatives to be incorporated into the project. The monetary evaluations can be found in TM-5B and TM-6 (**Appendix F**). The locations of the monetary evaluations of the alternatives in these documents are as follows:

- Pumping Systems:
  - **Appendix F**, TM-5B, Section 6.0, Pages 46-55
- SSTs 1-4 Drainage Improvements:
  - **Appendix F**, TM-6, Section 4.0, Pages 21-24
  - **Appendix F**, TM-6, Section 7.1, Pages 28-32
- SSTs 1-4 Pipe Gallery Flooding Mitigation:
  - **Appendix F**, TM-6, Section 5.0, Pages 24-27

2.2.1 Sunk Costs

Sunk costs are the investments or financial commitments made before or during project planning. These costs are not included in the cost-effectiveness analysis since they have already been committed regardless of the alternative selected. Sunk costs typically include the cost of existing facilities and land, outstanding bond indebtedness, and the cost of preparing the project planning document.

The sludge feed system is located at the WRRF and cannot be relocated or decommissioned. Sunk costs are not applicable to this project.

2.2.2 Present Worth

The present worth of the construction of this project is calculated as follows:

$$PW = F * \frac{1}{(1+i)^n}$$

Where:

$$F = Future\ Value = Estimated\ construction\ cost = \$19{,}000{,}000$$

$$PW = Present\ worth\ of\ one - time\ expenditures$$

$$i = Discount\ rate = 2.2\%$$

$$n = Number\ of\ years = 2.3\ years\ to\ construction\ mid - point.$$

The real discount rate was determined from the Federal Office of Management and Budget (OMB) from Appendix C of OMB Circular A-94 for a 3-year analysis. The number of years is calculated based on the time from present day (February 2025) to the anticipated mid-point of construction, estimated as June 2027, which is 2.3 years. This results in an estimated present worth of $18,100,000.

2.2.3 Salvage Value

Relative to the overall construction costs, potential salvage values are insignificant and have thus not been included in the monetary evaluation of alternatives.

2.2.4 Escalation

Escalation in the monetary evaluation for SRF loan approval is limited to energy costs and land value. The sludge feed system is a unit process of the WRRF and cannot be relocated and the value of the land is not considered as it cannot be sold. Energy usage is anticipated to be similar compared to the existing systems. Additionally, energy usage is considered to be similar between the evaluated alternatives.

2.2.5 Interest During Construction

Interest during construction was assumed in the most recent Opinion of Probably Construction Cost (OPCC) as five percent per year and is included in the overall project cost calculation. It was assumed for the purposes of alternatives analysis that all evaluated alternatives will result in similar construction schedules and thus similar interest rates.

2.2.6 User Costs

The cost to users is determined based on the duration of the SRF loan and overall project cost, as described in **Section 3.8.** Refer to that section for details on the end costs to users.

2.2.7 Project Delivery Method

The project delivery method for this project is traditional design-bid-build.

2.3 Environmental Evaluation

All improvements proposed within this project plan will be limited to existing wastewater infrastructure at the existing WRRF. Additionally, the construction methods are expected to have minimal environmental impact. Soil erosion and sediment control measures are included in the capital cost of the project and will be enforced during construction. Efforts will be made to mitigate and minimize construction noise and interruptions to traffic within and around the WRRF.

2.4 Alternative Comparison

As described in **Section 2.1**, the no-action alternative is not a viable option. Also, decommissioning or relocating these existing facilities is not practical. Accordingly, improving the performance of the existing sludge feed system is the most cost-effective and practical alternative that can meet the project objectives. Alternative analyses performed during the conceptual design phase is summarized in the technical memorandum included in **Appendix F**.

3.0 Selected Alternative

3.1 Summary

The upgrades associated with the WRRF Improvements to the Sludge Feed System for Solids Processing project are required to improve system resiliency, provide operational flexibility, and improve ease of operation and maintenance to sustain unit process reliability. Alternative selections were based on evaluation of cost and non-cost parameters to determine the appropriate improvements for implementation. Support system improvements including site/civil, structural, architectural, HVAC, plumbing, electrical, and instrumentation and controls are included to accommodate the required process modifications. This section contains a high-level summary of the work to be performed at the WRRF as part of this project.

3.1.1 SSTs 1-4 Pipe Gallery

- Replacement of SFPs 1-4, seal water booster pumps, and associated piping and appurtenances. New equipment sized and configured to incorporate sludge conveyance loops and provide discharge location flexibility.
- New process sump and sump pumping system to mitigate gallery flooding.
- Replacement of HVAC equipment.
- Lighting upgrades.
- Additional pipe flushing and washdown station locations.
- New lifting devices and appurtenances to facility maintenance activities.
- Civil, Architectural, Structural, Plumbing, Electrical, and I&C improvements needed to support the process mechanical and HVAC improvements.

3.1.2 SSTs 5/6 Pump Building

- Replacement of SFPs 5 and 6 and associated piping and appurtenances. New equipment to include three rotary lobe sludge feed pumps with upstream grinders, sized and configured to incorporate sludge conveyance loops and provide discharge location flexibility.
- Replacement of building sump pumps.
- Replacement of HVAC equipment.
- Lighting upgrades.
- Additional pipe flushing and washdown station locations.
- New floor opening and lifting devices and appurtenances to facility maintenance activities.
- Civil, Architectural, Structural, Electrical, and I&C improvements needed to support the process mechanical, plumbing, and HVAC improvements.

3.1.3 Miscellaneous Improvements

- Sludge Dewatering Complex I, Sludge Dewatering Complex II, and Biosolids Dryer Facility: New piping and instrumentation to provide sludge conveyance loops.
- Sludge Processing Complex A: Conversion of existing room to SFP Electrical Room to house the new SFP VFDs.
- Sludge Processing Complex A: Replacement of Control and Telecom Rooms HVAC equipment.

3.2 Design Parameters

3.2.1 Design Criteria

Analysis of the dewatering systems' sludge demands was performed to assist in developing the sludge feed system design criteria. Minimum and maximum values for the feed sludge total solids, flow, solids loading, and header pressures were evaluated to establish the overall system requirements. The selected design criteria for the sludge feed systems are presented in **Table 3.1** and **Table 3.2**.

Table 3.1: Design Criteria (Normal Operation)

Parameter	BDF (Min/Avg/Max)	C-I (Min/Avg/Max)	C-II (Min/Avg/Max)
Feed Sludge Total Solids (%)	2.5/4.0/6.0	3.0/5.2/8.3	3.0/5.2/8.3
Feed Sludge Flow (gpm)	350/1,137/2,400	221/439/726	221/439/726
Feed Sludge Solids Loading (dtpd)	105/262/420	28/119/248	28/119/248
Feed Sludge Header Pressure (psi)	5/10/25	25/32/40	15/22/30

Table 3.2: Design Criteria (BDF Outage)

Parameter	BDF (Min/Avg/Max)	C-I (Min/Avg/Max)	C-II (Min/Avg/Max)
Feed Sludge Total Solids (%)	-	3.0/4.3/8.3	3.0/4.3/8.3
Feed Sludge Flow (gpm)	-	221/439/1,500[1]	221/439/1,800[1]
Feed Sludge Solids Loading (dtpd)	-	28/119/390[1]	28/119/469[1]
Feed Sludge Header Pressure (psi)	-	25/32/40	15/22/30

[1]Values based on using 2 of the 4 BDF feed pumps to supply sludge to C-I during a BDF outage.

Table 3.3 displays that the sludge feed system design criteria result in total solids loading capacities that meet the NPDES Permit requirements during normal operation and BDF outage scenarios.

Table 3.3: Solids Loading Recommendation vs NPDES Permit Requirements

Facility/Permit Requirement	Average Solids Loading (dtpd)	Maximum Solids Loading (Normal Operation) (dtpd)	Maximum Solids Loading (BDF Outage) (dtpd)
BDF	262	420	0
C-I	119	248	390
C-II	119	248	469
WRRF Total	**500**	**916**	**859**
NPDES Permit Requirements	500	850	

Equipment design criteria were developed based on requirements to meet the overall sludge feed system demands. Equipment design criteria are presented in **Table 3.4**.

Table 3.4 Sludge Feed Pumping Improvements Design Criteria

System Component	Units	Value	Notes
Sludge Feed Pumps 1-4			
Number	EA	4	3 duty+1 standby (normal max operating scenario)
Location	--	SSTs 1-4 Pipe Gallery	--
Pump Type	--	Horizontal Rotodynamic Chopper	--
Design Flow Range	gpm	1,000 – 1,800	Includes return flow
Design Total Dynamic Head Range	ft	50 – 110	--
Design Sludge Total Solids Content Range	% of weight	2.5% – 6.0%	--
Drive Type	--	VFD	--
Motor Size	Hp	100	--
Impeller Material	--	Heat treated cast alloy steel	--
Manufacturer (basis of design)	--	Vaughan	--
Model (basis of design)	--	HE6W8	--
Sludge Feed Pumps 5-7			
Number	EA	3	2 duty+1 standby (normal max operating scenario)
Location	--	SSTs 5/6 Pump Building	--
Pump Type	--	Positive Displacement Rotary Lobe	--
Design Flow Range	gpm	700 – 1,000	Includes return flow
Design Total Dynamic Head Range	ft	50 – 150	--
Design Sludge Total Solids Content Range	% of weight	3.0% – 8.3%	--
Drive Type	--	VFD	Constant torque
Motor Size	Hp	100	--

System Component	Units	Value	Notes
Lobe Material	--	Buna-N coated metal	--
Manufacturer (basis of design)	--	Swaby	Boerger or Netzsch as an alternate
Model (basis of design)	--	LOBELINE™ 660	BLUEline XL2650 or Tornde® XLB-6/2 as an alternate
Sludge Grinders 5-7			
Number	EA	3	--
Location	--	SSTs 5/6 Pump Building	--
Type	--	Inline	--
Design Flow Range	gpm	700 – 1,000	Up to 2 psi pressure drop
Design Sludge Total Solids Content Range	% of weight	3.0% – 8.3%	--
Drive Type	--	Constant	--
Motor Size	Hp	5	--
Manufacturer (basis of design)	--	Vogelsang	--
Model (basis of design)	--	XRP 136-200Q	--

3.2.2 Flow Schematics

The existing sludge feed system process flow schematic is presented in **Figure 3.1**. Normal operation includes:

- SSTs 1/2 and SFPs 1/2 dedicated to conveying sludge to Sludge Dewatering Complex II.
- SSTs 3/4 and SFPs 3/4 dedicated to conveying sludge to the Biosolids Drying Facility.
- SSTs 5/6 and SFPs 5/6 dedicated to conveying sludge to Sludge Dewatering Complex I.

System flexibility includes:

- Limited flexibility to use SFPs to convey sludge to alternative discharge locations due to pump sizing and limited interconnections.

The proposed sludge feed system process flow schematic after improvements is presented in **Figure 3.2**. Normal operation includes:

- SSTs 1-4 and SFPs 1-4 dedicated to conveying sludge to the Biosolids Drying Facility.
- SSTs 5/6 and SFPs 5-7 dedicated to conveying sludge to Sludge Dewatering Complex I and/or Sludge Dewatering Complex II.

System flexibility includes:

- SSTs 1-4 and SFPs 1-4 can convey sludge to Sludge Dewatering Complex I or Sludge Dewatering Complex II during a BDF outage.

SSTs 5/6 and SFPs 5-7 can convey sludge to the BDF if required during outage scenarios.

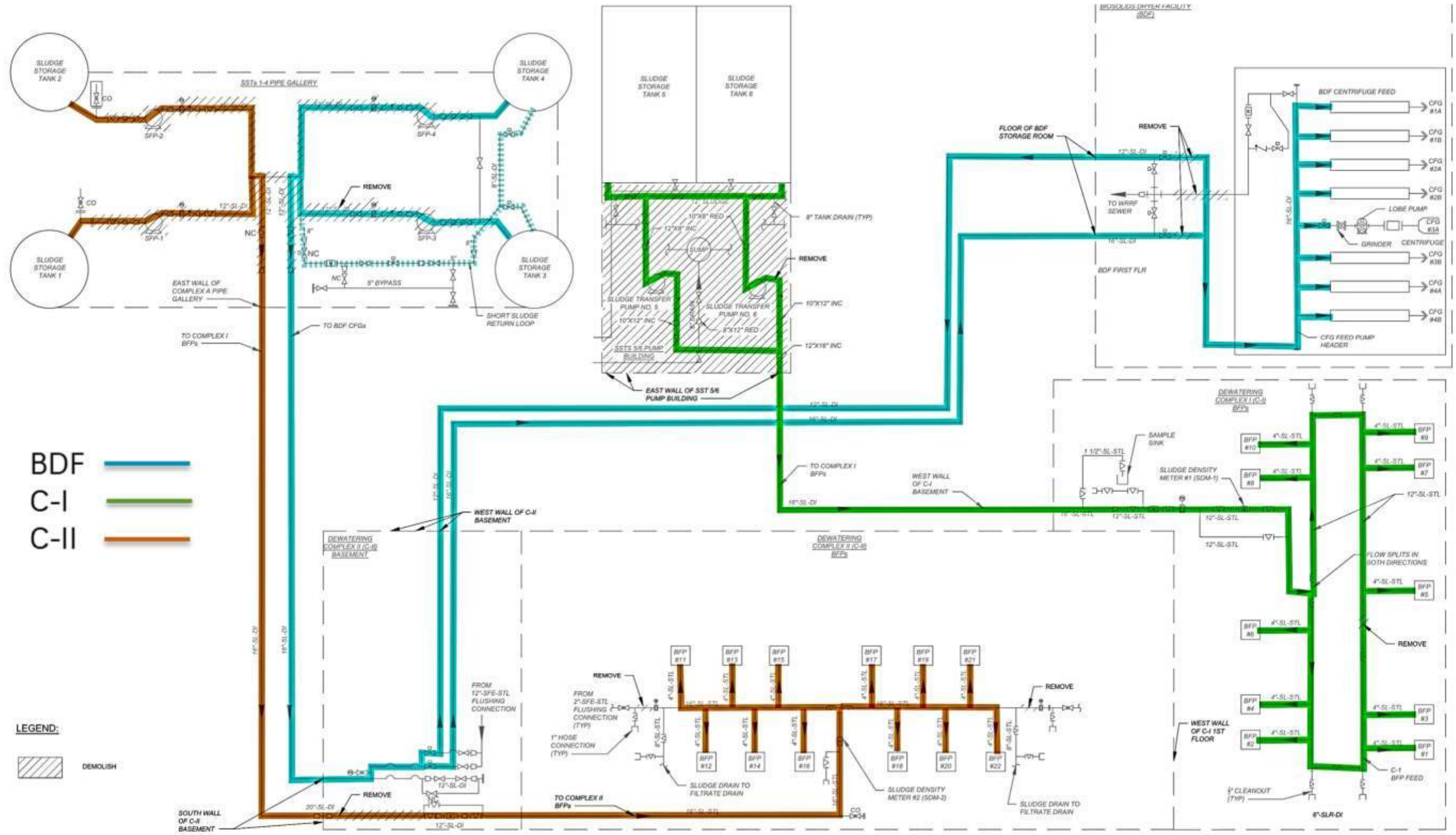


Figure 3.1: Existing Process Flow Schematic

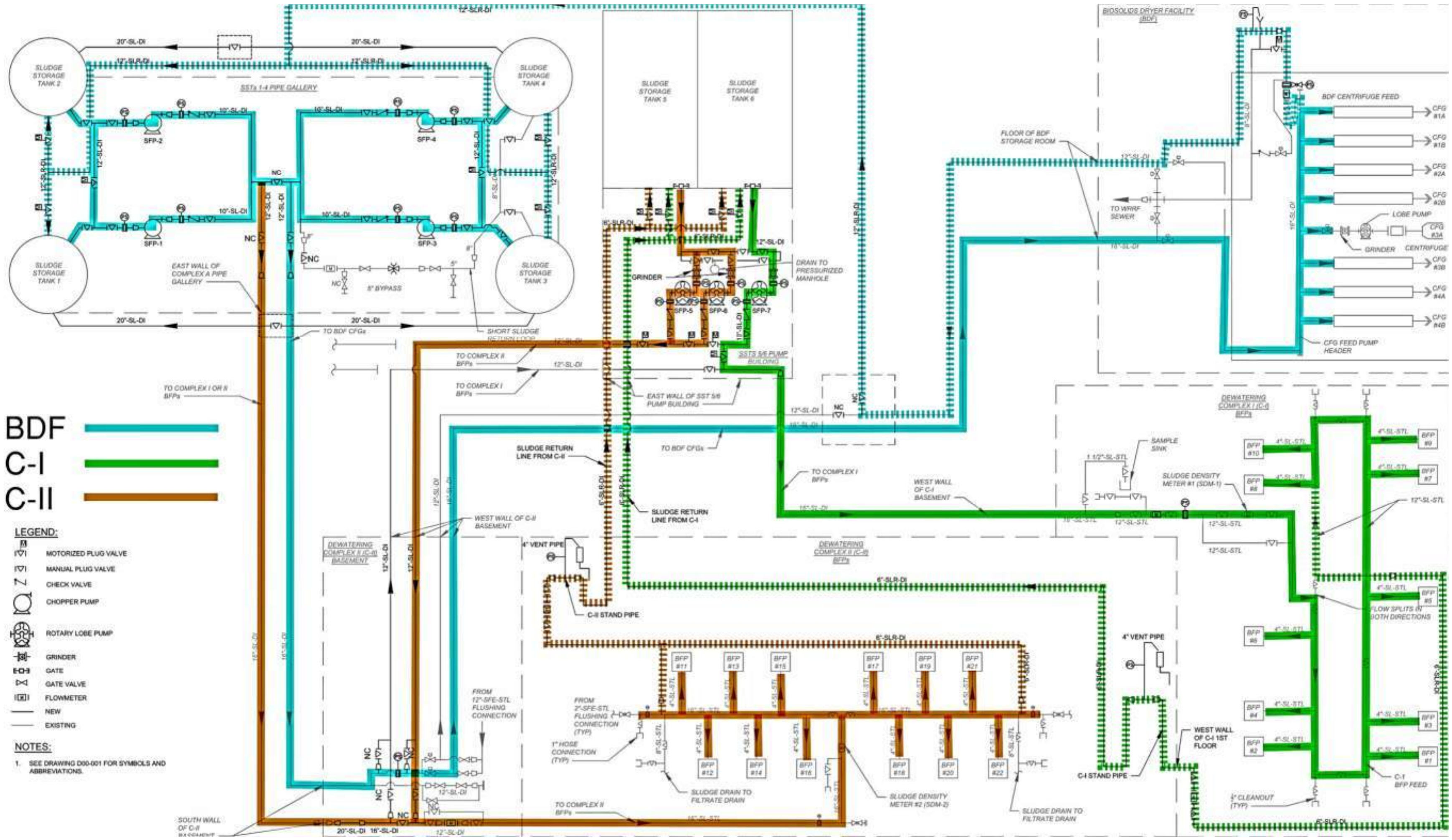


Figure 3.2: Proposed Process Flow Schematic

3.2.3 Soil and Erosion Control

Project site work is limited to excavation associated with installation of yard piping and valve vaults. Soil erosion and sedimentation control details were developed and are provided in **Figure 3.3**.

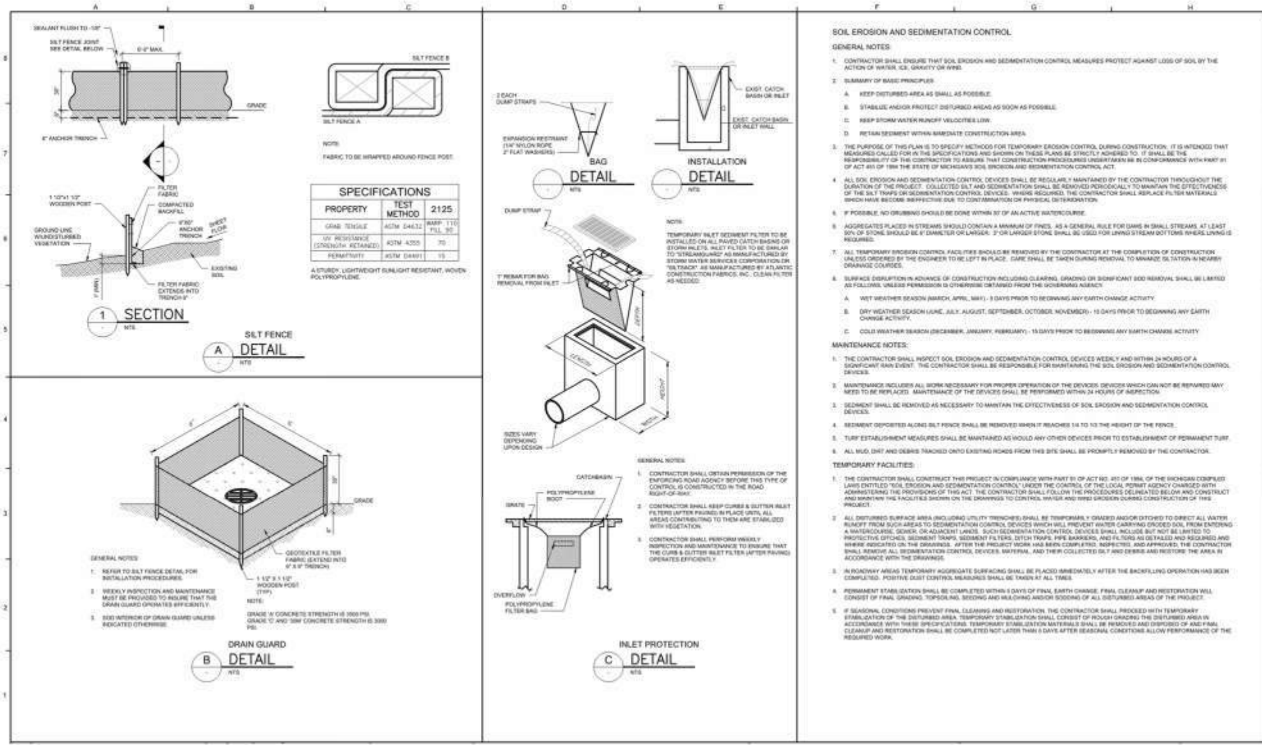


Figure 3.3 – Soil Erosion and Sedimentation Control Details

3.2.4 NPDES Permit Requirements

WRRF's current NPDES permit (Permit No. MI0022802 dated July 2019) requires the plant's solids handling processes to meet the following capacity requirements:

- Average capacity of 500 dry tons per day (dtpd), calculated as a calendar monthly average.
- Peak capacity of 850 dtpd, calculated as a 10-day average. NOTE – EGLE has indicated that this NPDES element is no longer required and will be removed from future NPDES updates.

There are no specific requirements on the flow rates or percent solids of the feed sludge to the dewatering facilities. The NPDES permit requires WRRF to:

- Maintain a monthly average solids inventory of less than 750 dtpd, when there are less than 5 days of discharge from the Detroit River outfall (Point 049A) during the month and maintain a calendar quarterly average solids inventory not to exceed 1,000 dtpd. Solids inventory is defined as the total solids in the Complex A and B gravity thickeners, determined daily in dtpd.
- Notify EGLE within one business day if solids are recycled from the gravity thickeners to the head of the WRRF for more than 72 hours and provide an explanation for the recycled solids. Recycled solids are defined as a total suspended solids (TSS) overflow concentration of 1,000 mg/l or greater from the Complex A thickeners.

- At least 10 days in advance of scheduled maintenance and within 24 hours after initiation of diversion due to emergency conditions, the permittees shall notify EGLE of the reason for the diversion and the expected duration of the diversion.

The proposed improvements as part of this project are designed to meet or exceed the NPDES requirements.

3.3 Proposed Improvements

3.3.1 SSTs 1-4 Pipe Gallery (BDF Sludge Feed Pumps)

Proposed improvements include replacement and reconfiguration of equipment and appurtenances associated with the sludge feed system and its support systems.

Improvements include:

- Provide four chopper pumps dedicated to conveying sludge from SSTs 1-4 to the BDF CFGs under normal operating conditions. These pumps will also serve as primary backup to convey sludge to the C-I BFPs if needed during a BDF outage.
- Provide two seal water booster pumps to boost Low Pressure Secondary Water pressure to feed the SFP seal water assemblies.
- Provide seal water assemblies for each sludge feed pump.
- Provide New 20-inch ductile iron tank interconnection pipes on the east and west sides of the pipe gallery in the yard to connect each pair of SSTs (SSTs 2/4 and SSTs 1/3). 20-inch plug valves in valve vaults will be provided on each line to isolate the SST pairs when needed.
- Provide flooding mitigation sump with duplex sump pumps.

3.3.2 SSTs 5/6 Pump Building (C-I and C-II Sludge Feed Pumps)

Proposed improvements include replacement and reconfiguration of equipment and appurtenances associated with the sludge feed system and its support systems.

Improvements include:

- Provide three rotary lobe pumps to convey sludge from SSTs 5/6 to the C-I and C-II BFPs.
- Provide seal water assemblies for each sludge feed pump.
- Provide three grinders, one on suction side piping of each SFP.

3.3.3 Sludge Conveyance Loops

Providing return sludge lines from the end of each existing sludge header back to the SSTs (resulting in a full sludge loop) is one of the project objectives. Sludge modeling and hydraulic analysis was performed to determine that the return excess sludge can be conveyed back to the SSTs by the SFP line pressures with no intermediate pumping or return sludge wells required.

Design of the sludge conveyance loops considered:

- Return sludge line sizing to ensure minimum required velocities are met to minimize solids settling.
- Minimizing low points or pipe traps where solids can accumulate.
- Providing flushing and drainage locations.
- Provisions provided on each sludge loop to maintain the required pressures at the dewatering equipment branch locations.
- Freeze protection in exposed piping locations.

3.3.3.1 BDF Sludge Conveyance Loop

- The existing 16-inch BDF sludge feed line will become the primary feed line for the sludge loop.
- The existing 12-inch BDF sludge feed line will be converted to an excess sludge return line for the sludge loop. Provisions will be provided to allow this 12-inch piping to serve as the feed line during an outage of the 16-inch primary feed line.
- A new valve vault north of SST-6 will be provided to house plug valves associated with the BDF sludge feed loop.
- A 12-inch ductile iron excess sludge return line will be provided from the 12-inch sludge lines at the valve vault to SSTs 1-4 to complete the return loop.
- The existing blowoff standpipe downstream of the centrifuge feed branches will be raised to provide a relatively constant and consistent backpressure on the BDF sludge feed header. The standpipe will be provided with a 4" vent extending through the building roof. Drainage piping will be provided at the vent opening on the roof to contain and convey any sludge overflow should the line become over pressurized. A radar level sensor will be provided to continuously monitor sludge level in the standpipe to be used as an early indicator of system issues and over pressurization.
- Provisions (return lines with manual throttling pinch valves) will be provided in the SSTs 1-4 Pipe Gallery to allow either BDF line (12" or 16") to be used to feed the BDF if either line needs to be removed from operation. This will result in the system temporary being operated similarly to how the system has been operated prior to the project improvements (i.e., no loop, "dead end" configuration).

3.3.3.2 C-I Sludge Conveyance Loop

- The existing 12 and 16-inch ductile iron feed line will remain and serve as the feed portion of the C-I sludge feed loop.
- A 6-inch ductile iron excess sludge return line will be provided from the sludge feed header in the C-I basement back to SSTs 5/6.
- A standpipe with an elevated open to atmosphere air intake/discharge vented through the roof will be provided on the C-II fourth floor. The top of the sludge return line standpipe will be set at an elevation of 164 feet to provide the required backpressure at the C-I BFPs. Drainage piping

will be provided at the vent opening on the roof to contain and convey any sludge overflow should the line become over pressurized. A radar level sensor will be provided to continuously monitor sludge level in the standpipe to be used as an early indicator of system issues and over pressurization.

3.3.3.3 C-II Sludge Conveyance Loop

- The existing 16-inch ductile iron feed line will remain and serve as the feed portion of the C-II sludge feed loop.
- A 6-inch ductile iron excess sludge return line will be branched from each end of the sludge feed header on the C-II fifth floor, combined, and routed back to the SSTs 5/6.
- A standpipe with an elevated open to atmosphere air intake/discharge vented through the roof will be provided in the C-II stairwell. The top of the sludge return line standpipe will be set at an elevation of 215 feet to provide the required backpressure at the C-II BFPs. Drainage piping will be provided at the vent opening on the roof to contain and convey any sludge overflow should the line become over pressurized. A radar level sensor will be provided to continuously monitor sludge level in the standpipe to be used as an early indicator of system issues and over pressurization.

3.3.4 Ancillary Improvements

3.3.4.1 Civil

- Valve vault and yard piping improvements required to implement the sludge conveyance loops.
- Concrete pavement, sidewalk, and curb removal and replacements to accommodate yard piping improvements.

3.3.4.2 Architectural

- Conversion of Complex A Instrumentation Shop to Sludge Complex A SFP Electrical Room to house the SFP 1-4 VFDs.
- Replacement of Complex A control console located in the Control Room.
- Replacement of Complex A Control and Telecom Room drop ceilings to accommodate HVAC and lighting replacements.
- Re-coating of walls in SFP process areas.
- Miscellaneous wall and roof penetration repairs and weatherproofing.

3.3.4.3 Structural

- Installation of a sump in SSTs 1-4 Pipe Gallery for flooding mitigation sump pumps.
- Installation of vaults in SSTs 1-4 Pipe Gallery to accommodate below slab process piping.
- Concrete column modifications in SSTs 5/6 Pump Building to accommodate pump layout.
- First floor slab modifications in SSTs 5/6 Pump Building to provide access to equipment located in basement.

- Minor modifications associated with equipment pads and equipment lifting devices.

3.3.4.4 HVAC and Plumbing

- Replacement of HVAC equipment serving SSTs 1-4 Pipe Gallery, SSTs 5/6 Pump Building, SFP Electrical Room, and Control and Telecom Rooms.
- Replacement of SSTs 5/6 Pump Building sump pumps.
- Minor process drainage improvements including widening of trench drain in SSTs 5/6 Pump Building and modifications to drain piping network in SSTs 1-4 Pipe Gallery to accommodate new vaults.

3.3.4.5 Electrical and I&C

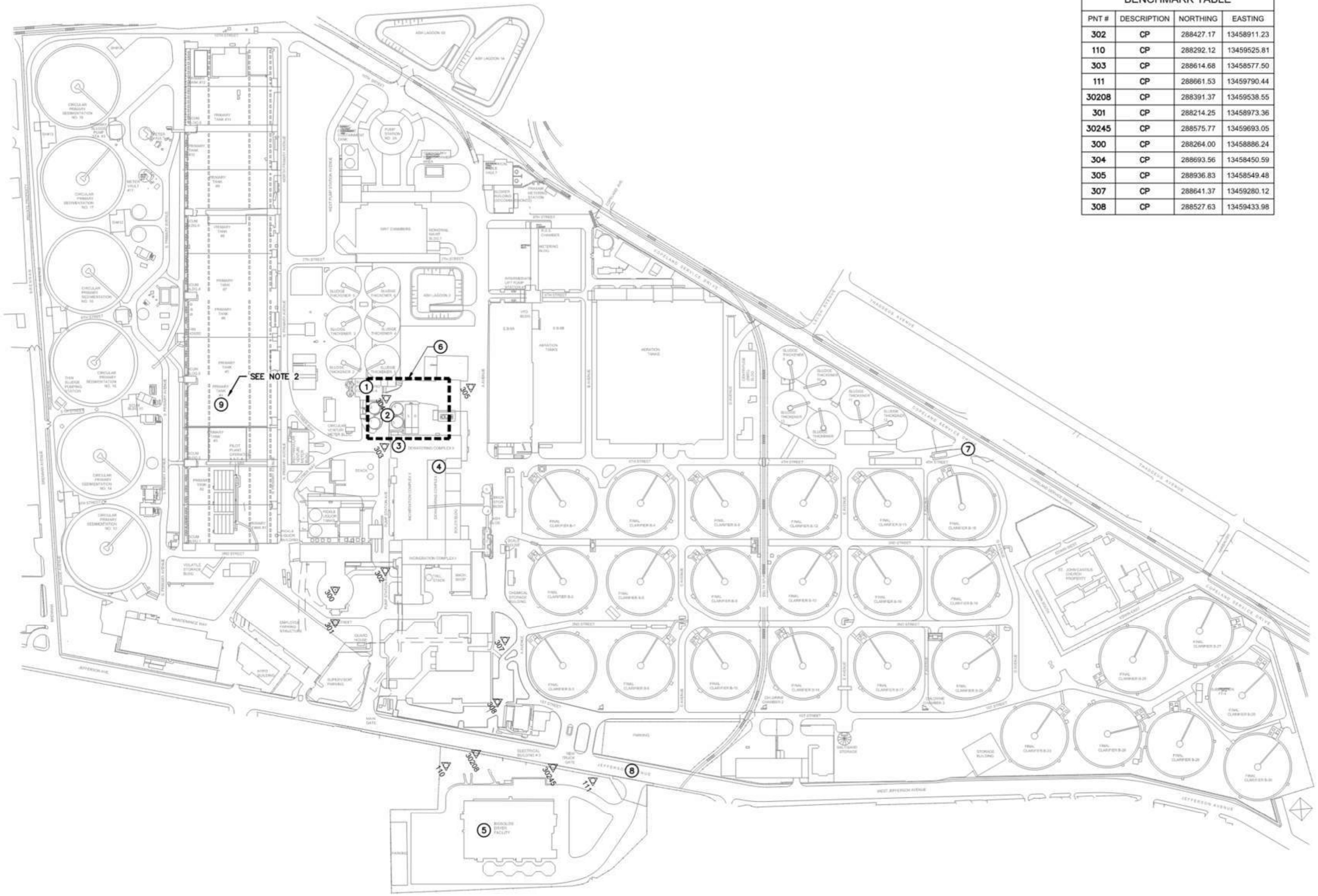
- Power and control improvements associated with upgrades required to implement the process mechanical improvements.
- New VDFs to be provided and located at grade level.
- Upgrades to electrical distribution equipment including new MCCs and modifications to existing MCCs.
- Lighting improvements in the SSTs 1-4 Pipe Gallery, SSTs 5/6 Pump Building, Control Room, Telecom Room, and SFP Electrical Room.
- Replacement of sludge storage tank ultrasonic level sensors with radar level sensors.
- Sludge conveyance loop instrumentation to allow for monitoring and diagnostics of sludge feed system.
- Modifications to the sludge feed system pump control methodology to improve ease of operation, system reliability, and flexibility.

3.4 Useful Life

The design useful life of the project is determined using a weighted average, calculated as the sum of each asset's dollar value times its estimated useful life, divided by the total estimated dollars spent on assets. The design life of this project is calculated to be 30.3 years. Thus, a 30-year SRF loan is requested.

3.5 Project Maps

The Water Resource Recovery Facility located at 9300 W. Jefferson, Detroit, MI 48209. Graphics showing the location and an aerial view of the WRRF are shown in **Figure 1.1** and **Figure 1.2**. A Site Plan of the WRRF and BDF is shown in **Figure 3.4**. All work associated with this project will occur at the WRRF and BDF facilities.



BENCHMARK TABLE			
PNT #	DESCRIPTION	NORTHING	EASTING
302	CP	288427.17	13458911.23
110	CP	288292.12	13459525.81
303	CP	288614.68	13458577.50
111	CP	288661.53	13459790.44
30208	CP	288391.37	13459538.55
301	CP	288214.25	13458973.36
30245	CP	288575.77	13459693.05
300	CP	288264.00	13458886.24
304	CP	288693.56	13458450.59
305	CP	288936.83	13458549.48
307	CP	288641.37	13459280.12
308	CP	288527.63	13459433.98

PROJECT WORK AREAS AND CODED NOTES:

(1) SLUDGE PROCESSING COMPLEX A

(2) SSTS 1-4 PIPE GALLERY (BELOW GRADE) AND SLUDGE STORAGE TANKS

(3) DEWATERING COMPLEX II (C-II)

(4) DEWATERING COMPLEX I (C-I)

(5) BIOSOLIDS DRYER FACILITY (BDF)

(6) SEE SHEET C01-102 FOR ENLARGED PARTIAL SITE PLAN.

(7) CONTRACTORS SHALL ACCESS THE WRRF SITE VIA THE JEFFERSON AVE COPELAND SERVICE DRIVE ENTRANCE.

(8) CONTRACTORS SHALL ACCESS THE BDF SITE VIA THE JEFFERSON AVE ENTRANCE. (COORDINATE WITH FACILITY OWNER AND OPERATOR)

(9) CONTRACTORS DESIGNATED PARKING AND STAGING AREA.

NOTES:

1. VERTICAL DATUM IS CITY OF DETROIT VERTICAL CONTROL SYSTEM (1960 ADJUSTMENT). DATUM CAN BE CONVERTED TO NAVD88 BY ADDING 479.215 FEET.
2. CONTRACTOR TO SUBMIT DELIVERY, STAGING, AND REMOVAL PLANS FOR ENGINEERS' REVIEW. THE PLAN SHALL INCLUDE STRUCTURAL EVALUATION FOR STATIC AND DYNAMIC LOADS ASSOCIATED WITH DELIVERY AND STAGING OF MATERIALS AND TEMPORARY FACILITIES. THE PLAN SHALL DEMONSTRATE COMPLIANCE WITH THE MAXIMUM ALLOWABLE VEHICLE AXLE LOAD OF 3,000 LBS AND DISTRIBUTED LOAD OF 200 LB/SQFT. FOR ANY ITEMS THAT COULD NOT COMPLY WITH THE MAXIMUM ALLOWABLE LOADS, OWNER WILL PROVIDE ADDITIONAL SITES WITHIN A 2-MILE RADIUS OF WRRF UPON CONTRACTOR'S REQUEST.

Figure 3.4 – WRRF and BDF Site Plan

3.6 Water and Energy Efficiency

Components of the project are designed to incorporate energy and water usage efficiency. All process water demands including seal water, washdown, and flushing connection locations will be met using water reused from the WRRF's secondary water source. Pipe flushing durations and frequencies are expected to be reduced based on a reduction in solids settlement in the pipelines resulting from increased flowthrough velocities. The sludge feed pumps will be replaced with lower horsepower pumps designed to operate at higher efficiencies. Unnecessary sludge feed header pressure spikes, and associated energy inefficiencies, due to operational challenges associated with the existing system will be eliminated with implementation of the sludge conveyance loops. Additional energy required to return excess sludge through the loop will benefit the system by providing additional recirculation and mixing of the sludge storage tanks. Overall, the net energy usage associated with the improved sludge feed system is expected to be neutral or a slight improvement from the existing system. However, the system will operate at a higher efficiency with overall system benefits. Additional energy efficiencies will be realized in the replacement of aging HVAC equipment and replacement of area lighting fixtures with high efficiency LED lighting.

3.7 Schedule for Design and Construction

A preliminary schedule for design and construction of the selected alternatives is presented in **Table 3.5**:

Table 3.5 – Proposed Project Schedule

Project Milestone Description	Actual/*Projected* Dates
Design Contract Start	3/15/2023
Construction Document Ready for Bid	*4/4/2025*
Construction Notice to Proceed	*3/16/2026*
Construction Substantial Completion	*11/17/2028*
Construction Final Completion	***5/17/2029***

3.8 Cost Summary

Construction cost for the rehabilitation of sludge feed system at the WRRF per the recommended rehabilitation method is estimated to be $19,000,000, which is a Class 1 estimate for budgetary purposes as defined by the American Association of Cost Engineering International. The cost carries an expected accuracy range of (-) 10% to (+) 15 percent.

In addition to the construction cost, the total project cost also includes:

- Design: $3,600,000
- Construction Administration: $1,750,000

The total project cost is $24,350,000.

The CWSRF loan is anticipated to be financed for a 30-year term at 2.75 percent interest. The equivalent annual cost for this project is determined using the following equation:

$$A = PW * \left[\frac{i * (1+i)^n}{(1+i)^n - 1}\right]$$

Where:

$$A = Equivalent\ Annual\ Cost$$

$$PW = Present\ Worth = Total\ Project\ Cost = \$24{,}350{,}000$$

$$i = SRF\ Interest\ Rate = 2.75\%$$

$$n = Term\ of\ SRF\ Loan = 30\ years$$

Therefore, the equivalent annual cost is $1,200,000.

The number of households that will be impacted by this project is estimated to be 1.16 million. The per household unit cost is thus $1.04 per year.

3.9 Implementability

The WRRF is owned and operated by GLWA. GLWA is a regional utility with broad statutory authority. GLWA has entered contracts with its suburban customers, which establish the terms and conditions for receiving and treating wastewater and overseeing the operation and maintenance of the system. GLWA has substantial experience in the financing of capital improvements under a variety of programs. It has a proven track record for using system revenues to retire its debt on new facilities and projects. GLWA is responsible for the legal, financial, and managerial aspects of the WRRF and will be the loan applicant for the proposed project.

4.0 Environmental and Public Health Impacts

Formal contact with SHPO, THPO, USFWS, MNFI, and EGLE Water Resources Division will be made to review potential beneficial and adverse effects of the project to the environmental and/or public health.

4.1 Direct Impacts

Direct impacts are environmental impacts directly attributed to the construction and operation of the project. The effects of the proposed project on environmental factors have been analyzed.

The WRRF Improvements to the Sludge Feed System for Solids Processing project will not have any direct negative impacts to the environment and public. In general, the project is creating improvements to the existing system and negative impacts during construction to the environmental and public will be minimal and confined. Completion of the project will result in additional system flexibility, redundancy, and resiliency which is critical to maintaining the quality of the WRRF effluent discharge to the Rouge River.

The project is located within existing facilities at the WRRF and BDF sites. Disturbance of traffic patterns outside of the fence lines are not anticipated. Excavation for yard piping and vaults may temporarily disturb soil and alter drainage patterns, necessitating erosion control measures to prevent sediment runoff. The estimated cost per household annual user cost is $1.06 per year.

Non-performance of the project could result in direct impacts to the environment, namely the Rouge River. The sludge feed system is a critical step in the WRRF's ability to process solids and maintain the facility's solids throughput capacity. System failure could result in excessive solids buildup which could cause inefficiencies in the WRRF's treatment processes and potentially lead to poor effluent water quality, odor issues, and permit compliance issues.

4.2 Indirect Impacts

Indirect impacts resulting from the proposed project include temporary impacts to air and noise pollution. The most significant air quality impacts are associated with construction debris and dust. Additionally, heavy equipment and construction noise may pollute surrounding areas outside the sites. Temporary changes to the natural environment and aesthetics of the area during construction will be restored upon completion. The project's site work is located near the center of the WRRF. As a result, indirect impacts outside of the WRRF and BDF properties are not anticipated. Because the proposed project is confined to previously constructed sites, there are no anticipated impacts to the following:

- Changes in the rate, density, or type of development (residential/commercial/ industrial).
- Changes in land use (i.e., open space, floodplains, prime agricultural land, shorelands, forested areas, or other natural habitats).
- Changes in water quality due to facilitated development.
- Impacts on cultural, human, social, and economic resources.
- Resource consumption over the useful life of the project.

4.3 Cumulative Impacts

Cumulative impacts are those impacts to the environment which increase in magnitude over time, or those which result from individually minor but collectively significant actions taking place over time. There are no anticipated cumulative impacts that would increase over time.

5.0 Mitigation

Where impacts cannot be avoided, mitigation measures will be taken. These are described in the following sections.

5.1 Mitigation of Short-Term Impacts

The most significant short-term impacts will be on the surface and subsurface where excavation will take place for the installation of yard piping and associated valve vaults. Many mitigation techniques can be used to minimize construction impacts, including traffic and safety hazard control, dust control, noise control, and soil erosion and sedimentation control. Each of these will be included within the construction contract. Restoration and/or replacement of roads, vegetation, and utilities will also be handled within the construction contract.

5.2 Mitigation of Long-Term Impacts

It is not anticipated that there will be any long-term impacts at the construction site.

5.2.1 General Construction

Mitigation measures would be developed to ensure that sensitive environments will not suffer permanent damage. In locations proposed for construction, permits will be obtained, and complete mitigation measures outlined within the permit will be adhered to.

5.2.2 Siting Decisions

All improvements will be made at the existing WRRF and BDF within the footprint of the existing sites.

5.2.3 Operational Impacts

No new operational impacts are expected. Operation of the upgraded system is expected to improve ease of operation and operational flexibility. Odors, aerosols, and noise were not identified as major issues with this unit process and the upgrades included in this project will not affect these.

5.3 Mitigation of Indirect Impacts

The proposed project does not involve expansion of the facilities or implementation of a new treatment facility. The proposed work will not influence the rate of development, population density, zoning, or land use. Therefore, no direct impacts are foreseen as a part of this project.

6.0 Public Participation

The WRRF Improvements to the Sludge Feed System for Solids Processing is included in GLWA's current Capital Improvement Plan (CIP) which is available to the public at glwater.org/CIP. The CIP page includes system background and business case information as well as CIP project descriptions and general information.

6.1 Public Meeting

A Public Hearing for the WRRF Improvements to the Sludge Feed System for Solids Processing Project Plan will be held at the GLWA Water Board Building, online via Zoom Video conferencing, and through telephonic hearing. The intent of the Public Hearing meeting is to discuss the need for the project, principal alternatives, environmental impacts, description of the recommended alternative, and associated cost estimates and user chargers, and scheduling of the proposed project.

6.2 Public Meeting Advertisement

The Public Hearing will be advertised online on the GLWA website and the Michigan Chronicle and on print through the Detroit Legal News and Detroit Free Press newspapers fifteen days before the hearing date in accordance with SRF guidelines. Copies of the draft project plan detailing the proposed project will be available for public review.

6.3 Public Meeting Summary

The following topics will be discussed at the public hearing:

- Project background
- A description of the existing facilities
- Project Scope
- Project Benefits
- Proposed method of financing
- Comparison of environmental impacts for the principal alternatives
- The recommended alternative
- Proposed monthly user costs for the implementation of the recommended alternative for the average residential customer
- Project Schedule

7.0 Technical Considerations

The scope of this project work is limited to the WRRF sludge feed system and does not contain any elements relating to infiltration and inflow removal, sewer system evaluation, structural integrity of sewer lines, a fiscal sustainability plan, or special assessment district properties.

Appendix A: WRRF Wetland Map

WRRF Wetland Map

January 21, 2025

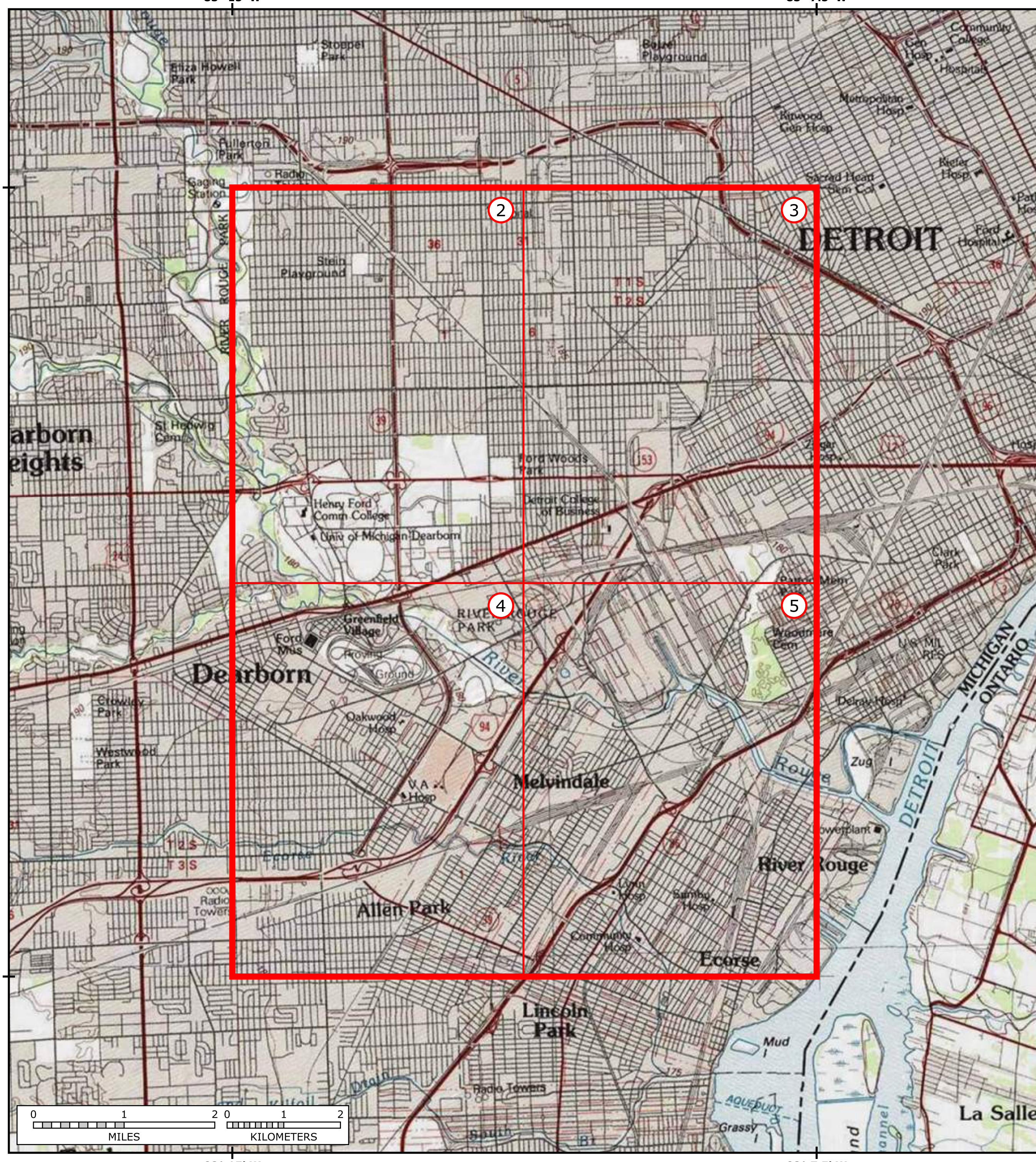
Wetlands

- Estuarine and Marine Deepwater
- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Other
- Riverine

This map is for general reference only. The US Fish and Wildlife Service is not responsible for the accuracy or currentness of the base data shown on this map. All wetlands related data should be used in accordance with the layer metadata found on the Wetlands Mapper web site.

Appendix B: Existing Topography USGS Quadrangle Maps

83° 15' W 83° 7.5' W



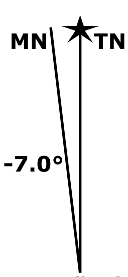
83° 15' W 83° 7.5' W

42° 22.5' N

42° 15' N

This map was created from a seamless mosaic of detailed USGS maps at topo.com

Refer to the pages indicated on the above index for detailed 7.5' series USGS maps. As with all maps, inaccuracies may exist and conditions may change. User assumes all risk associated with the use of this map.



2010 Declination

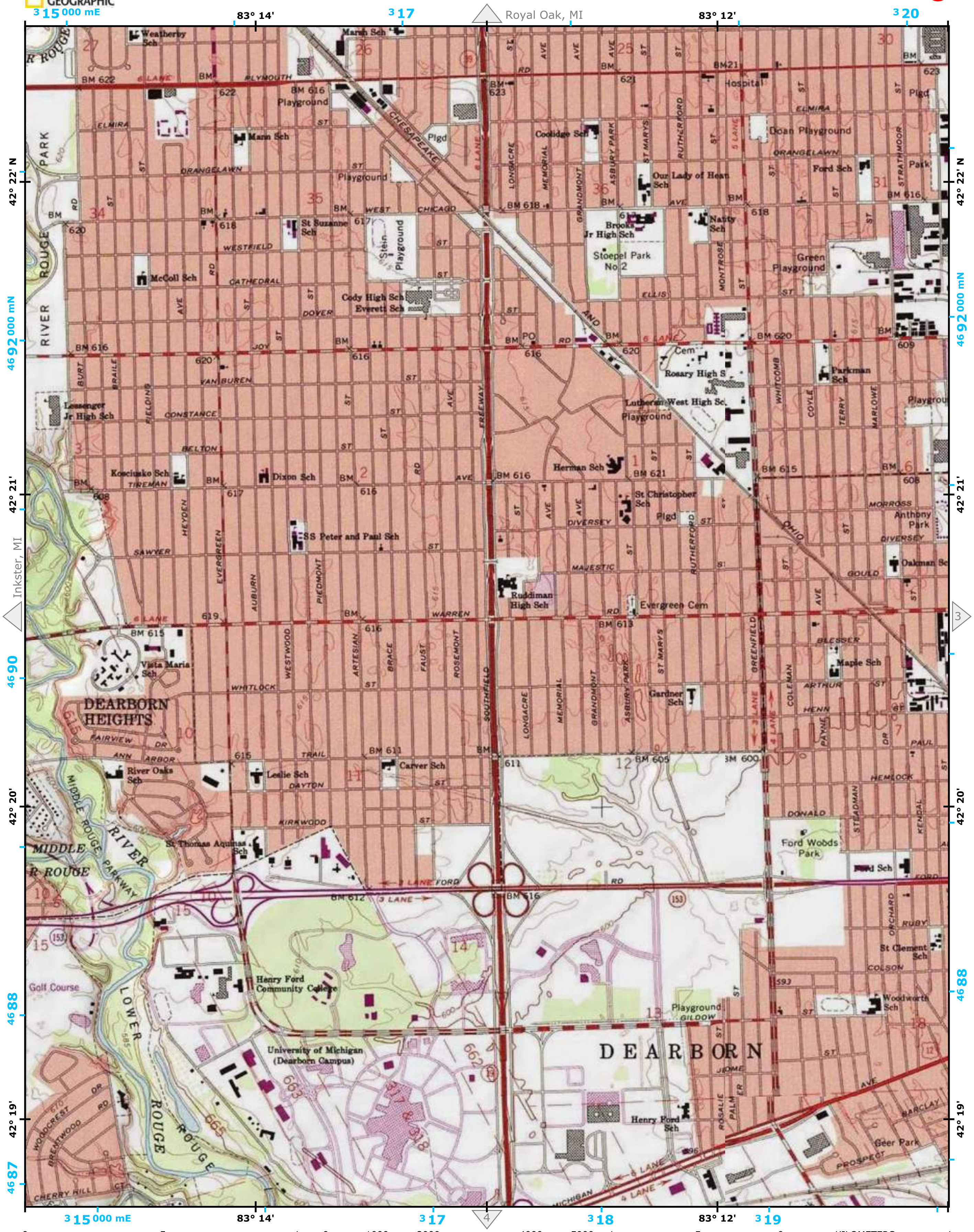
Michigan

USGS Revision Date: 1983
Contour Interval on 7.5' Maps: 5 ft

Adjoining 7.5' Quads

NW	N	NE
W	*	E
SW	S	SE

NW: Redford, MI
N: Royal Oak, MI
NE: Highland Park, MI
W: Inkster, MI
* Dearborn, MI
E: Detroit, MI
SW: Flat Rock NE, MI
S: Wyandotte, MI
SE: Wyandotte, MI



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Dearborn, MI

USGS 7.5' Map Series

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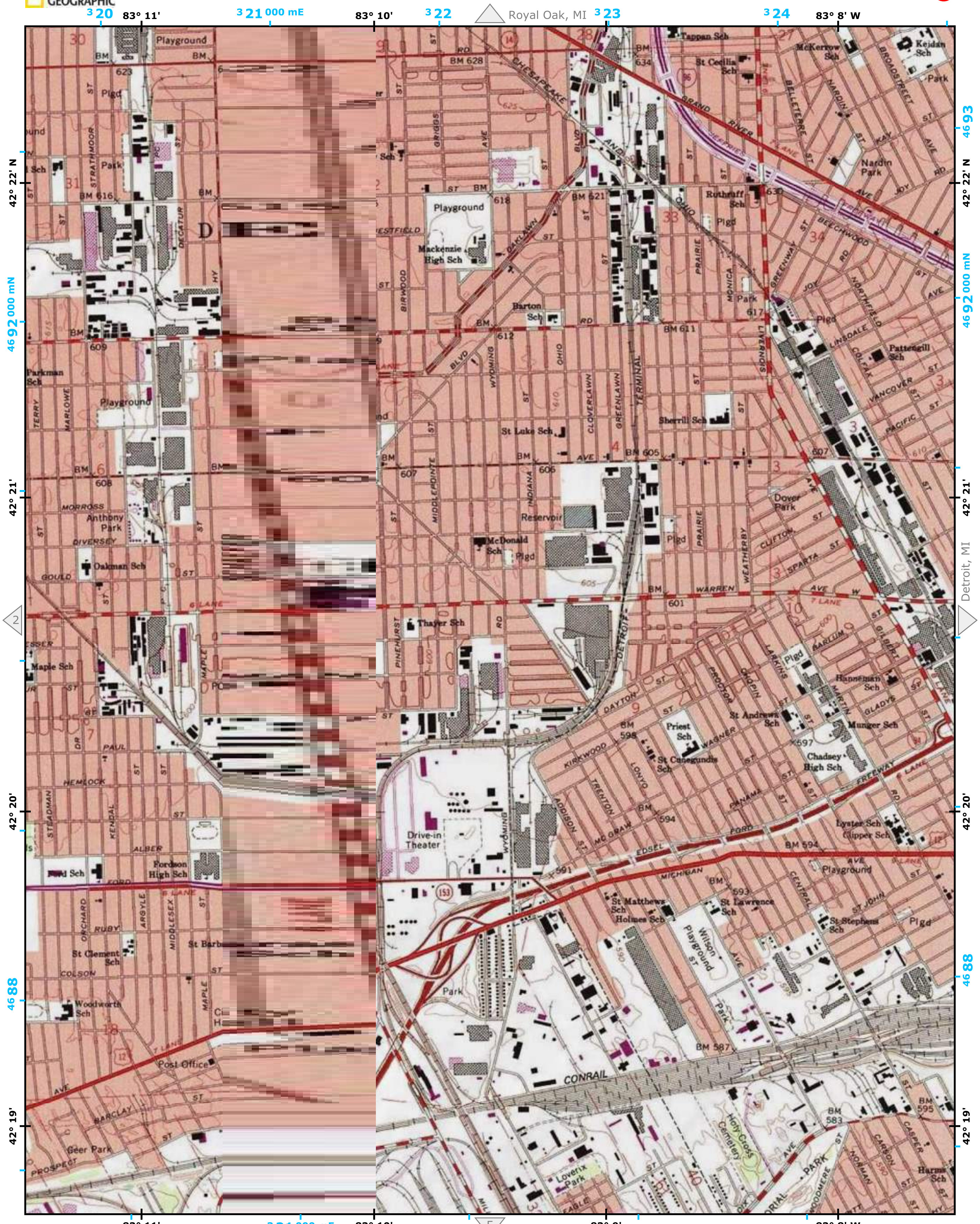

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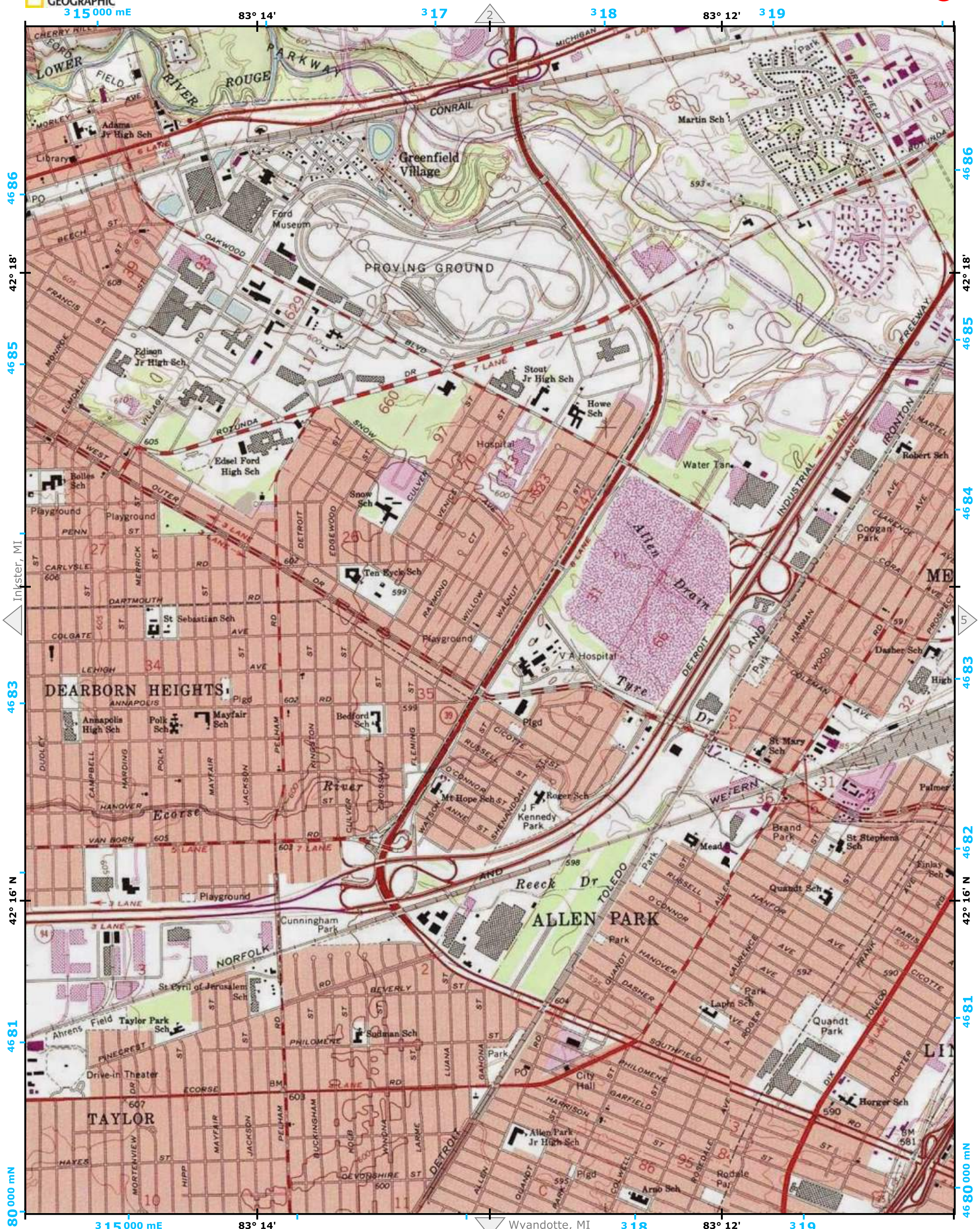

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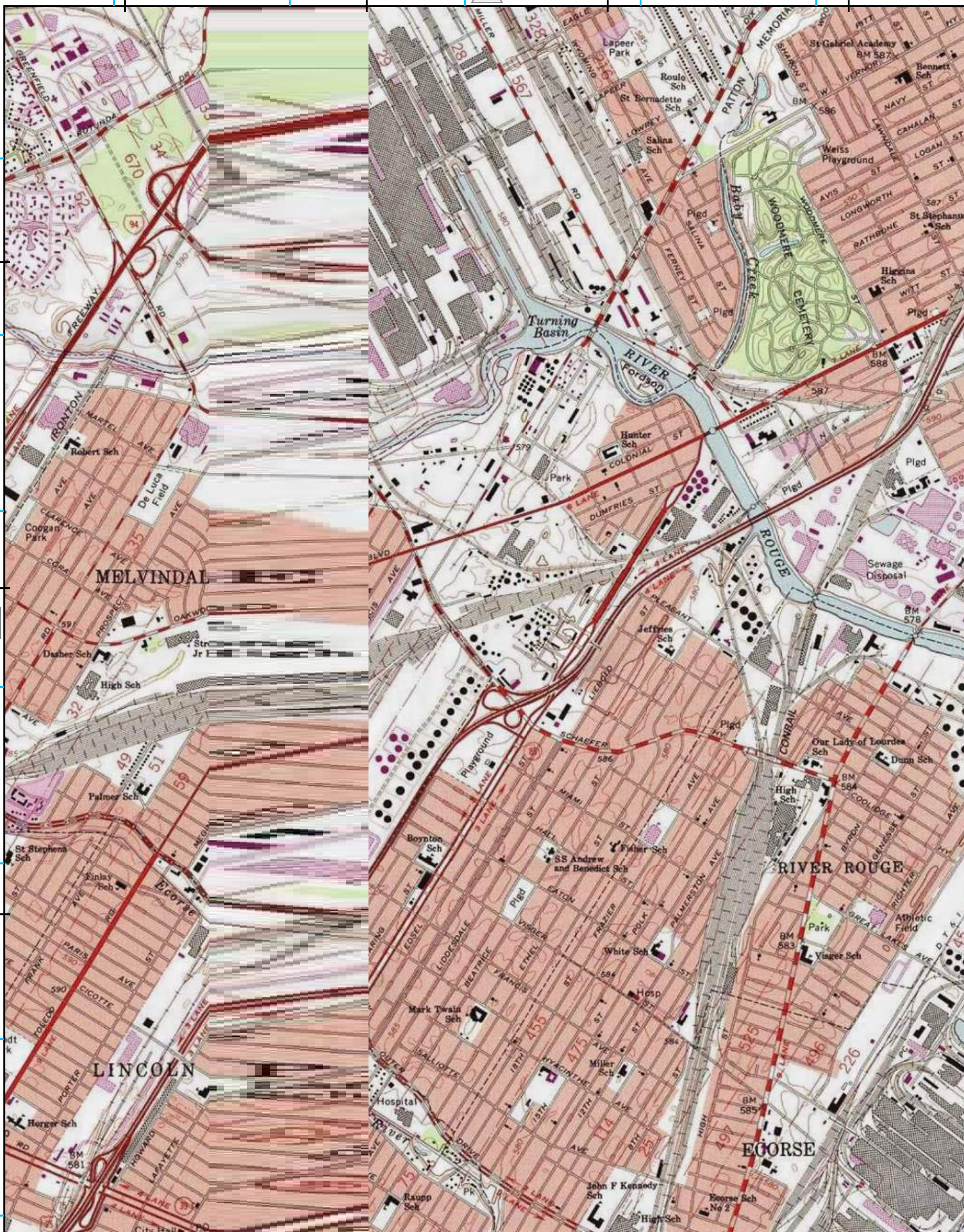

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Wyandotte, MI

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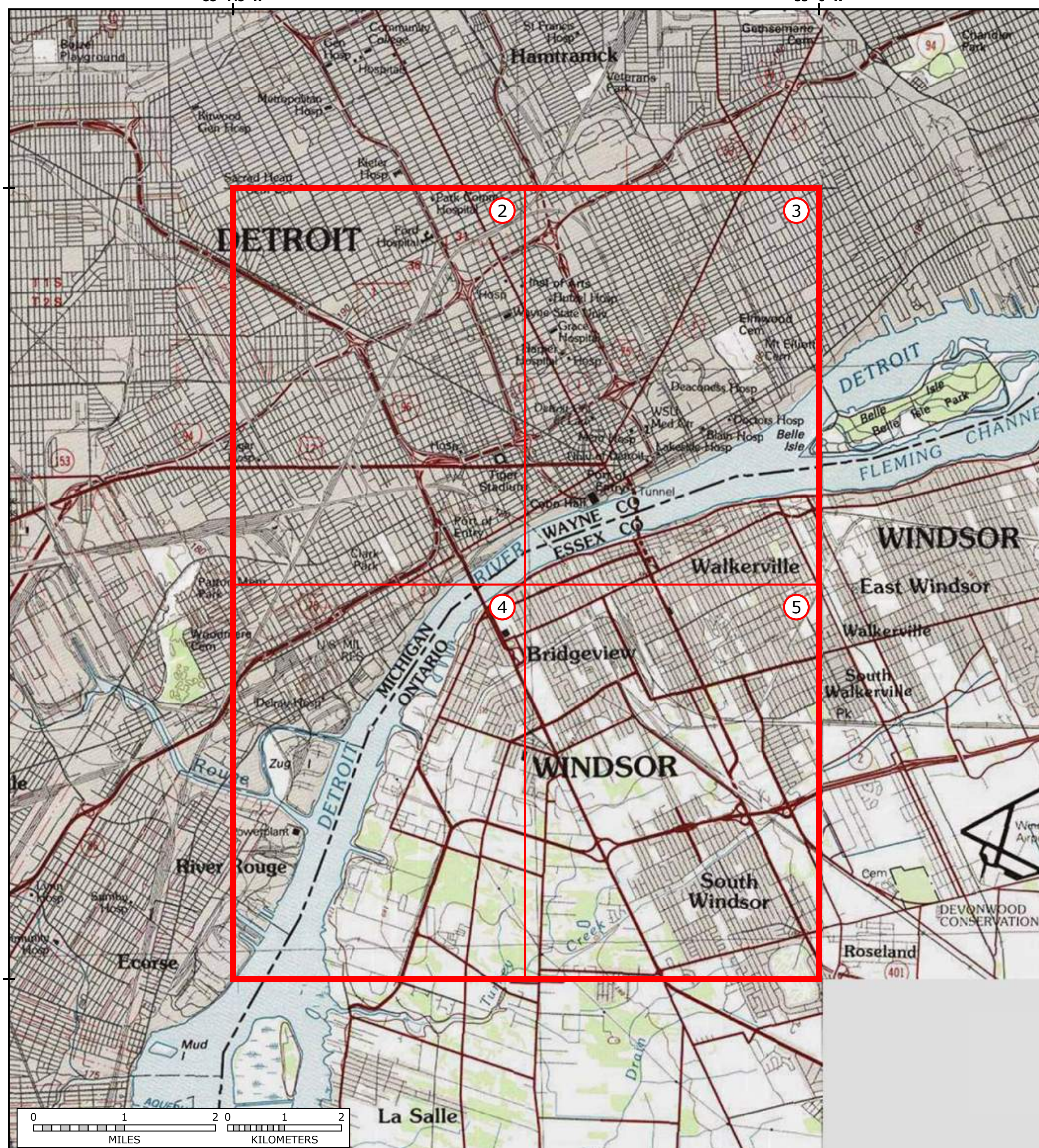
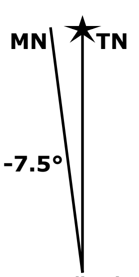


This map was created from a seamless mosaic of detailed USGS maps at topo.com

Refer to the pages indicated on the above index for detailed 7.5' series USGS maps. As with all maps, inaccuracies may exist and conditions may change. User assumes all risk associated with the use of this map.

NATIONAL GEOGRAPHIC USGS science for a changing world



2010 Declination

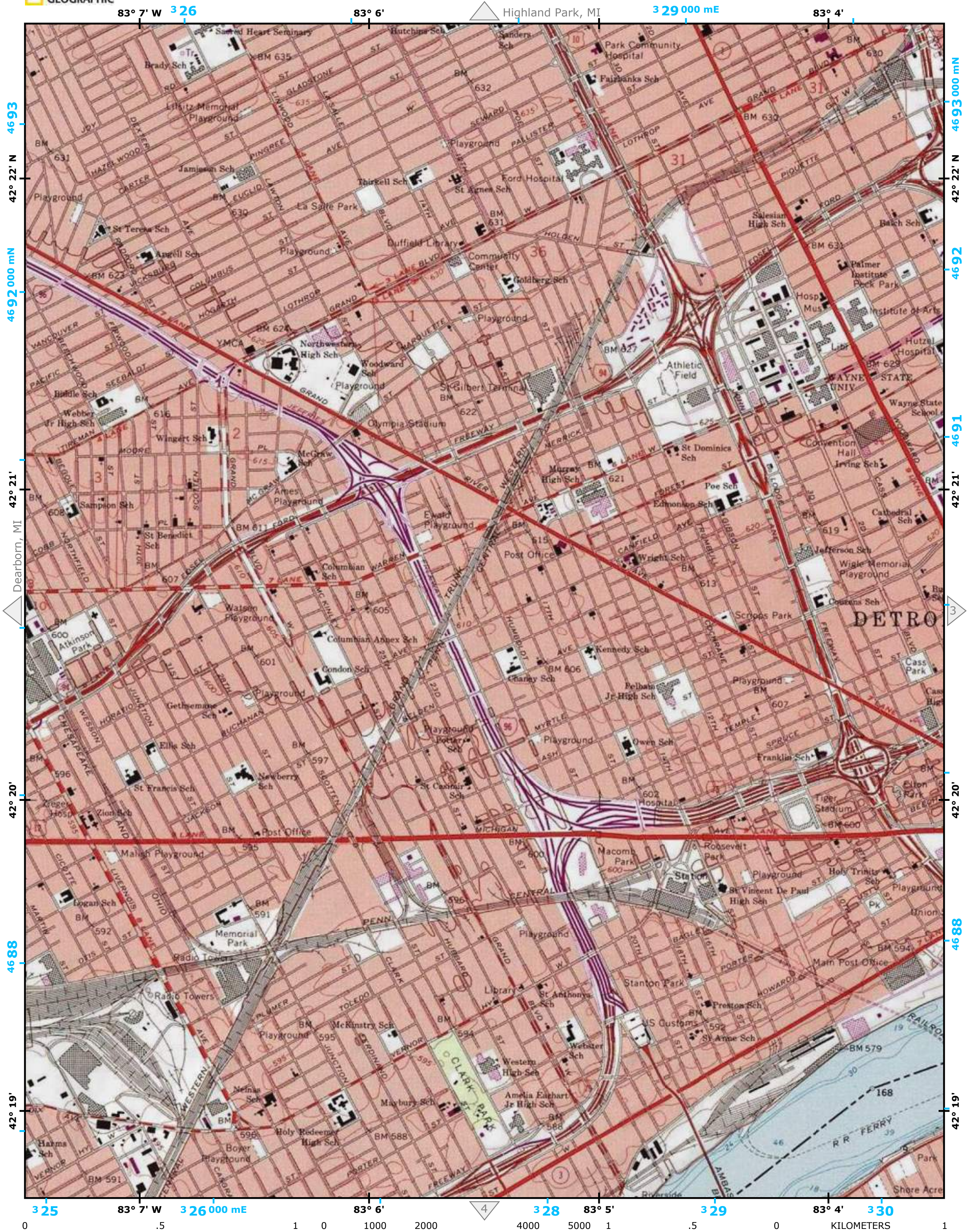
Michigan

USGS Revision Date: 1980
Contour Interval on 7.5' Maps: 5 ft

Adjoining 7.5' Quads

NW	N	NE
W	*	E
SW	S	SE

NW: Royal Oak, MI
N: Highland Park, MI
NE: Grosse Pointe, MI
W: Dearborn, MI
* Detroit, MI
E: Belle Isle, MI
SW: Wyandotte, MI
S: Wyandotte, MI
SE: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Brady Sch
Lilsitz Memorial Playground
Jamieson Sch
St Teresa Sch
Angell Sch
Playground
Thirkell Sch
St Agnes Sch
Ford Hospital
La Salle Park
Duffield Library
Community Center
Goldberg Sch
Park Community Hospital
Fairbanks Sch
Salesian High Sch
Balch Sch
Palmer Institute
Peck Park
Institute of Arts
Hutzel Hospital
WAYNE STATE UNIV
Wayne State School
Athletic Field
Northwestern High Sch
Woodward Sch
YMCA
St Gilbert Terminal
Olympia Stadium
Biddle Sch
Webber Jr High Sch
Wingert Sch
McGraw Sch
Ames Playground
Sampson Sch
St Benedict Sch
Ewald Playground
Murray High Sch
St Dominics Sch
Convention Hall
Irving Sch
Poe Sch
Edmonson Sch
Cathedral Sch
Post Office
Wright Sch
Jefferson Sch
Wigle Memorial Playground
Columbian Sch
Watson Playground
Atkinson Park
Columbian Annex Sch
Condon Sch
Chaney Sch
Kennedy Sch
Scripps Park
Cousens Sch
DETRO
Cass Park
Pelham Jr High Sch
Gethsemane Sch
Ellis Sch
Newberry Sch
St Francis Sch
St Casimir Sch
Potter Sch
Owen Sch
Franklin Sch
Tiger Stadium
Hospital
Zion Sch
Post Office
Maiga Playground
Macomb Park
Roosevelt Park
Station
St Vincent De Paul High Sch
Holy Trinity Sch
Logan Sch
Memorial Park
Radio Towers
Stanton Park
Main Post Office
Preston Sch
US Customs
St Anne Sch
St Anthonys Sch
Library
McKinstry Sch
Webster Sch
Western High Sch
CLARK PARK
Amelia Earhart Jr High Sch
Maybury Sch
Holy Redeemer High Sch
Bower Playground
Harms Sch
Shore Acres
RR FERRY
FREEWAY
GRAND RIVER
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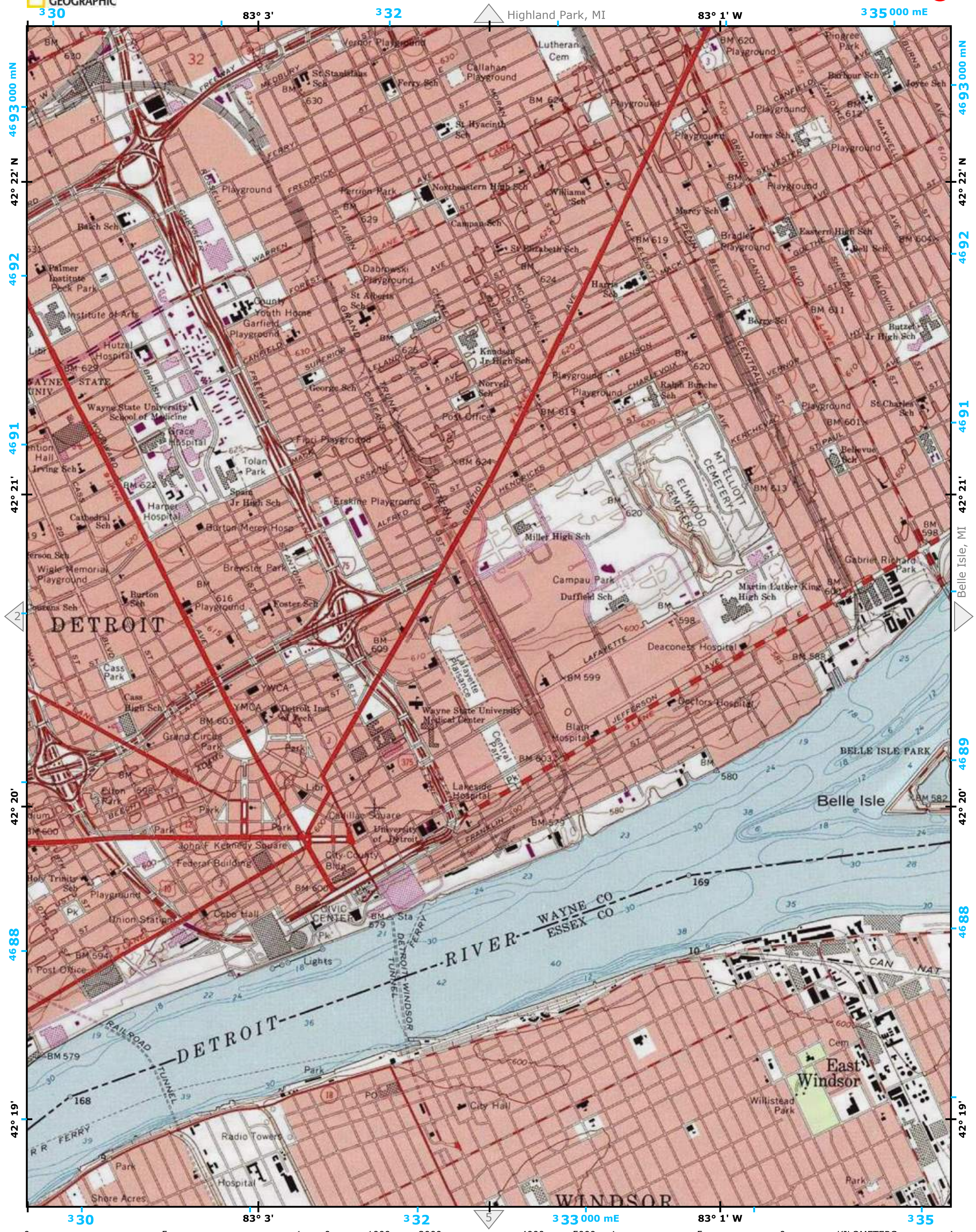

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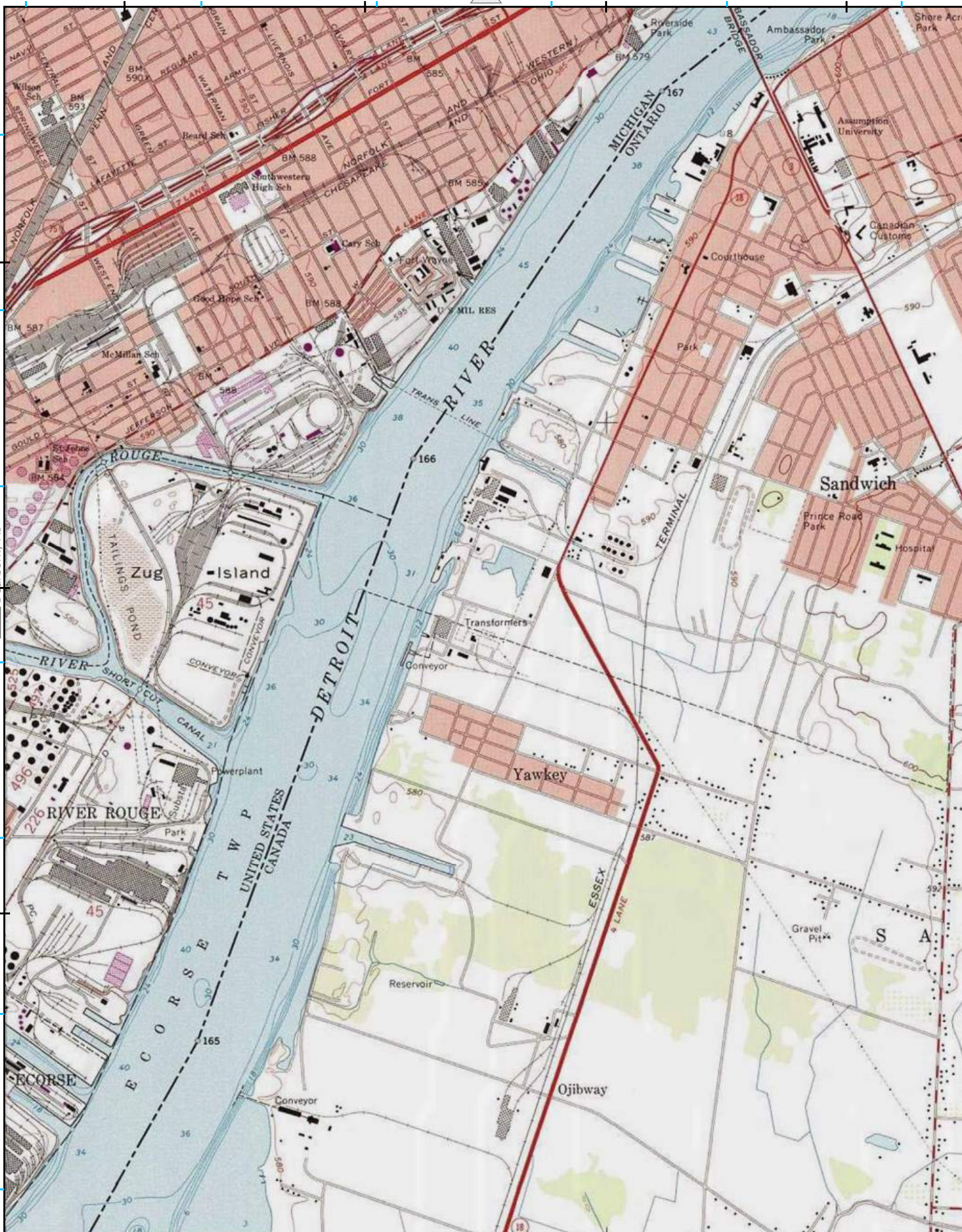
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42° 16' N
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ROUGE
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SHORT CUT CANAL
ECORSE
E C O R S E T W P
DETROIT
RIVER
UNITED STATES
CANADA
MICHIGAN
ONTARIO
AMBASSADOR BRIDGE
Riverside Park
Ambassador Park
Shore Acres Park
Assumption University
Canadian Customs
Courthouse
Park
Sandwich
Prince Road Park
Hospital
Transformers
Conveyor
Powerplant
Yawkey
Reservoir
Ojibway
Gravel Pit
ESSEX
TERMINAL
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Fort Wayne
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Southwestern High Sch
Good Hope Sch
Cary Sch
McMillan Sch
Beard Sch
Wilson Sch
St Johns Sch
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Appendix C: FEMA Flood Hazard Map

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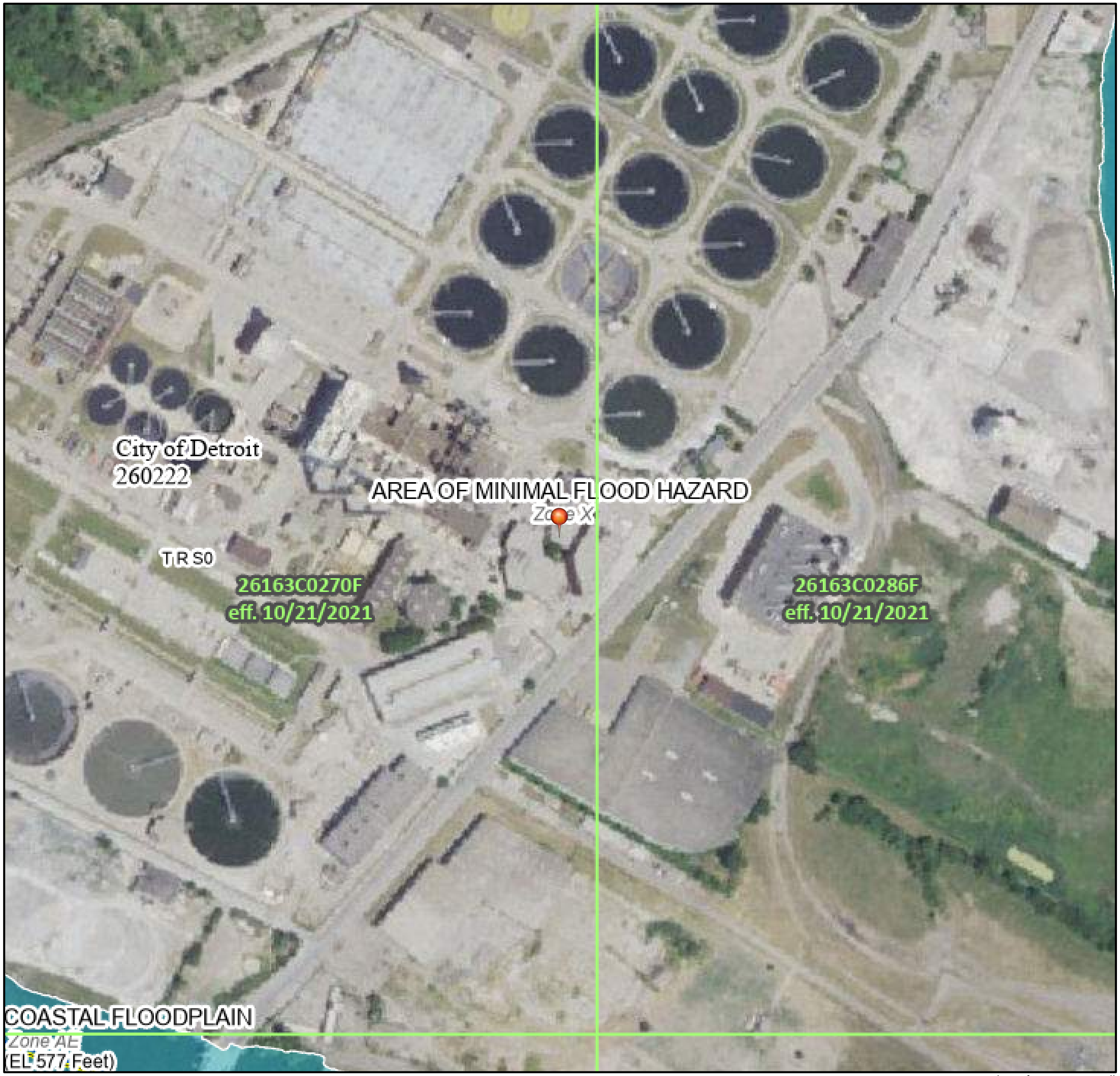

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Appendix D: TM-3 Existing Conditions

Technical Memorandum 3

To: *Jared Buzo, METCO*
Sham Sihabdeen, AECOM
Chris Wilson, GLWA

From: *Steve Wyman, CDM Smith*
Mohsen Sadatiyan, CDM Smith

Date: *September 8, 2023*

Subject: *Great Lakes Water Authority (GLWA)*
Contract No. 2202790 – Water Resource Recovery Facility (WRRF) Improvements to the Sludge Feed System for Solids Processing
TM-3 Existing Conditions

1.0 Purpose and Background

Great Lakes Water Authority (GLWA) owns and operates the Water Resource Recovery Facility (WRRF) located at 9300 W. Jefferson, Detroit, MI 48209. WRRF is a conventional activated sludge plant with a wet weather design capacity of 1,444 million gallons per day (MGD) and serves approximately one-third of the State of Michigan's population. This facility is one of the largest wastewater treatment plants in the world, with the capacity to treat up to 1,700 MGD through primary treatment and 930 MGD through secondary treatment.

Many of the components of the facility are 80 years old. In service for about 50 years, the majority of the process units were built and expanded in the 1970s. Influent pumping and a large portion of preliminary and primary treatment facilities went online in 1940, sludge incineration went online in the 1950s and 1970s, and secondary treatment was started in the 1970s with the advent of the Clean Water Act. The facility was expanded in the 1990s to treat flow from the Northern Interceptor–East Arm, with the construction of Pump Station No. 2 and associated preliminary treatment and optimized for wet weather flow in the early 2000s. The Biosolids Drying Facility went online in 2016, allowing the decommissioning of the Complex I incinerators. Disinfection of primary effluent was implemented in 2019.

WRRF generates solids through primary and secondary clarification. Solids handling processes include gravity thickening, blending, storage, dewatering, incineration, and drying treatment processes. Thickened primary sludge (TPS) and thickened waste activated sludge (TWAS) is blended prior to being discharged into six sludge storage tanks (SSTs). The sludge feed system, comprised of sludge feed pumps (SFPs), sludge piping, and flow control equipment, supplies thickened blended sludges from the SSTs to sludge dewatering equipment at three different dewatering facilities. These dewatering facilities include belt filter presses (BFPs) located in Sludge Dewatering Complex I (C-I); BFPs in Sludge Dewatering Complex II (C-II); and centrifuges (CFGs) in the Biosolids Drying Facility (BDF). Under normal operating conditions, BDF CFGs process 60 to 70 percent of WRRF's solids. BFPs in C-I and C-II are used to dewater the remaining sludge not processed by the BDF or when the BDF equipment is offline for maintenance. C-II is also equipped with CFGs which were discontinued by GLWA prior to 2018 in favor of utilizing the C-I and C-II BFPs to supplement dewatering at the BDF. Dewatered sludge from C-I and C-II is incinerated onsite and dried sludge from BDF is land-applied offsite.

The service life of many of the existing SFPs has been exceeded, and all SFP equipment and piping are understood to be oversized for the feed rates required at the dewatering facilities. Additionally, sludge feed piping "dead ends" at each of the dewatering facilities result in sludge feed header pressures that are difficult to maintain within the operating range required for the sludge flow control equipment at each piece of dewatering equipment. The end result of the aged pumping equipment, oversized sludge feed components, dewatering facility locations, and piping configurations is a sludge feed system that is difficult to operate and maintain.

This project, WRRF Improvements to the Sludge Feed System for Solids Processing (the Project), involves making improvements to the dewatering sludge feed pumping systems, improving drainage of SSTs 1-4, and mitigating flooding of the Sludge Processing Complex A basement. The scope includes conducting discipline-specific condition assessments and evaluations in order to recommend cost-effective upgrades and improvements to achieve robust, sustainable, and long-term upgrades while reducing maintenance efforts, improving operational flexibility, and maintaining treatment operations at all times. This assessment and evaluation work will be documented in technical memoranda (TMs). This document is Technical Memorandum 3 (TM-3) and covers the existing conditions of the project work areas.

The purpose of TM-3 is to summarize the existing conditions of the project work areas based on discipline specific assessments and input provided by GLWA Operations and Maintenance (O&M) staff. Process Mechanical, Structural, Electrical, Instrumentation and Control, HVAC, and Plumbing assessments were performed by the CDM Smith Team.

2.0 Site Survey and 3D Scanning

Spicer Group surveyors and laser scanning crew were onsite from April 25 through April 28, 2023 to conduct a site survey of the project area and perform 3D laser scanning of select project areas. The area surveyed included the site around SSTs 1-6, the existing underground pipe route between the SSTs and BDF, the west side of the BDF property, and the area north of the Screened Final Effluent (SFE) Pump Station as shown in **Figure 2-1**. Grade and structure elevations were measured and documented throughout the site survey.

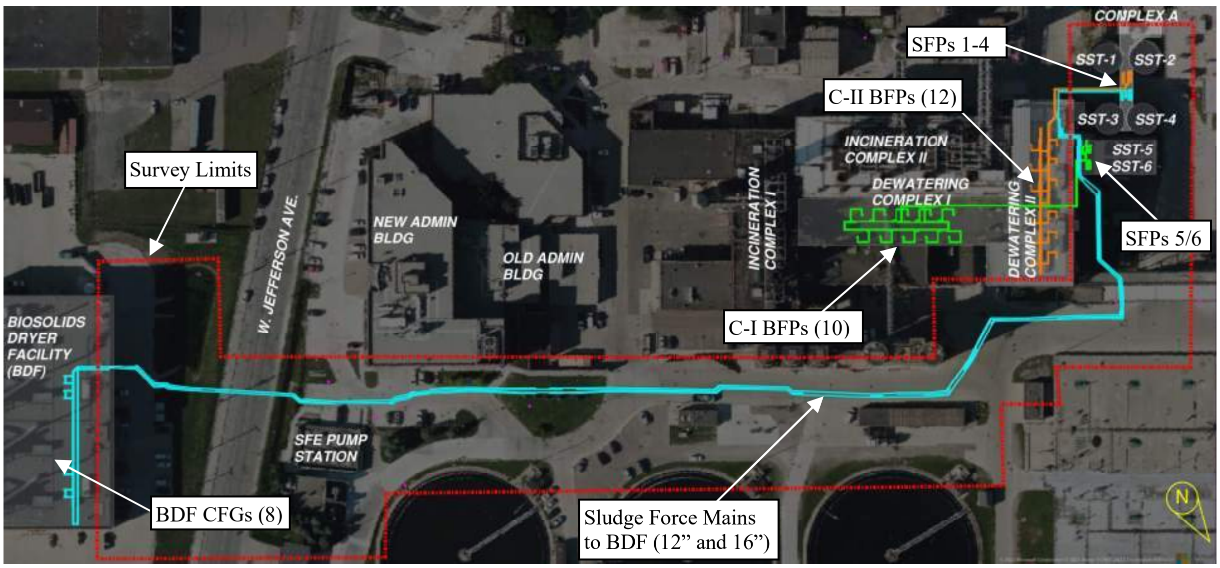


Figure 2-1: Limits of Site Survey

3D laser scanning was performed using a Leica RTC360 3D laser scanner capable of capturing precise data with a 3D point accuracy of 1.9 mm at a 10-meter distance. Laser scanning services were provided for the following project work areas:

- SSTs 1-4 Pipe Gallery
- Complex A Gallery (beneath the Electrical Room)
- Complex A Electrical Room
- Stair House No. 5
- SSTs 5/6 Pump Building
- Exterior of SSTs

Data from a total of 480 scanning locations was obtained to provide full coverage of the work areas listed above. Calibration and registration of the scanning data to a unified point cloud was performed to allow the collected information to be used for the project's BIM model development.

3.0 Existing Conditions Assessments

CDM Smith and METCO engineers were onsite on April 25, 2023 to perform Process Mechanical, HVAC, Plumbing, Structural, Electrical, and Automation assessments of the existing WRRF project work areas. Engineer(s) specializing in each discipline performed visual assessment of the overall condition for each work area at the time of the assessments. Observations and findings stemming from these assessments are documented in this TM-3.

4.0 Sludge Storage Tanks 1-4 (SSTs 1-4)

SSTs 1-4 are used to store blended thickened primary sludge (TPS) and thickened waste activated sludge (TWAS) prior to it being conveyed to the dewatering facilities for processing. The tanks were constructed in 1971 as part of Contract PC-241 and were originally equipped with center supported sludge collection equipment that has since been removed. The tanks are above/below grade, cylindrical, reinforced concrete structures with cone-shaped bottoms **(Figure 4-1)**. The dimensions of each tank and critical elevations are displayed in **Table 4-1.**

Figure 4-1: Sludge Storage Tank 3 (typical of SST 1-4)

Table 4-1: SSTs 1-4 Dimensions

Tank Name	Volume (gal)	Diameter (ft)	Maximum SWD/Elev. (ft)	Minimum SWD/Elev. (ft)	Top of Wall Elev. (ft)	Overflow Inv. Elev. (ft)	Outlet Pipe Inv. Elev. (ft)
SST-1	210,000	35	28/124	11/107[1]	126	124	90
SST-2	210,000	35	28/124	11/107[1]	126	124	90
SST-3	210,000	35	28/124	2/98[1]	126	124	90
SST-4	210,000	35	28/124	2/98[1]	126	124	90

[1] Based on operational data from 5/2020 - 5/2023

4.1 Process Mechanical Assessment

4.1.1 In-Tank Piping

Coarse bubble mixing systems are provided in SSTs 1-4 to keep solids in suspense. The mixing system for SSTs 1/2 includes three 60-horsepower (hp) blowers housed in a blower building south of SST-2, stainless steel air piping, and coarse bubble air diffusers at approximate elevation 97 ft. The mixing system for SSTs 3/4 includes three 60-hp blowers housed in a separate blower building south of SST-2, stainless steel air piping, and coarse bubble air diffusers at approximate elevation 97 ft. The blowers supplying air to SSTs 3/4 also supply air to the SSTs 5/6 mixing system. The air piping and diffuser arrangement varies between SSTs 1/2 and SSTs 3/4 as shown in **Figure 4-2**.

Figure 4-2: Mixing Air Piping and Diffuser Arrangement (SST-1 on top / SST-3 on bottom)

The 8-inch air headers from the blower buildings to the SSTs are concrete encased where they cross the top slab of the SSTs 1-4 Pipe Gallery just below Pump Station Avenue **(Figure 4-3)**.

Figure 4-3: Concrete Encased Air Piping above SSTs 1-4 Pipe Gallery (looking west)

Sludge is conveyed to each SST via an 18-inch blended sludge line. These pipes penetrate the tank walls from the SSTs 1-4 Pipe Gallery and are then routed vertically within the tanks to a discharge elevation of approximately 124 ft.

Limited visual assessments were performed on the in-tank piping for SSTs 1-4. Assessments were performed from the top of the tanks and limited to visible elements above the waterline for the tanks in service. The condition of the piping observed for the offline/drained tanks is considered representational of the in-service tanks. Overall, the condition of the in-tank piping is good with only minor surface corrosion observed in various locations.

4.1.2 Upstream/Downstream Piping

Blended TPS from Sludge Processing Complex A gravity thickeners and TWAS from Sludge Processing Complex B gravity thickeners is transferred to the blending location through two pressurized 16” lines. Process piping upstream and downstream of the SSTs is shown in **Figure 4-4**.

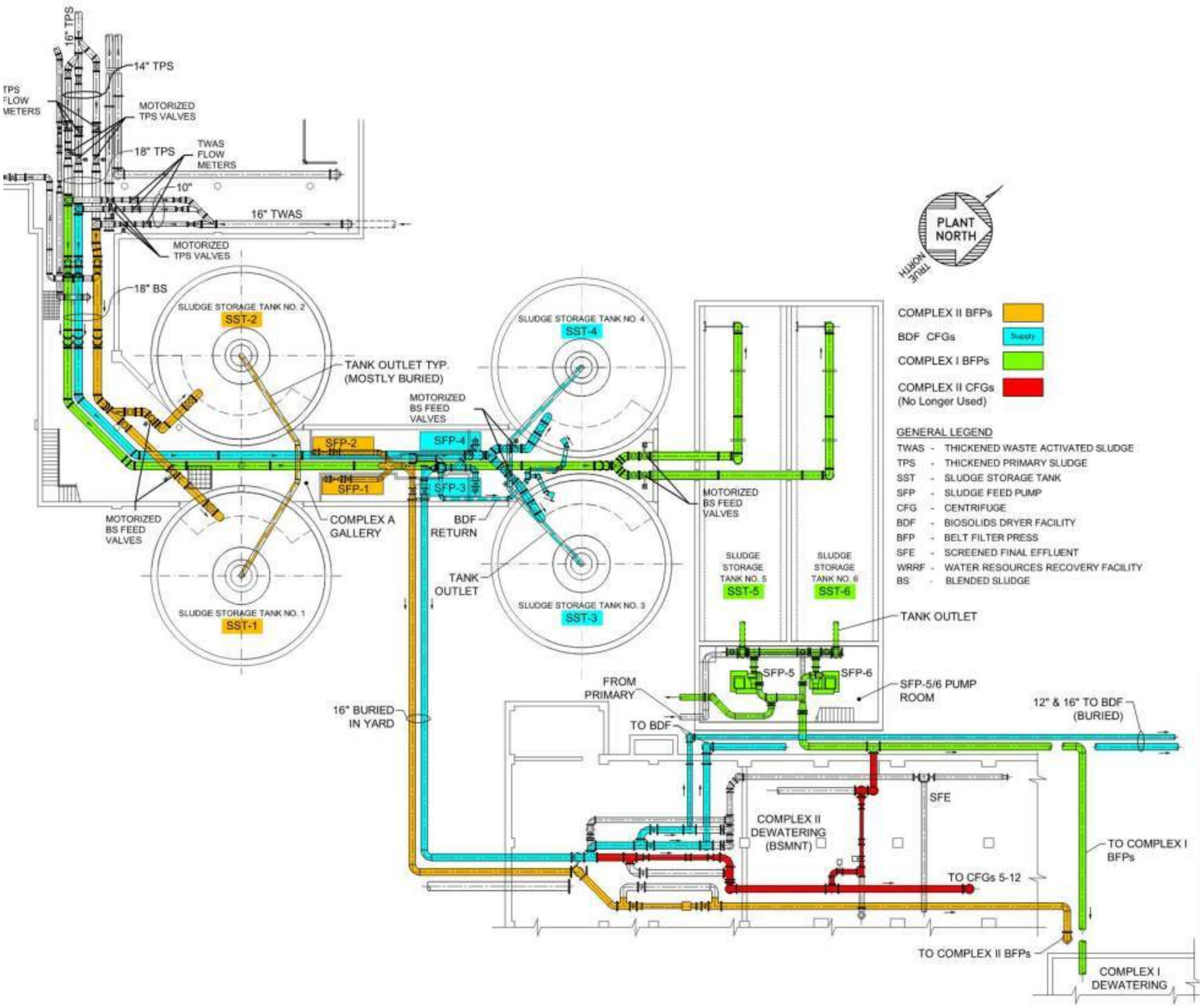


Figure 4-4: Sludge Storage Tank Piping Layout

The 16-inch TPS and TWAS headers from the gravity thickener complexes split into three smaller diameter pipelines (10-inch for TWAS and 14-inch for TPS) before being piped together to form three 18-inch blended sludge lines that feed the SSTs. Each of the 18-inch blended sludge lines feeds two SSTs with the tank pairs being SST 1/2, SST 3/4, and SST 5/6. The 10-inch TPS and 14-inch TWAS lines are equipped with magnetic flowmeters and motorized valves just upstream of the 18-inch blending tee connection points. The 18-inch blended sludge lines to each SST are equipped with motorized valves prior to penetrating the tank and being routed vertically to a discharge elevation of approximately 124 ft within the tanks.

During normal operating conditions, each SST has a dedicated sludge feed pump (SFP). Piping and valves are provided to allow either pump in a pair (SFPs 1/2 or SFPs 3/4) to pump from the other's dedicated SST. This interconnection is not currently being utilized. SSTs 1/2 and their associated

SFPs 1/2 feed sludge to the upper level C-II BFPs. SSTs 3/4 and their associated SFPs 3/4 feed sludge to the centrifuges (CFGs) at the BDF.

SFP suction piping is located below the tank floor and extends from the SST center sludge sump to the SFPs located in the SSTs 1-4 Pipe Gallery. The suction piping slopes upward from an invert elevation of 90 ft at the sludge sump to a centerline elevation of 98.27 ft at the pumps. The low points of the storage tank bottom cones are approximately 6 ft and 8.27 ft below the floor of the SSTs 1-4 Pipe Gallery and SFP centerlines, respectively.

Each SST is equipped with an 18-inch overflow pipe that penetrates the tank wall at an invert elevation of 124 ft and is then routed vertically down to grade on the exterior of the tanks (see **Figure 4-1**). The overflow piping connects to two sanitary sewer manholes on the east and south sides of the SSTs 1-4 Pipe Gallery and then tie-into interceptors that convey the flows to Pump Station No. 1.

4.2 Structural Assessment

Visual structural assessments were performed on SSTs 1-4. Assessments were focused on identifying cracks, spalls, and/or other deteriorations that would point to major structural concerns. Assessments were performed from the top and exteriors of the tanks and limited to visible elements above the waterline for the tanks in service. Overall, the structural condition of the tanks is good. Minimal deterioration was observed at what appears to be the normal waterline of the tanks. This deterioration is likely limited to the surface and does not indicate any underlying issues.

4.3 HVAC Assessment

There is no HVAC equipment associated with SSTs 1-4.

4.3.1 Existing NFP 820 Classification

SSTs 1-4 are open to the atmosphere. The National Fire Protection Association (NFPA-820-2020, Table 6.2, Row 10, line c – SLUDGE STORAGE, WET WELLS, PITS, AND HOLDING TANKS) classifies the envelope 18 inches above the water surface and unenclosed areas within 10 feet horizontally from the wetted walls as Class I, Division 2, Group D. The area beyond the envelope is Unclassified.

4.4 Electrical Assessment

Exposed conduits on and near SSTs 1-4 are a combination of painted rigid metallic (RMC) and PVC-coated rigid metallic (PVC-RMC). There are signs of corrosion on the exterior of the RMC, associated fittings, and enclosures **(Figure 4-5)**.

Figure 4-5: Corroded Conduits and Enclosures

4.5 I&C Assessment

Each SST is equipped with an ultrasonic level sensor and transmitter **(Figure 4-6)**. The transmitters are located in the SSTs 1-4 Pipe Gallery and are functional and integrated with the Ovation DCS to display level reading on the HMI graphics. It is anticipated the existing level sensors will be replaced with radar level sensors and transmitters to provide more accurate level readings and current product offerings for sensing the level in the SSTs.

Figure 4-6: Typical SST 1-4 Ultrasonic Level Sensor

5.0 Sludge Storage Tanks 5/6

SSTs 5/6 are used to store blended TPS and TWAS prior to it being conveyed to the dewatering facilities for processing. The tanks are above/below grade, rectangular, reinforced concrete structures with a common central divider wall **(Figure 5-1)**. The dimensions of each tank and critical elevations are displayed in **Table 5-1.**

Figure 5-1: Sludge Storage Tank 6

Table 5-1: SSTs 5/6 Dimensions

Tank Name	Volume (gal)	Dimensions Length/Width (ft)	Maximum SWD/Elev. (ft)	Minimum SWD/Elev. (ft)	Top of Wall Elev. (ft)	Overflow Inv. Elev. (ft)	Outlet Pipe Inv. Elev. (ft)
SST-5	230,000	70.33/18.25	23/123	0/100[1]	126	123	97
SST-6	230,000	70.33/18.25	23/123	0/100[1]	126	123	97

[1] Based on operational data from 5/2020 - 5/2023

5.1 Process Mechanical Assessment

5.1.1 In-Tank Piping

Air mixing systems are provided in SSTs 5/6 to keep solids in suspense. The mixing systems include three 60-hp blowers housed in a blower building south of SST-2 (same blowers used for SSTs 3/4 mixing systems), stainless steel air piping, and duckbill type nozzles. The air nozzles are located along the centerline of each rectangular tank at approximate elevation 101 ft **(Figure 5-2)**.

Figure 5-2: SST-6 Mixing Air Piping and Nozzles

Sludge is conveyed to each storage tank through an 18-inch blended sludge line from the SSTs 1-4 Pipe Gallery. These pipes are routed through the tanks to their discharge locations located at the west end and then routed vertically to their discharge invert elevation of 122.75 ft **(Figure 5-3)**.

Figure 5-3: SST-6 Sludge Inlet Pipe Discharge and Overflow Weir

Limited visual assessments were performed on the in-tank piping for SSTs 5/6. Assessments were performed from the top of the tanks and limited to visible elements above the waterline for the tank in service (SST-5). The condition of the piping observed for the offline/drained tank (SST-6) is considered representational of the in-service tank (SST-5). Overall, the condition of the in-tank piping is good with only minor surface corrosion observed in various locations.

5.1.2 Upstream/Downstream Piping

SST 5/6 piping upstream of the SSTs 1-4 Pipe Gallery is discussed in Section 4.1.2. The 18-inch blended sludge line that conveys sludge to SSTs 5/6 passes through the SSTs 1-4 Pipe Gallery prior to branching into two 18-inch lines near the north wall. Each line is equipped with a manual and motorized plug valve prior to penetrating the building wall and being routed to SSTs 5/6. Drainage connections are provided upstream and downstream of the isolation valves **(Figures 5-4 and 5-5)** to allow the lines to be drained during outages to prevent freezing during winter months.

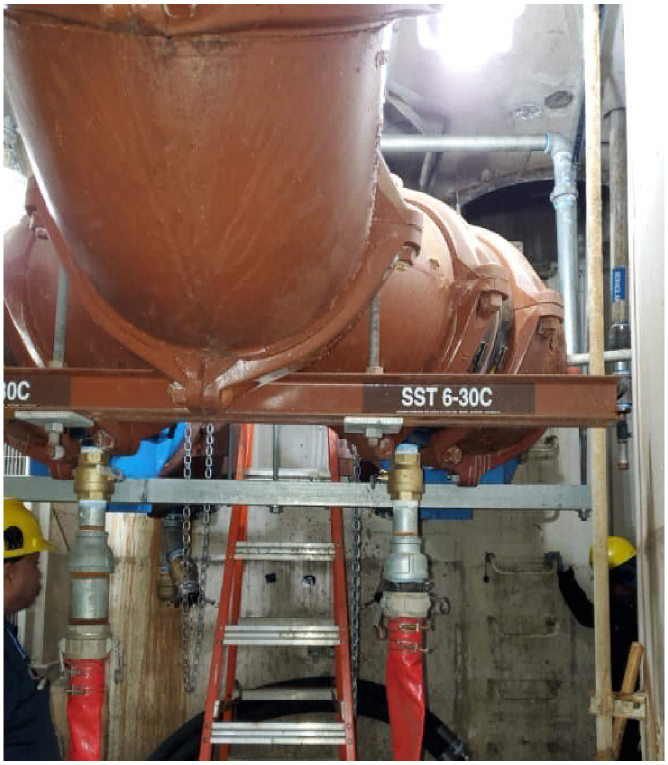


Figure 5-4: SST 5/6 Sludge Inlet Pipe Drainage Ports Upstream of Isolation Valves

Figure 5-5: SST 5/6 Sludge Inlet Pipe Drainage Ports Downstream of Isolation Valves

During normal operating conditions each storage tank has a dedicated SFP (SFP-5 serves SST-5, SFP-6 serves SST-6). Piping and valves are provided to allow either pump to draw suction from either tank. SFPs 5/6 draw suction from a sludge sump located on the east end of the tanks. The suction piping is horizontal and has an approximate centerline elevation of 96.5 ft which is approximately 3 ft below the tank floor. SSTs 5/6 and their associated SFPs 5/6 feed sludge to the BFPs at Dewatering Complex I.

Each SST is equipped with an overflow trough on its west side with a top of weir elevation of 123 ft (see **Figure 5-3**). The bottoms of the troughs are connected to an adjacent overflow structure with a 12" pipe that discharges to a sanitary sewer manhole. The sanitary sewer manhole and piping tie-into interceptors that convey flows to Pump Station No. 1.

5.2 Structural Assessment

Visual structural assessments were performed on SSTs 5/6. Assessments were focused on identifying cracks, spalls, and/or other deteriorations that would point to major structural concerns. Assessments were performed from the tops and exteriors of the tanks and limited to visible elements above the waterline for the tanks in service. Overall, the structural condition of the tanks is good. Minimal deterioration was observed at what appears to be the normal waterline of the tanks. This deterioration is likely limited to the surface and does not indicate any underlying issues.

5.3 HVAC Assessment

There is no HVAC equipment associated with SSTs 5/6.

5.3.1 Existing NFP 820 Classification

SSTs 5/6 are tanks that store blended sludge prior to it being pumped to the WRRF dewatering facilities. With the tanks open to the atmosphere, the NFPA 820 Classification per NFPA-820-2020, Table 6.2, Row 10, line c – SLUDGE STORAGE, WET WELLS, PITS, AND HOLDING TANKS classifies the envelope 18 inches above the water surface and unenclosed areas within 10 feet horizontally from the wetted walls as Class I, Division 2, Group D. The area beyond the envelope is unclassified.

5.4 Electrical Assessment

Exposed conduits on and near SSTs 5/6 are a combination of painted rigid RMC and PVC-RMC. There are signs of corrosion on the exterior of the RMC and associated fittings.

5.5 I&C Assessment

Each SST is equipped with two sets of ultrasonic level sensors and transmitters as shown in **Figure 5-6**. The level sensors installed at the lower elevation (extending down below the tank top of wall) are not functional. The level sensor and transmitter installed at the higher elevation are functional and integrated with the Ovation DCS to display the level reading on the HMI graphics. It is anticipated the existing level sensors will be replaced with radar level sensors and transmitters to provide more accurate level readings and current product offerings for sensing the level in the SSTs.

Figure 5-6: SST-6 Level Sensors

6.0 SSTs 1-4 Pipe Gallery

The SSTs 1-4 Pipe Gallery **(Figure 6-1)** houses the pumps, piping, and appurtenances associated with SSTs 1-4 and is located below Pump Station Avenue (between SSTs 1-4). The 18-inch pipe conveying sludge to SSTs 5/6 also passes through SSTS 1-4 Pipe Gallery prior to existing through the north wall. The gallery is accessed via Stair House No. 5 located south of SST-1 and connects to the basement of Sludge Processing Complex A. The SSTs 1-4 Pipe Gallery floor elevation (96.17 ft) is approximately 5.33 ft lower than the basement of Sludge Processing Complex A as seen in **Figure 6-2**.

Figure 6-1: SSTs 1-4 Pipe Gallery

Figure 6-2: Ramp from SSTs 1-4 Pipe Gallery to Sludge Processing Complex A Basement

6.1 Process Mechanical Assessment

6.1.1 Sludge Feed Pumps 1-4

SFPs 1-4 convey blended TPS and TWAS from SSTs 1-4 to the Dewatering Complex II BFPs and Biosolids Dryer Facility centrifuges. Each pump is shown in **Figure 6-3** and pertinent data/information is displayed in **Table 6-1**.

Figure 6-3: SFP-1 (top left), SFP-2 (top right), SFP-3 (bottom left), and SFP-4 (bottom right)

Table 6-1: SFP 1-4 Data/Information

Parameter	SFP-1	SFP-2	SFP-3	SFP-4
Status	Operational	Operational	Operational	Operational
Pump Type	Chopper	Chopper	Chopper	Chopper
Pump Model	Vaughan HE8P10B	Vaughan HE4V8TSEC2-155	Vaughan HES8P10TS-150	Vaughan HES8P10TS-150
Power (hp)	200	60	250	250
Flow (gpm)	2400	800	2400	2400
Head (ft)	185	125	190	190
Voltage (V)/ Phase/ Frequency (Hz)	460/3/60	460/3/60	460/3/60	460/3/60

Parameter	SFP-1	SFP-2	SFP-3	SFP-4
Amps	230	69	285	285
VFD	Rockwell	Yes	Yes	Yes
VFD Location	SSTs 1-4 Pipe Gallery	Complex A Electrical Room	Basement of Complex A	Basement of Complex A
Pump Speed (RPM)	1785	1300	1785	1785
Installation Year	2013	2023	2015	2015
Seal Water	Yes	Yes	Yes	Yes
Motor Type	Induction	Induction	Induction	Induction
Enclosure Type	TEFC	TEFC	TEFC	TEFC
Upstream Tank	SSTs 1/2	SSTs 1/2	SSTs 3/4	SSTs 3/4
Downstream Dewatering Facility	C-II BFPs	C-II BFPs	BDF CFGs	BDF CFGs
Install Contract	N/A	2102646	PC-792	PC-792
Suction Size	10”	8”	10”	10”
Discharge Size	8”	4”	8”	8”

SFP-1 was replaced in 2013 and appears to be in good condition. SFP-2 was replaced during this assessment in 2023 and is in like new condition. SFPs-3 and 4 are approximately 8 years old and are in fair condition. SFPs 1-4 are equipped with suction piping with isolation valves and pressures gauges and discharge piping with check valves, isolation valves, and pressure gauges. Visual inspection determined that many of the pressure gauges are not currently operational.

6.1.2 Sludge Piping

SST sludge feed, SFP suction, and SFP discharge piping in the SSTs 1-4 Pipe Gallery is ductile iron with flanged or Victaulic joints. The SFP suction piping is visibly aged and appears to be the same piping from the original installation in the early 1970s. The discharge piping associated with SFPs 1/2 also appears to be from the original installation with the exception of some valves which appear newer. Most of the SFP 3/4 discharge piping was installed as part of the PC-792 construction contract (BDF project) in 2015. An 8-inch return line was provided as part of this contract which includes manual and motorized isolation valves, a motorized flow control pinch valve, and a flow meter. The return line branches off the pump discharge header and returns flow back to SSTs 1/2 at elevation 104.7 ft. Duckbill check valves are provided on the pipe discharge ends within the tanks. Gate and plug type valves are used on the pump suction and discharge sludge piping in this gallery.

Each pair of SSTs 1/2 and SSTs 3/4 includes 12-inch interconnect piping located beneath the floor slab. Isolation valves are provided on the interconnect piping between SST-1 and SST-2, and SST-3 and SST-4. 3 ft x 3 ft x 2.5 ft deep valve pits are provided on each end of the pipe gallery to house the interconnect piping valves **(Figure 6-4)**. Plant staff have indicated that failure to control the flow from the tanks into the pit while draining a tank has resulted in the SSTs 1-4 Pipe Gallery to be flooded with sludge in the past.

Figure 6-4: Valve Sump on South End of SSTs 1-4 Pipe Gallery

Exterior piping corrosion and coating failures were observed in many locations **(Figure 6-5)**. These defects appear to be superficial in nature and do not pose a risk to the structural integrity of the piping systems at this time.

Figure 6-5: Corrosion and Coating Failure on SST Feed Lines

Hard material (vivianite) was observed on the interior of a 16" TWAS pipe segment that was removed by WRRF personnel **(Figure 6-6)**. The buildup resulted in an estimated 25% reduction of pipe cross-section and likely further reduced the pipes hydraulic capacity due to increased wall roughness. This pipe segment is upstream of the project work area but was presented to the project team for consideration. The observed material is being removed as part of an ongoing construction project (2023).

Figure 6-6: 16" TWAS Interior Buildup

6.1.3 Ancillary Equipment and Piping

A 4-inch low-pressure secondary water (LPSW) line enters the pipe gallery through the west wall between SST-2 and SST-4. The LPSW line supplies the pipe gallery wash water and seal water systems. Two booster pumps located on the south side of SFPs 1 and 2 are used to raise the LPSW pressure inside the pipe gallery for the seal water system. A seal water assembly including shutoff/isolation valves, pressure reducing valve (PRV), strainer, and pressure gauges, is installed at each SFP **(Figure 6-7)**.

Figure 6-7: LPSW Feed (top left), Booster Pump (top right) and Seal Water Assembly (bottom)

6.2 Structural Assessment

The SSTs 1-4 Pipe Gallery is a below grade reinforced concrete structure. The concrete appears in good condition with minimal cracking visible throughout the structure. Based on the visual inspection the structure is in good condition and no major repairs are recommended.

6.3 Plumbing Assessment

Plumbing systems in the SSTs 1-4 Pipe Gallery include sanitary drainage, compressed air, and natural gas piping systems. Low pressure-secondary water is discussed in Section 6.1.3.

The sanitary drainage for the pipe gallery includes general floor drains (3), valve pits equipped with floor drains (2), and pump curbed areas with floor drains (4), all connected to 6-inch cast iron sanitary piping **(Figure 6-8)**. The 6-inch piping combines at the southeast corner of the gallery into an 8-inch cast iron sanitary pipe that drains to manhole MH#3 (as identified on PC-241 sht. 76602), located just outside of the southeast corner of Stair House No. 5. Additionally, the roof conductor for the Stair House No. 5 roof is connected into the sanitary drainage. Piping condition was unable to be assessed due to location below the floor slab; however, floor drains show signs of corrosion, appeared in poor working condition, and have reached the end of their remaining useful life.

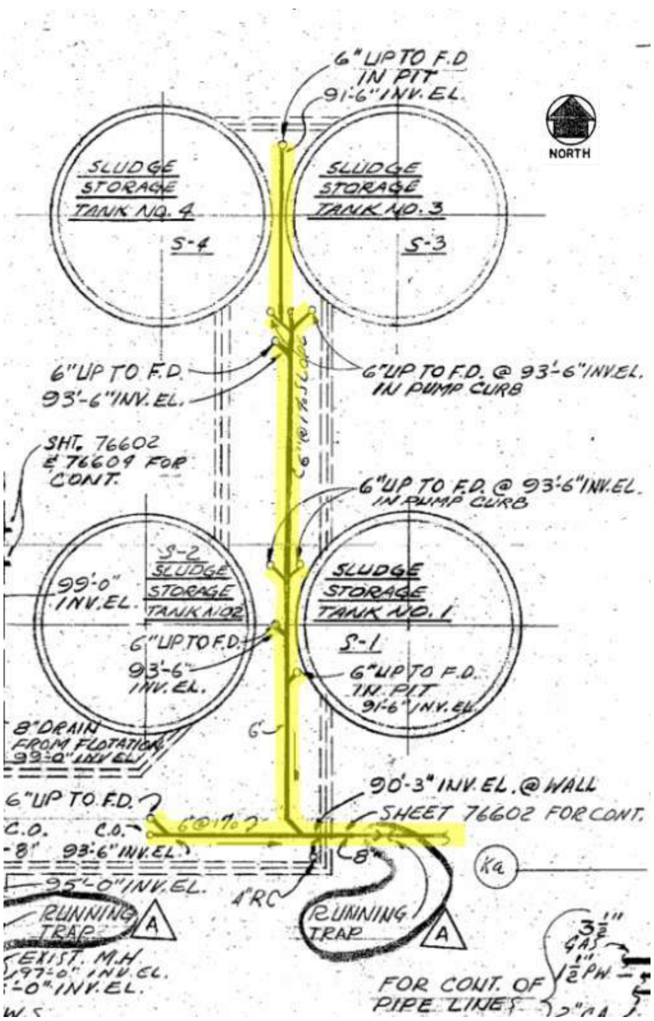


Figure 6-8: SSTs 1-4 Pipe Gallery Sanitary Drain Piping

A compressed air 2-inch main pipe enters the pipe gallery at the north end, with two service air connections with quick disconnect fittings serving the pipe gallery. The 2-inch compressed air main pipe continues to the west as it exits the pipe gallery to supply compressed air to the Sludge Processing Complex A Pipe Gallery. Compressed air piping appeared to be in moderate condition and has remaining useful life. However, the quick connect fittings appear to have been submerged in sanitary sludge from a past flood event and is recommended for replacement **(Figure 6-9)**.

Figure 6-9: 2-inch Compressed Air Line and Quick Connection Below Flood Line

A 1¼” natural gas branch fed from the 2” natural gas main in the Sludge Processing Complex A Pipe Gallery feeds the make-up air unit MA-A4.

6.4 HVAC Assessment

Ventilation for the SSTs 1-4 Pipe Gallery is provided by a grade mounted makeup air unit MA-A4 interlocked with the roof mounted exhaust fan EF-GE-A4. MA-A4 is installed on a concrete pad on grade located west of Stair House No. 5. EF-GE-A4 is installed on a concrete pad on grade located on the northeast side of SST-4. Currently, the existing ventilation system in the pipe gallery has a capacity of 4,000 cubic feet per minute (EF-GE-A4) and 4,000 cubic feet per minute (MA-A4). With an estimated volume of the space of 27,862 cubic feet, this equals 8.61 air changes per hour, which is higher than the recommended six air changes per hour for a pipe gallery per ASHRAE 62.1. Area takeoffs are shown in **Figure 6-10** and air changes per hour calculations are shown in **Table 6-2**.

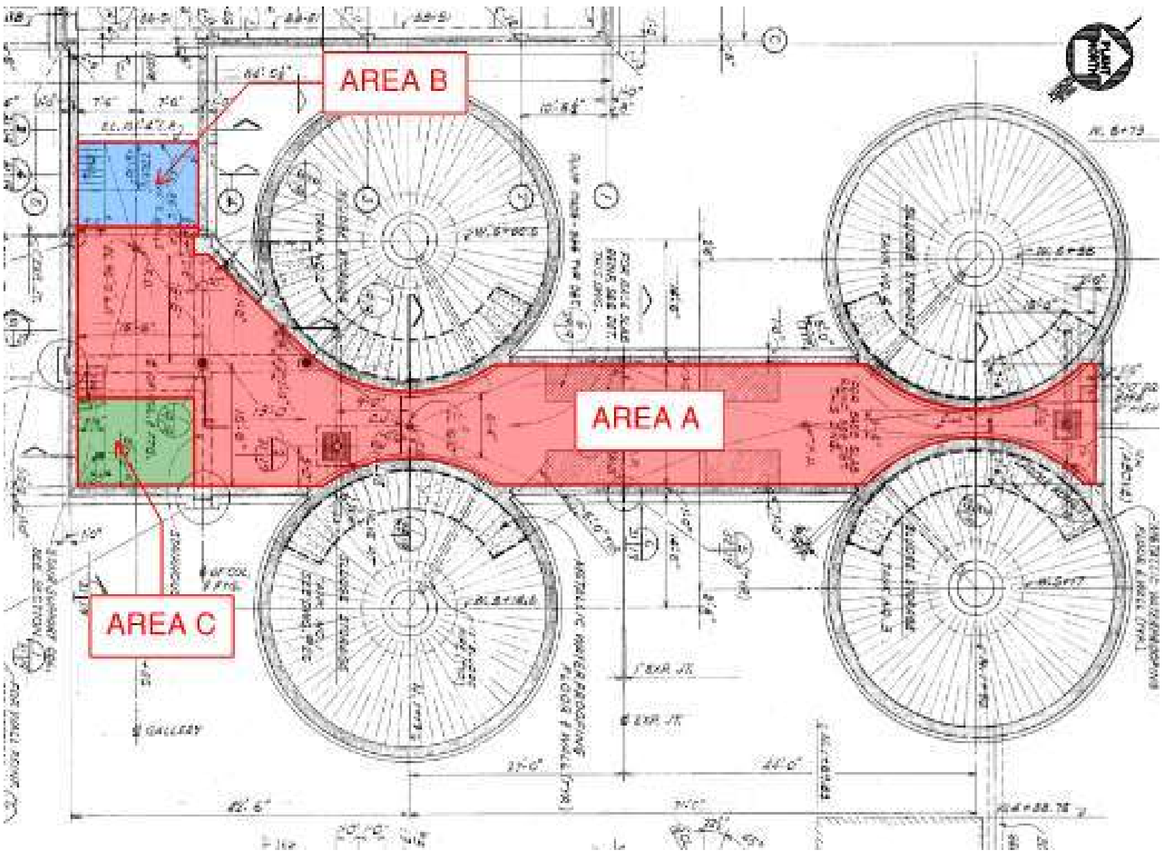


Figure 6-10: SSTs 1-4 Pipe Gallery – Area Takeoff

Table 6-2: SSTs 1-4 Pipe Gallery – Air Changes per Hour Calculation

Space	Area (sf)	Ceiling Ht.	Volume (cf)	Total Ventilation CFM	Air Changes/Hour
SSTs 1-4 Pipe Gallery Area A	1,780	11’-6”	20,470		
SSTs 1-4 Pipe Gallery Area B	160	17’-8”	2,832		
SSTs 1-4 Pipe Gallery Area C	160	28’-5”	4,560		
	Total Volume		27,862	4,000	8.61

Heat is provided by the same natural gas fired makeup air unit MA-A4 during the heating season with a total output of 198 MBH into the space via metal distribution ductwork. The supply air grilles/registers are located along the overhead ductwork. The makeup air unit is started or stopped locally at the unit’s main control panel or at the remote-control panel location using the unit start/unit stop push buttons. Temperature is controlled by a duct mounted thermostat set to

65°F (adjustable) to cycle the burner in stages (2 stages) and electronic modulating from 25% to 100% for second stage.

Table 6-3: SSTs 1-4 Pipe Gallery - Summary of Existing HVAC Parameters

Equipment	Manufacturer/Model	Capacity
Makeup Air Unit – MA-A4	TMI- DF-4K	4000 CFM with 198 MBH Heating output
Roof Mounted Exhaust Fan – EF-GE-A4	Greenheck-RBCE-3H24	4000 CFM

The makeup air unit condition is fair based on visual inspection and appears to be in working condition. There is minor corrosion inside the blower compartment of the unit, and the supply air registers and metal ductwork are in good condition.

The exhaust fan condition is fair based on visual inspection and appears to be in working condition. There is no observable corrosion, and the exhaust air registers & metal ductwork are in good condition.

The equipment listed above was installed in 2004, per the record drawings. The estimated remaining service life is less than 1 year.

6.4.1 Existing NFP 820 Classification

The SSTs 1-4 Pipe Gallery contains pumping units and piping that delivers blended sludge to the SSTs 1-4 and SFPs and associated piping that pump the blended sludge to the dewatering facilities. With the ventilation of the pipe gallery, including the Stair House No. 5, at over 6 air changes per hour, the NFPA 820 Classification per NFPA-820-2020, Table 6.2, Row 9, line b – SLUDGE PUMPING STATION DRY WELLS classifies the entire enclosed space as Unclassified. Note that this area is not physically separated from the Sludge Processing Complex A Pipe Gallery. NFPA 820 9.2.5 requires that ventilation systems serving Unclassified spaces adjacent to Classified spaces shall maintain a minimum differential pressure relative to ambient air pressure of 25 Pa (0.1 in. water column) under all operating conditions. As the space is connected to the Sludge Processing Complex A Pipe gallery, which is open to above grade Complex A spaces, it is assumed that the SSTs 1-4 Pipe Gallery is not pressurized.

6.5 Electrical Assessment

The variable frequency drive (VFD) for SFP-1 (SFP-1 VFD) and associated control stations and disconnect switches for SFP-2, SFP-3 and SFP-4 are located in the SSTs 1-4 Pipe Gallery. SFP-1 VFD is a standalone unit by Rockwell Automation in a stainless-steel enclosure. The VFD is fed from MCC-A3 in the Sludge Processing Complex A Electrical Room **(Figure 6-11)**.

Figure 6-11: SFP-1 VFD

Conduits and control cabinets located in the pipe gallery have been subjected to sludge spray and a corrosive atmosphere. There are some signs of corrosion on enclosures and non-PVC-coated conduits.

6.6 I&C Assessment

The SSTs 1-4 Pipe Gallery contains process instrumentation (pressure indicators, pressure switches, and flowmeters) associated with SFPs 1-4. The local control panels and VFDs are installed in either the pipe gallery or Sludge Complex A basement. Signals from the process instrumentation and VFDs are connected to the Ovation cabinets located in the S.L. Equipment Room No. 2. Limited assessment was completed on the process instrumentation and pump systems due to the anticipated replacement of both the pumps and associated instrumentation.

The basement area is equipped with a hazardous gas monitoring system to alarm on high concentrations of hydrogen sulfide and methane (LEL). A third sensor monitors the oxygen level. All three (3) sensors are tied into a Drager Regard 3920 unit **(Figure 6-12)**. The Drager unit provides a local display for sensor readings, outputs to an alarm beacon and horn, and current outputs to the Ovation Cabinet for integration and display on the Ovation Operator Workstations. The unit is functional and is expected to be retained under the Project.

Figure 6-12: Hazardous Gas Monitoring System

7.0 SSTs 5/6 Pump Building

The SSTs 5/6 Pump Building houses the pumps, piping, and appurtenances associated with SSTs 5/6 and is connected to the east side of the SSTs. This building is accessed via a man door on the south **(Figure 7-1)** or the loading dock double door on the north. The upper-level houses electrical equipment associated with the pumps and building appurtenances. SFPs 5 and 6 and their associated piping are located in the basement. A 2-ton monorail crane and floor hatches are provided at the upper-level to get equipment and materials in and out of the basement.

Figure 7-1: SSTs 5/6 Pump Building

7.1 Process Mechanical Assessment

7.1.1 Sludge Feed Pumps 5 and 6

SFPs 5 and 6 convey blended TPS and TWAS from SSTs 5 and 6 to the Dewatering Complex I BFPs. Each pump is shown in **Figure 7-2** and pertinent data/information is displayed in **Table 7-1**.

Figure 7-2: SFP-5 (top), SFP-6 (bottom)

Table 7-1: SFP 5/6 Data/Information

Parameter	SFP-5	SFP-6
Status	Out of Operation	Operational
Pump Type	Recessed Impeller	Chopper
Pump Model	Wemco Torque Flow type C	Vaughan HE8P10C
Power (hp)	150	150
Flow (gpm)	2400	2400
Head (ft)	130	145
Voltage (V)/ Phase/ Frequency (Hz)	460/3/60	460/3/60
Amps	281	175
VFD	ASI Robicon 454 GT	Rockwell
VFD Location	SSTs 5/6 Pump Building (upper level)	SSTs 5/6 Pump Building (upper level)
Pump Speed (RPM)	1170	1785
Installation Year	2005	Unknown
Seal Water	Yes	Yes
Motor Type	Induction	Induction
Enclosure Type	TEFC	TEFC
Upstream Tank	SSTs 5/6	SSTs 5/6
Downstream Dewatering Facility	C-I BFPs	C-I BFPs
Install Contract	PC-744 (DWP-1016)	N/A
Suction Size	10”	8”
Discharge Size	8”	N/A

SFP-5 is in poor condition and is no longer operational. SFP-6 appears to have been replaced in the last 10 years and is in good condition (exact replacement date unknown). A pile of rags remaining from pump maintenance was observed on the baseplate of SFP-6 **(Figure 7-3)** during the assessment. SFPs 5/6 are equipped with suction piping with isolation valves and pressures gauges and discharge piping with check valves, isolation valves, and pressure gauges.

Figure 7-3: SFP-6 Rag Pile on Pump Base Plate

7.1.2 Sludge Piping

SFP suction and discharge piping in the SSTs 5/6 Pump Building is ductile iron with flanged joints. Most of this piping was installed as part of the PC-744 (DWP-1016) project in 2005. Valve types include gate and plug valves. Minor piping corrosion and coating failures were observed **(Figure 7-4)**. These defects appear to be superficial in nature and do not pose a risk to the structural integrity of the piping systems at this time.

Figure 7-4: Pipe Corrosion and Coating Failures

7.1.3 Ancillary Equipment and Piping

Two secondary water lines serve this building to provide flushing and seal water. The line used for flushing water enters the basement on the north side, includes a backflow preventer, and connects to the end of the pump suction header **(Figure 7-5)**. The line used for seal water enters the basement on the east side and supplies seal water to SFPs 5/6. A seal water booster pump is installed on the column near SFP-5 but is no longer active. A seal water assembly including shutoff/isolation valves, PRV, strainer, and pressure gauge is installed at SFP-6 **(Figure 7-5)**. Severe corrosion and previous repairs were observed on the flushing water line **(Figure 7-6)**. This pipe should be replaced as part of the Project's improvements.

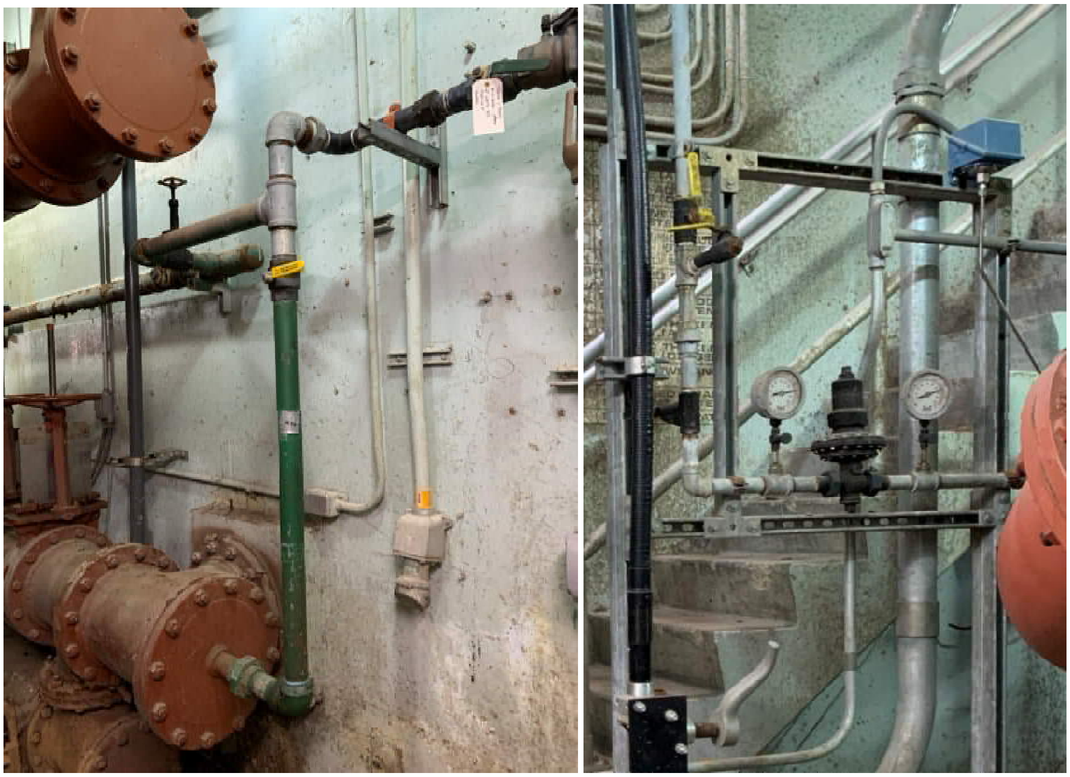


Figure 7-5: Flushing Water (left), SFP-6 Seal Water Assembly (right)

Figure 7-6: Severe Corrosion on Flushing Water Line

A 4 ft x 5 ft x 4 ft deep sump is located in the southwest corner of the basement and contains two submersible pumps **(Figure 7-7)**. The pump discharges combine into a 4-inch pipe that exits the building on the south side and connects to a sanitary sewer manhole in the yard. A 3-inch branch off the discharge connects to the lower SFPs 5/6 suction header. The sump collects process leakage and seal water discharges.

Figure 7-7: SSTs 5/6 Pump Building Sump

7.2 Structural Assessment

The SSTs 5/6 Pump Building is a masonry superstructure supported on a concrete basement. The concrete appears to be in good condition with minimal cracking visible throughout the structure. The masonry also shows no cracking or damage. Based on the visual inspection the structure is in good condition and no major repairs are recommended.

7.3 Plumbing Assessment

Plumbing systems in the SSTs 5/6 Pump Building include storm water drainage, sump pump discharge piping, and natural gas piping systems. Low pressure-secondary water is discussed in Section 7.1.3.

The storm water drainage piping for the SSTs 5/6 Pump Building provides primary and emergency drainage for the building's roof. The emergency roof drain is piped down from the roof, drained through the building, and exits the wall to drain to splash to grade. The primary roof drain is piped down from the roof, drained through the building, and exits the structure to drain to the 6" storm discharge. Roof drains and drainage piping appeared to be in good condition and do not require replacement at this time unless it interferes with proposed sludge pumping/piping improvements.

Seal water drain piping from the sludge feed pumps drain into the sump located in the southwest corner of the lower level. Duplex sump pumps pump the drainage to either the pressurized manhole located in the building or pumped up and out to a manhole located to the south of the building. Isolation valves are provided on the sump pump discharge pipe to allow the duplex sump pumps to pump to either manhole. The drain piping appeared to be in moderate condition. The condition of the sump pumps were not able to be determined due to no access to the sump during the assessment.

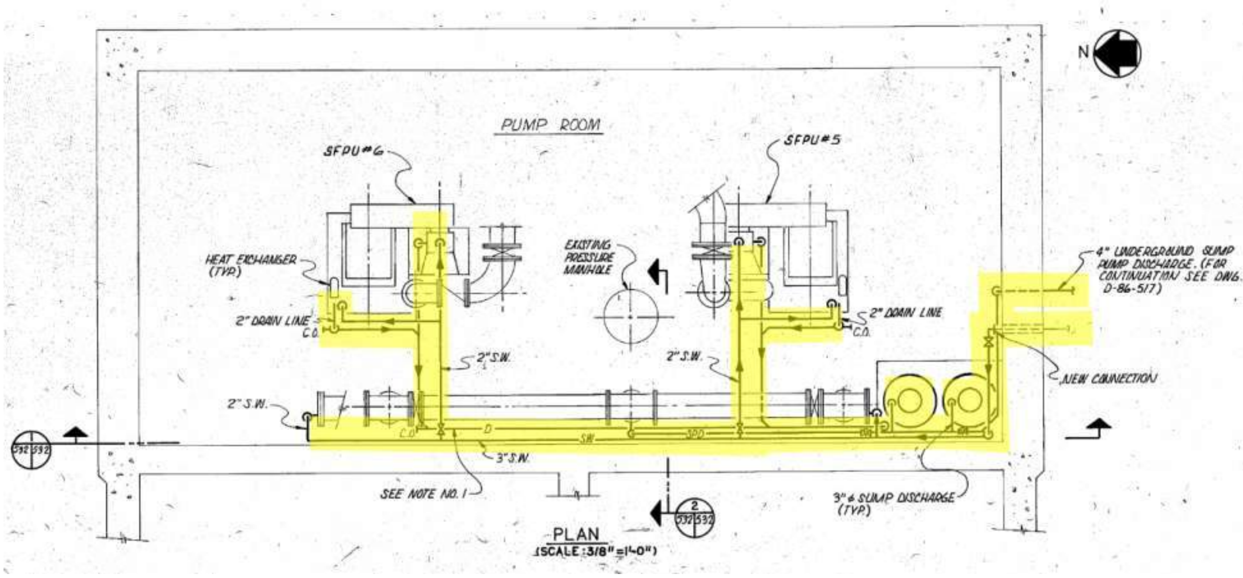


Figure 7-8: SSTs 5/6 Pump Room Seal Water, Drain Piping, and Sump Pump Layout

A 2-inch natural gas line fed from the 3.5-inch underground natural gas main located to the east of the building supplies natural gas to feed the make-up air unit MA-A5, located on top of the building.

7.4 HVAC Assessment

Ventilation for the SSTs 5/6 Pump Building is provided by the roof mounted makeup air unit MA-A5 interlocked with the roof mounted exhaust fan EF-GE-A7, located on top of the building. Currently, the existing ventilation system in the pump building has a capacity of 1,600 cubic feet per minute (EF-GE-A7) and 1,600 cubic feet per minute (MA-A5). With an estimated volume of the space of 22,531 cubic feet, which equals 4.26 air changes per hour, and less than the recommended five air changes per hour for a pump building per ASHRAE 62.1. Area takeoffs are shown in **Figure 7-9** and air changes per hour calculations are shown in **Table 7-2**.

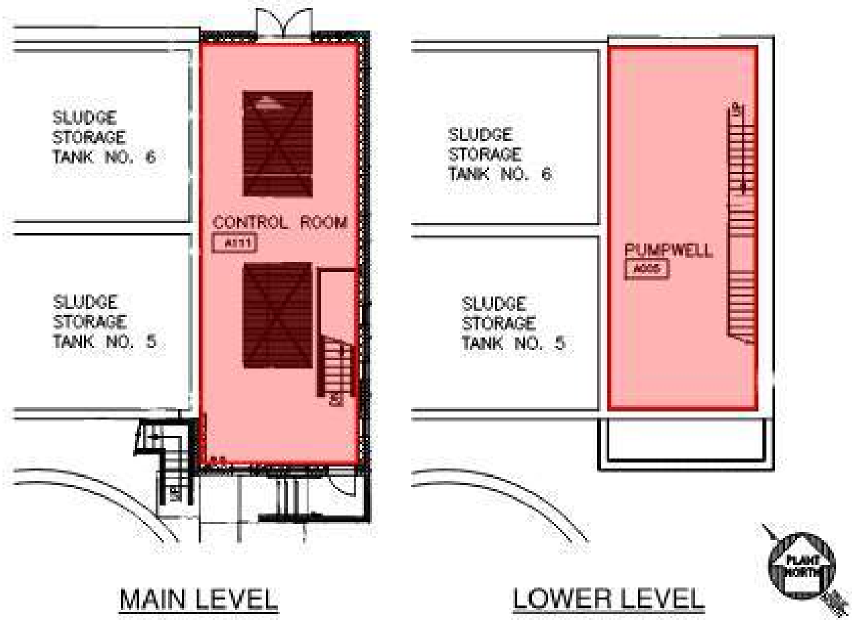


Figure 7-9: SSTs 5/6 Pump Building – Area Takeoff

Table 7-2: SSTs 5/6 Pump Building – Air Changes per Hour Calculation

Space	Area (sf)	Ceiling Ht.	Volume (cf)	Total Ventilation CFM	Air Changes/Hour
SSTs 5/6 Pump Building – Main Level	770	13'-6"	10,395		
SSTs 5/6 Pump Building – Lower Level	617	19'-8"	12,136		
	Total Volume		22,531	4,000	4.26

Heat is provided by the same natural gas fired makeup air unit MA-A5 during the heating season with a total output of 105 MBH into the space via metal distribution ductwork. The supply air grilles/registers are located along the overhead ductwork. The makeup air unit is "Sterling" and model number is unknown due to deterioration of the nameplate. The makeup air unit is started or stopped locally at the unit's main control panel or at the remote-control panel location using the unit start/unit stop push buttons. Temperature is controlled by a duct mounted thermostat set to 65°F (adjustable) to cycle the burner in stages (2 stages) and electronic modulating from 25% to 100% for second stage.

Table 7-3: SSTs 5/6 Pump Building - Summary of Existing HVAC Parameters

Equipment	Manufacturer/Model	Capacity
Makeup Air Unit – MA-A5	STERLING	1600 CFM with 105 MBH Heating output
Roof Mounted Exhaust Fan – EF-GE-A7	COOK-135 ACE	1600 CFM

The makeup air unit condition is poor based on visual inspection. There is significant visible corrosion on the unit, while the supply air registers and metal ductwork are in good condition.

The exhaust fan condition is fair based on visual inspection and appears to be in working condition. There is no observable corrosion and the observed exhaust air registers and metal ductwork are in good condition.

The equipment listed above was installed in 2004 based on the nameplate data. The estimated remaining service life is less than 1 year.

7.4.1 Existing NFP 820 Classification

The SSTs 5/6 Pump Building contains the SFPs and associated piping used to convey the blended sludge to the dewatering facilities. With the ventilation of both the Control Room (upper level) and Pump Room (lower level) at less than 6 air changes per hour, the NFPA 820 Classification per NFPA-820-2020, Table 6.2, Row 9, line a – SLUDGE PUMPING STATION DRY WELLS classifies the entire enclosed space as Class I, Division 2, Group D.

7.5 Electrical Assessment

The SST 5/6 Pump Building is powered by two (2) motor control centers (MCC), MCC-A5 and MCC-A6 **(Figure 7-10)**. The MCCs and VFDs are located on the ground level floor in an unclassified area (with proper ventilation). Each MCC contains starters for ancillary equipment to the SFPs and feeder breakers to the VFDs for SFP-5 (SFP-5 VFD) and SFP-6 (SFP-6 VFD). Both MCC-A5 and MCC-A6 are Eaton Cutler-Hammer Freedom Series 2100 type MCC installed in 2004 as part of Project No. PC-744, DWP-1016.

Figure 7-10: MCC-A5 with SFP-5 VFD and MCC-A6

Each pump VFD is a standalone unit. SFP-5 VFD is by ASI Robicon installed in 2004 as part of Project No. PC-744, DWP-1016. SFP-6 VFD is by Rockwell Automation installed in 2015 as part of 2014 WWRF Dewatering contract.

Conduits and control cabinets located in the basement have been subjected to sludge spray and a corrosive atmosphere **(Figure 7-11)**. There are some signs of corrosion on enclosures and non-PVC-coated conduits.

Figure 7-11: Sludge Covering Control Station

7.6 I&C Assessment

The process instrumentation and equipment for SFPs 5 and 6 are split between the upper and lower levels of the SSTs 5/6 Pump Building. The pumps and associated process instrumentation are located in the basement, while the VFDs and control panels are located upstairs. The I/O signals from the SFPs are integrated into the Ovation Controller and Network Cabinet located in S.L Complex A Equipment Room No. 2. Limited assessment was completed on the process instrumentation and pump system due to the anticipated replacement of both the pumps and associated instrumentation.

A hazardous gas monitoring system has recently been added to monitor methane and oxygen limits in the stairway of SSTs 5/6 Pump Building **(Figure 7-12)**, along with the hydrogen sulfide concentration. A Drager Regard 3920 unit is tied to three (3) sensors. The unit appears to be functional and in good condition.

Figure 7-12: SSTs 5/6 Pump Building Hazardous Gas Monitoring System

8.0 Complex A Gallery (beneath Electrical Room)

8.1 HVAC Assessment

Ventilation for the Sludge Processing Complex A Pipe Gallery is provided by three roof mounted makeup air units, MA-A1, MA-A2 and MA-A3, interlocked with five roof mounted exhaust fans, EF-GE-A1, EF-GE-A2, EF-GE-A3, EF-GE-A4 and EF-GE-A9. Locations of this ventilation equipment is shown in **Attachment A**. The MA units are interlocked with their associated exhaust fans as shown below.

- Makeup air unit (MA-A1) interlocked with Exhaust fans (EF-GE-A1, A2 and A3)
- Makeup air unit (MA-A2) interlocked with Exhaust fans (EF-GE-A4)
- Makeup air unit (MA-A3) interlocked with Exhaust fans (EF-GE-A9)

The existing ventilation system in the Complex A Pipe Gallery has a total capacity of 23,500 cubic feet per minute (exhaust fans) and 24,000 cubic feet per minute (makeup air units), while maintaining a slightly positive pressure. With an estimated volume of the space at 192,347 cubic feet, this equals 7.49 air changes per hour, which is higher than the recommended six air changes per hour for a pipe gallery per ASHRAE 62.1. Area takeoffs are shown in **Figure 8-1** and air changes per hour calculations are shown in **Table 8-1**.

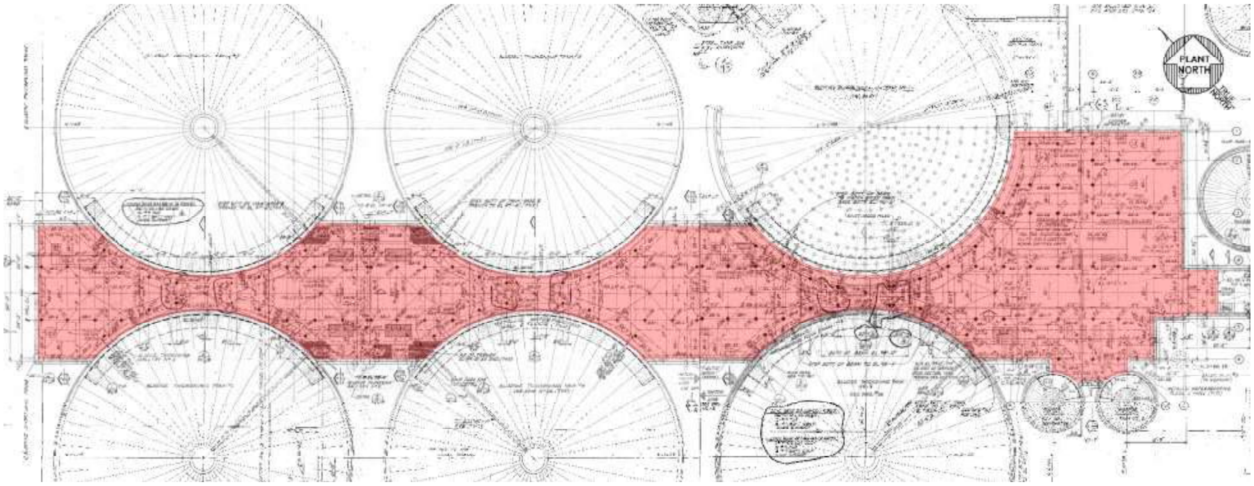


Figure 8-1: Sludge Processing Complex A Pipe Gallery – Area Takeoff

Table 8-1: Sludge Processing Complex A Pipe Gallery – Air Changes per Hour Calculation

Space	Area (sf)	Ceiling Ht.	Volume (cf)	Total Ventilation CFM	Air Changes/Hour
Sludge Processing Complex A Electrical Room	15,805	12'-2"	192,347	24,000	7.49

Heat is provided by the same natural gas fired makeup air units (MA-A1, MA-A2 and MA-A3) during heating season, with a total output of 1,584 MBH into the space via metal distribution ductwork. The supply air grilles/registers are located along the overhead ductwork. The makeup air units is started or stopped locally at the unit's main control panel or at the remote-control panel location using the unit start/unit stop push buttons. Temperature is controlled by a duct mounted thermostat set to 65°F (adjustable) to cycle the burner in stages (2 stages) and electronic modulating from 25% to 100% for second stage.

Table 8-2: Sludge Processing Complex A Pipe Gallery - Summary of Existing HVAC Parameters

Equipment	Manufacturer/Model	Capacity
Makeup air unit – MA-A1	TMI- DF-9K	9000 CFM with 594 MBH Heating output
Makeup air unit – MA-A2	TMI- DF-5K	5000 CFM with 330 MBH Heating output
Makeup air unit – MA-A3	TMI- DF-10K	10000 CFM with 660 MBH Heating output
Roof mounted exhaust fan – EF-GE-A1	COOK-120 ACE	3500 CFM
Roof mounted exhaust fan – EF-GE-A2	GREENHECK-RBCE-3H30	3500 CFM
Roof mounted exhaust fan – EF-GE-A3	GREENHECK-RBCE-3H30	3500 CFM
Roof mounted exhaust fan – EF-GE-A4	GREENHECK-RBCE-3H24	4000 CFM
Roof mounted exhaust fan – EF-GE-A9	GREENHECK-RBCE-3H30	9000 CFM

The makeup air units' condition are fair based on visual inspection and appear to be in working condition. There is no observable corrosion, and the supply air registers, and metal ductwork are in good condition.

The exhaust fans' condition are fair based on visual inspection and appear to be in working condition. There is no observable corrosion and exhaust air registers and metal ductwork are in good condition.

The equipment listed above was installed in 2004, based on the nameplate data. The estimated remaining service life is less than 1 year.

8.1.1 Existing NFP 820 Classification

The Sludge Processing Complex A Pipe Gallery contains pumping units and piping that delivers primary sludge to the six sludge thickening tanks and delivers thickened sludge through the SSTs 1-4 Pipe Gallery to SSTs 1-4. With the ventilation of the pipe gallery at over 6 air changes per hour, the NFPA 820 Classification per NFPA-820-2020, Table 6.2, Row 9, line b – SLUDGE PUMPING STATION DRY WELLS as the primary purpose of the space is for pumping, classifies the entire space as Unclassified. The pipe gallery has openings above that create a direct connection to the Complex A Control Building Staging A101 room. This room and other areas in the Control Building with a door opening or other opening that connects to this room have the same classification, Unclassified. If the air changes were verified to be less than 6 per hour, the gallery and the connected Control Building would be classified as Class I, Division 2, Group D. A gas-tight physical separation would be required to separate the gallery from Complex A Control Building. Also note that this area is not physically separated from the SSTs 1-4 Pipe Gallery. NFPA 820 9.2.5 requires that ventilation systems serving Unclassified spaces adjacent to Classified spaces shall maintain a minimum differential pressure relative to ambient air pressure of 25 Pa (0.1 in. water column) under all operating conditions.   As the space is above grade Complex A spaces, it is assumed that the Basement of Sludge Processing Complex A Pipe Gallery is not pressurized.

8.2 Electrical Assessment

The SFP-3 VFD and SFP-4 VFD are in located in the Complex A Gallery. The VFDs are standalone units in stainless steel enclosures. The VFDs are fed from MCC-A3 and MCC-A4 in the Electrical Room above the gallery. The VFDs were installed as part of Project No. PC-792 Package 4 in 2016.

Figure 8-2: SFP-3 VFD

9.0 Complex A Electrical Room

9.1 HVAC Assessment

Ventilation for the Sludge Processing Complex A Electrical Room is provided by the roof mounted air handling unit AHU-A3, and an intake louver with a motorized damper, both interlocked with two roof mounted exhaust fans (EF-EE-A5 and EF-EE-A6). Locations of this ventilation equipment is shown in **Attachment A**. The existing ventilation system in the Electrical Room has a capacity of 5,000 cubic feet per minute (exhaust fans) and 5000 cubic feet per minute (air handling unit and intake louver). The ventilation/cooling only system modulates its return air dampers and fresh ai intake louver to control the temperature in the room based on established setpoints. Area takeoffs are shown in **Figure 9-1** and air changes per hour calculation are shown in **Table 9-1**.

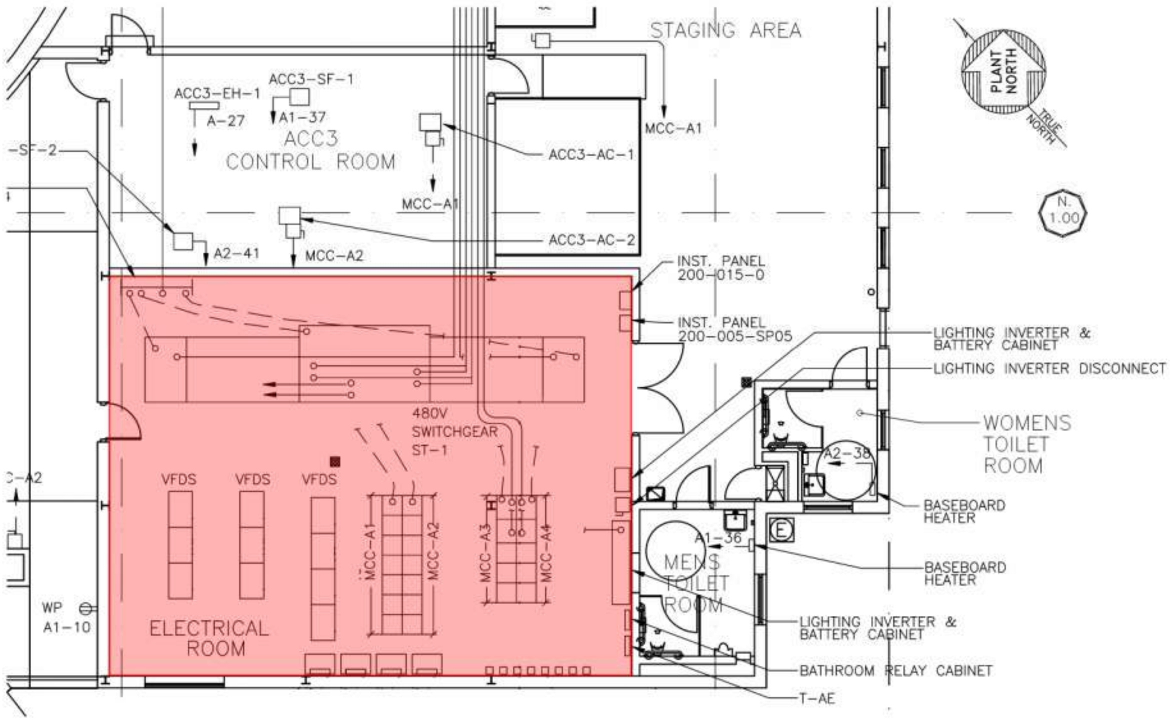


Figure 9-1: Sludge Processing Complex A Electrical Building – Area Takeoff

Table 9-1: Sludge Processing Complex A Electrical Building – Air Changes per Hour Calculation

Space	Area (sf)	Ceiling Ht.	Volume (cf)	Total Ventilation CFM	Air Changes/Hour
Electrical Room	1,450	19'-3"	27,913	5000	10.75

Air conditioning for the room is provided by the same air handling unit (AHU-A3) during cooling season with a total sensible output of 146 MBH into the space via metal distribution ductwork. The supply air grilles/registers are located along the overhead ductwork. Controls are locally controlled by wall thermostats located in the conditioned space, and set to 80°F (adjustable)

Table 9-2: Sludge Processing Complex A Electrical Room - Summary of Existing HVAC Parameters

Equipment	Manufacturer/Model	Capacity
Air Handling Unit – AHU-A3	Addison DC-10	2500 CFM with 146 MBH cooling output
Roof mounted exhaust fan – EF-EE-A5	COOK-270 ACE	5000 CFM
Roof mounted exhaust fan – EF-EE-A-6	COOK-270 ACE	5000 CFM

The air handling unit's condition is fair based on visual inspection and appears to be in working condition. The supply air registers and metal ductwork are in good condition.

The exhaust fans' condition are fair based on visual inspection and appear to be in working condition. There is no observable corrosion and exhaust air registers and metal ductwork are in good condition.

The equipment listed above was installed in 2004, based on the nameplate data. The estimated remaining service life is less than 1 year.

9.1.1 Existing NFP 820 Classification

The Complex A Electrical Room (shown as Substation A104 on the PC-744 Drawings) is located in the Complex A Control Building. Because the Electrical Room has a direct connection to the Staging A101 Room with direct openings to the Complex A Pipe Gallery, the room shares the same classification as the gallery, Unclassified.

9.2 Electrical Assessment

Electrical equipment located in the Sludge Processing Complex A Electrical Room are Substation ST-1, MCC-A1, MCC-A2, MCC-A3, and MCC-A4. The room is an unclassified area with NEMA 1 and 12 suitable constructions.

The primary power source for the SFPs and the associated systems is provided through a 480-volt substation, ST-1. ST-1 is a double-ended substation with two (2) – 2000kVA transformers and a main-tie-main configuration **(Figure 9-2)**. The medium voltage switches are Eaton Cutler-Hammer Type MVS Metal-Enclosed Load Interrupter Switchgear and the low voltage section is Eaton Cutler-Hammer Magnum DS Metal-Enclosed LV Switchgear. Main Bus A feeds MCC-A1, MCC-A3, and MCC-A5. Main Bus B feeds MCC-2A, MCC-4A, and MCC-A6. ST-1 was installed as part of Project PC-744, DWP-1016 in 2004.

Figure 9-2: Substation ST-1

MCC-1A and MCC-2A contain controllers and feeders for process equipment associated with the dewatering process. MCC-3A contains controllers and feeders for ancillary equipment, and feeder breakers for SFP-1 VFD and SFP-3 VFD. MCC-4A contains controllers and feeders for ancillary equipment, and feeder breakers to SFP-2 VFD (under construction) and SFP-4 VFD **(Figure 9-3)**. Each MCC is an Eaton Cutler-Hammer Freedom Series 2100 type MCC installed in 2004 as part of Project No. PC-744, DWP-1016.

Figure 9-3: MCC-A4

10.0 Sludge Piping

The existing piping systems are used to convey sludge from the six sludge storage tanks to the three dewatering facilities. Each header is a pressurized pipeline that "dead ends" at the dewatering equipment (no return lines). **Table 10-1** provides a summary of information for each sludge pipe segment.

Table 10-1: Sludge Piping Information

Pipe Function	Pipe Section Start Location	Pipe Section End Location	Exposed /Buried	Project Installed	Year Installed	Material	Pipe Lining	Remarks
C-II BFP Feed	SFPs 1/2 Suction	SFPs 1/2 Discharge	Exposed	PC-744 (DWP-1016)	2006	DI	Unknown	-
	SSTs 1-4 Pipe Gallery	C-II Basement	Buried	PC-241	1971	DI[1]	Unknown	In Yard
	C-II Basement	C-II Basement	Exposed	PC-792	2016	DI 53	PROTECTO 401 ceramic epoxy	Figure 10-2
	C-II Basement	C-II 5th Floor	Exposed	PC-691[1]	1998[1]	DI	Unknown	-
	C-II 5th Floor	C-II BFPs	Exposed	PC-787	2012	STL XS	Liquid Epoxy (Tnemec N140 Pota-pox	Figure 10-3
BDF Feed	SFPs 3/4 Suction	SFPs 3/4 Discharge	Exposed	PC-792	2016	DI 53	PROTECTO 401 ceramic epoxy	-
	SSTs 1-4 Pipe Gallery	BDF Storage Room	Buried	PC-792	2016	DI PC350	PROTECTO 401	In Yard
	BDF Storage Room	BDF Centrifuge Mezzanine	Exposed	PC-792	2016	DI 53	PROTECTO 401 ceramic epoxy[1]	-
C-I BFP Feed	SFPs 5/6 Suction	SFPs 5/6 Discharge	Exposed	PC-616, PC-744 (DWP-1016)	1987 & 2006	DI	Unknown	-
	SFPs 5/6 Discharge	C-I Basement	Buried	PC-246	1971	DI[1]	Unknown	In Yard
	C-I Basement	C-I BFPs	Exposed	PC-787	2012	STL XS	Liquid Epoxy (Tnemec N140 Pota-pox	Figure 10-1

[1]Estimated/Most Probable

10.1 Dewatering Complex I Sludge Piping

Record drawings highlighting the C-I sludge feed pipe routing are included in **Attachment B**. SFPs 5/6 pump sludge from SSTs 5/6 to Dewatering Complex I (C-I) through a dedicated 16-inch line. The line exits the east wall of the SSTs 5/6 Pump Building basement, travels approximately 100 ft through the yard, and then enters the southwest corner of the C-I basement. The exposed steel pipe continues east through the basement of C-I at a centerline elevation of 104 ft before reducing from 16-inch to 12-inch after approximately 100 ft. The 12-inch line has one branch that connects to a drain and another branch that continues for approximately 60 ft before changing elevation to 112.25 ft and being equipped with a magnetic flow meter, pressure sensor, and solid density meter.

The 12-inch line then connects to a horizontal loop that is routed under the C-I basement ceiling. A 4-inch line branches off the loop to each of the 10 BFPs located on the floor above. The BFP feed lines each include a sludge grinder, flow meter, flow control valve, and manual and motorized isolation valves.

The inlet point of this sludge transfer line in the basement of SSTs 5/6 Pump Building is equipped with a manual shut off valve with position indicators. Other valves located on the main line are also manual. Pipe joints include Victaulic, flanged and welded. A few push-on type joint connections were observed at inlet points in the C-I basement. The buried pipe segment in the yard is the oldest part of this system and is believed to have been installed in the early 1970s as part of contract PC-246.

The sludge feed header in the basement of C-I was installed during contract PC-787 in 2012. No major deficiencies were observed during the visual assessments. Some localized minor corrosion and coating failures were observed. It was also noted that some coating colors do not match the WRRF process piping color standards which indicates that the sludge piping color should be brown **(Figure 10-1)**.

Figure 10-1: Sludge Feed Header in C-I Basement

10.2 Dewatering Complex II Sludge Piping

Record drawings highlighting the C-II sludge feed pipe routing are included in **Attachment C**. SFPs 1/2 pump sludge from SSTs 1/2 to Dewatering Complex II (C-II) through a dedicated 16-inch line. The line exits the east wall of the SSTs 1-4 Pipe Gallery, travels approximately 90 ft through the yard where it increases to 20-inch, and then enters the southwest corner of the C-II basement at a centerline elevation of 102 ft. Inside the basement the pipeline reduces to 16-inch and continues north and then east through the C-II basement and crawl space before arriving to the east side of the basement at a centerline elevation of 110.5 ft. **(Figure 10-2)**. A 12-inch magnetic flow meter is provided on the piping in the crawl space area.

Figure 10-2: Sludge Feed Header to C-II- Entering Basement (left), Through Crawl Space (right)

At the east end of the C-II basement the 16-inch ductile iron pipe is routed vertically up to a centerline elevation of 177.83 ft on the fifth floor. A 12-inch density meter is provided just above the floor penetration prior to the sludge header teeing into two branches **(Figure 10-3)**. Each 16-inch branch conveys sludge to six 6-inch BPF sludge feed lines (total of 12 BFPs). The BFP feed lines include a sludge grinder, flow meter, flow control valve, and manual and motorized isolation valves. The 6-inch feed lines reduce to 4-inch prior to discharging sludge to the BFPs at a centerline elevation of 183 ft. The end of each 16-inch sludge header branch (downstream of the BFP sludge feed line connections) is equipped with a pressure sensor. The sludge header passes behind a false wall and above an office false ceiling on the fourth floor which was not accessible for the assessment.

Figure 10-3: Density Meter and 16-inch Header Branches

Valves located on the sludge headers are manual. Pipe joints include Victaulic and flanged connections. Piping age and condition varies along the length of this piping system. The pipe segment in the SSTs 1-4 Pipe Gallery is estimated to be more than 50 years old. Piping in the C-II basement is approximately 25 years old. The piping on the fifth floor of C-II was installed in 2012.

A segment of the sludge header piping on the C-II fourth floor does not match the WRRF process piping color standards. In other locations throughout C-II the pipe labeling and flow arrows are missing and/or incorrect. In general, only localized minor corrosion and coating failures were observed throughout C-II. Minor to moderate corrosion and coating failures were observed on the piping segment located within the crawl space of the building.

10.3 Biosolids Dryer Facility (BDF) Sludge Piping

Record drawings highlighting the BDF sludge feed pipe routing are included in **Attachment D**. SFPs 3/4 pump sludge from SSTs 3/4 to the BDF through redundant parallel 12-inch and 16-inch sludge headers. Short sludge recirculation loops were installed on the SFP 3/4 discharge piping during Contract PC-792 in 2016 to recirculate excess/unused sludge back to the storage tanks. The recirculation loops were intended to ensure that SFP 3/4 do not operate below their minimum recommended flows and help to provide a steady flow/pressure of sludge to the BDF. Flow through the recirculation loop is controlled using pinch valves **(Figure 10-4)**. Plant staff have indicated that the pinch valves must operate mostly closed (1/8” to ¼” opening) to provide the required backpressure and only allow the unused sludge to return. This results in excessive wear which requires the valves to be replaced typically every six months.

Figure 10-4: Recirculation Control Pinch Valve

The 16-inch sludge header exits the east wall of the SSTs 1-4 Pipe Gallery, travels approximately 90 ft through the yard, and then enters the southwest corner of the C-II basement at a centerline elevation of 102 ft. This buried pipe segment between the SSTs 1-4 Pipe Gallery and C-II basement is more than 50 years old. Inside the basement the header splits into parallel 12-inch and 16-inch pipes which exit the C-II basement through the west wall at centerline elevations of 104.5 and 106.75 respectively. The parallel sludge headers are then routed approximately 1500 ft in the yard and cross under West Jefferson Avenue before entering the BDF Storage Room at elevation 109.5 ft.

The parallel 12-inch and 16-inch lines combine into a single 16-inch header in the BDF Storage Room which feeds the rest of the facility. The header is routed below the floor of the centrifuge mezzanine at a centerline elevation of 132.4 ft. An 8-inch line branches off the header to each of the 8 centrifuges located on the floor above. These centrifuge feed lines include a grinder, rotary lobe pump, flow meter, and motorized valves at a centerline elevation of 139.25 ft. Downstream of the centrifuge feed lines the 16-inch sludge header reduces to an 8-inch line with a sludge blow-off manifold consisting of a sludge header pressure transmitter, sludge blow-off flow meter, flow control pinch valve, and a surge relief valve **(Figure 10-5)**. Downstream of the surge relief the 8-inch pipe is routed back to the Storage Room and connects to a drain line which discharges to a manhole eventually conveying flows back to the WRRF headworks. The majority of the BDF sludge piping was installed as part of Contract PC-792 in 2016. No deficiencies were observed during the visual assessment of the exposed piping.

A 12-inch screened final effluent (SFE) water connection in the C-II basement is provided for flushing the 12-inch and 16-inch sludge headers with 90 psi to 110 psi water.

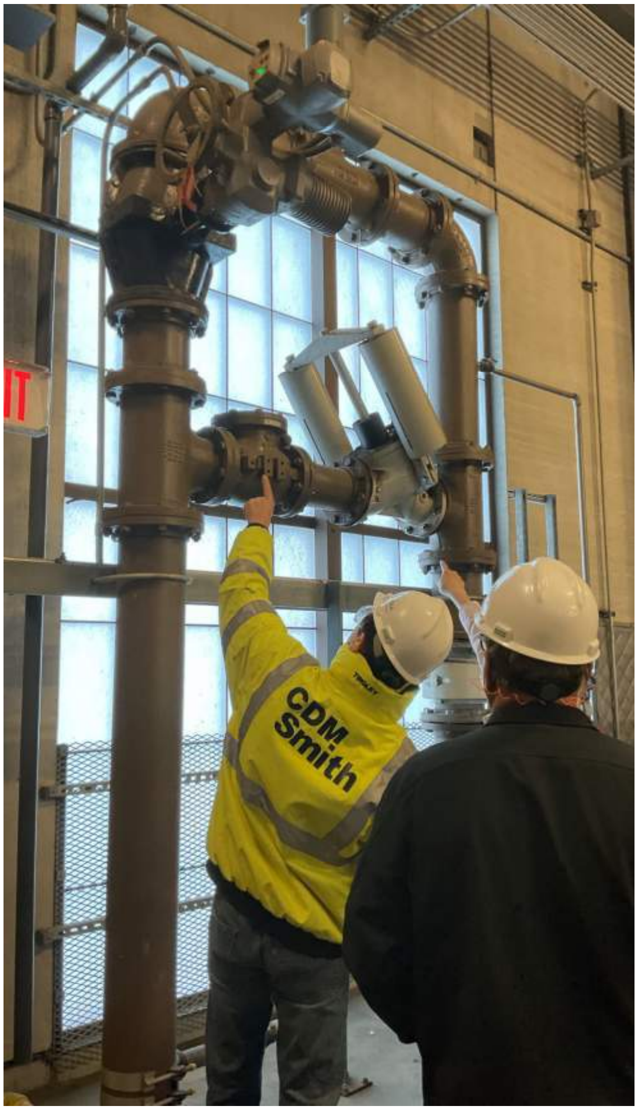


Figure 10-5: Sludge Header Blow-off Manifold

11.0 Instrumentation and Control

The field instrumentation and process equipment associated with the SSTs are tied into the existing plant distributed control system (DCS). Equipment Room No. 2 located in Sludge Processing Complex A contains two Ovation DCS cabinets with I/O modules and a third cabinet containing network hardware **(Figure 11-1)**. The I/O signals associated with the SSTs are tied into Ovation Drop 31/101. Next to the equipment room is a control room with two Ovation DCS workstations and two large screen monitors **(Figure 11-2)**. The network cabinet ties the SSTs process into the plant-wide DCS network monitored from the PCC in the Administration Building.

Figure 11-1: Ovation and Network Cabinets S.L. Complex A Equipment Room No. 2

Figure 11-2: S.L. Complex A Ovation Operator Workstations and Large Screen Displays

Many of the components within the Ovation controller and extended I/O cabinets are obsolete. GLWA has been replacing the obsolete Westinghouse modules with Emerson Ovation modules as failures and additional I/O needs have occurred **(Figure 11-3)**. An upgrade of the cabinet should be discussed with GLWA and coordinated with other on-going CIPs to eliminate obsolete components (I/O modules, power supplies, etc.) and replace with available Emerson Ovation hardware.

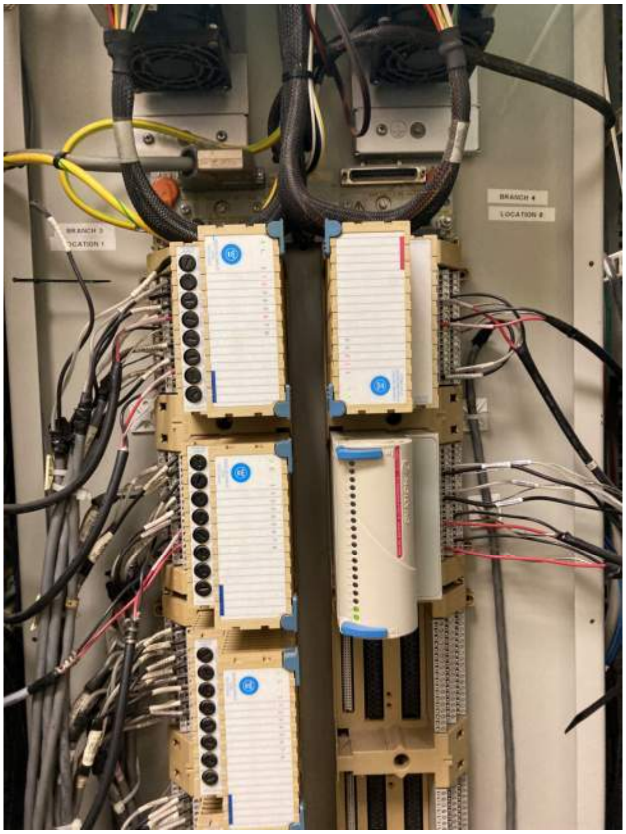


Figure 11-3: Westinghouse and Emerson Ovation Modules installed in Ovation Cabinets

In addition to the operator workstations provided in the control room, remote Ovation stations (ROS) units have been installed in the basement of Complex A for a remote location to access the Ovation HMI graphics **(Figure 11-4)**.

Figure 11-4: Complex A ROS for Ovation HMI Access

12.0 WRRF Operations and Maintenance Staff Input

Multiple meetings were held with WRRF staff to solicit background information and input on the challenges that the existing system's conditions present to the O&M staff. These meetings included:

- Project Quality Management Workshop (PQM) – April 14, 2023
- NEFCO BDF Requirements Meeting – April 25, 2023
- Maintenance Site Visit Meeting – May 31, 2023
- Operation and Maintenance Staff Meeting – June 28, 2023

The information and input received for each area is summarized in the subsequent sections.

12.1 General

- Consider ease of maintenance with all improvements. Cleanouts, flushing connections, and access for maintenance are needed.
- If inline instruments are provided there needs to be a way to isolate and maintain them without impeding operations.
- Improvements and sequence of construction needs to consider maintaining plant operations throughout construction.
- Eliminate single point and common-mode failures.

12.2 Sludge Storage Tanks

- Grit and rags accumulate on the bottom of the SSTs. A vacuum truck is used to remove this debris annually. This debris may be too excessive to pump.
- Tank pipes have become clogged with rags and grit in the past.
- Rags accumulate on the air piping within the tanks.
- Sludge becomes septic if it sits stagnant too long.
- Consistent blending of TPS and TWAS upstream of this project's scope has been an issue.
- Sludge percent solids has reached 9% in the SSTs. 15% has been previously recorded but this is uncommon. It is noted that 15% is very unlikely and that he readings were taken from inaccurate/out of calibration sludge density meters.
- Large grit loads occur after heavy rains.
- Existing level sensors are not accurate.
- Improvements need to maintain the existing tank volumes.
- Air mixing within the tanks results in dead zones.

12.3 Sludge Feed Pumps

- Pump materials of construction need to be able to handle grit and rags.
- Preference is to have as many pumps of the same size and type as possible for ease of maintenance and spare parts inventory.
- Flexibility to pump sludge from each SST to different dewatering facilities is desired.

- Flexibility to pump from one SST to another is desired.

12.4 SSTs 1-4 Pipe Gallery

- The tank drain valve on the interconnecting piping between SSTs 1 and 2 (located in the valve pit) was the point of failure that caused the pipe gallery to flood with sludge from the SSTs. Slugs of sludge clog the drain piping and then release quickly when unclogged. This rush of flow is excessive and overtakes the basement prior to the operator being able to close the valve.
- Pipe leaks/failures in the Sludge Processing Complex A basement have also flooded the SSTs 1-4 Pipe Gallery as a result of its lower elevation.

12.5 Biosolids Dryer Facility

- The feed lines to the Biosolids Dryer No. 1 train receives the highest amount of rags and debris as a result of being located at the end of the sludge header.

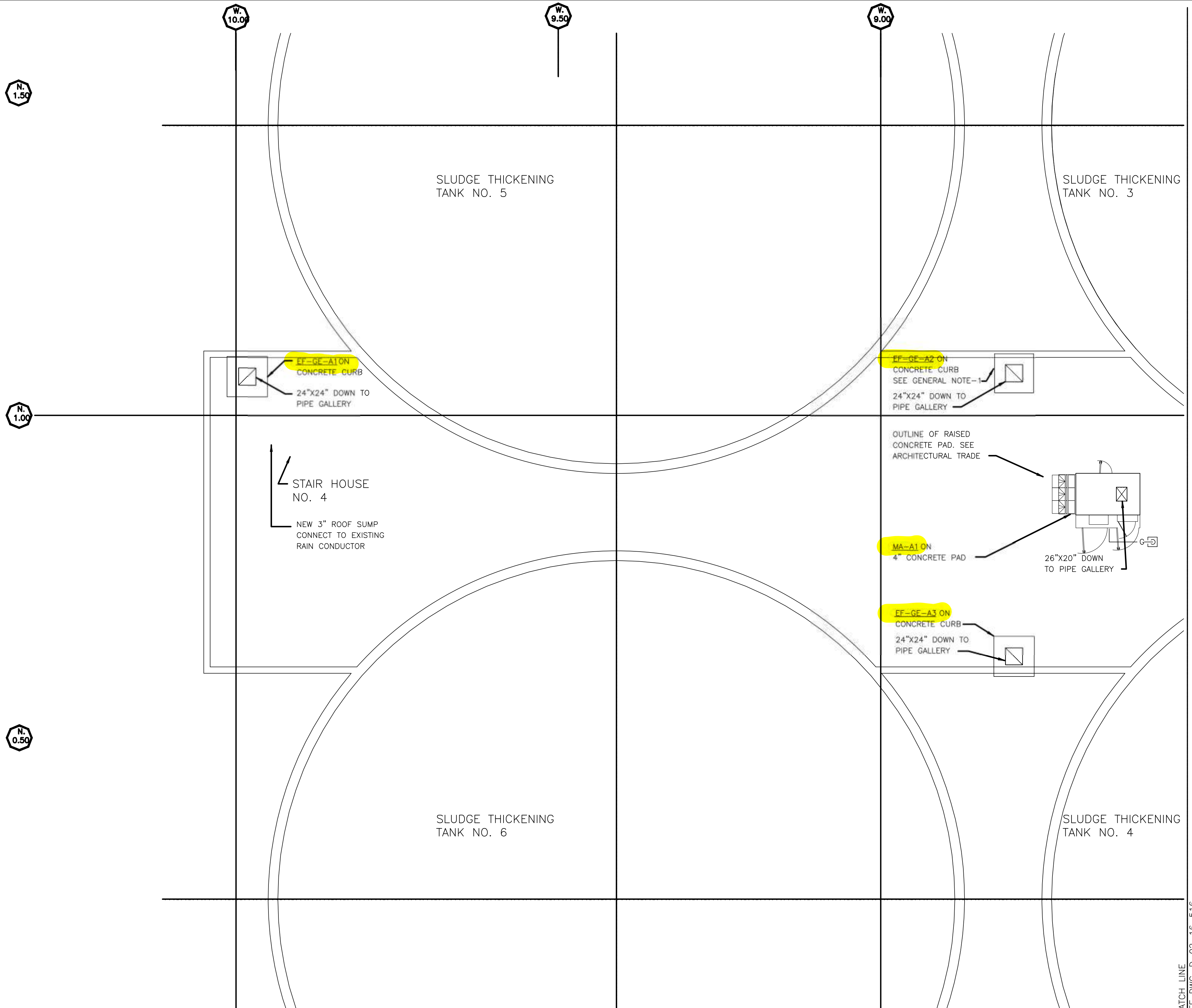
13.0 Summary

The WRRF has numerous pieces of sludge feed equipment that are past or approaching the end of their expected useful lives. The sludge feed pumps and piping are oversized for the feed rates required at each dewatering facility. In addition, the sludge feed piping “dead ends” at each of the dewatering facilities, resulting in sludge feed header pressures that are difficult to maintain within the operating range required for the sludge flow control equipment upstream of the dewatering equipment. Rags and grit not removed from upstream processes accumulates in the SSTs and presents additional challenges for the downstream sludge feed and dewatering systems. There is an urgent need to replace aged equipment that has reached its useful life, is not right-sized for the capacity needs, and/or has performance limitations.

cc: File

Attachment A

Sludge Processing Complex A
Ventilation Equipment Locations



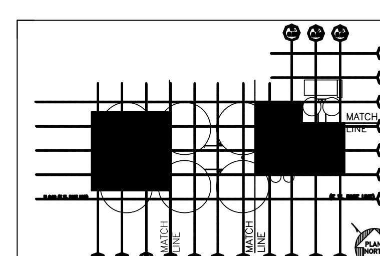
HVAC PLAN

0 2 4 8 12 16

GRAPHIC SCALE

GENERAL NOTES:

1. NOT ALL PIPING SHOWN. SEE PROCESS PIPING FOR ALL PIPING.
2. SEE CIVIL/SITE, ARCHITECTURAL, STRUCTURAL, PROCESS, ELECTRICAL, AND INSTRUMENTATION DRAWINGS FOR ADDITIONAL NEW WORK IN THE WORK AREAS SHOWN ON THIS SHEET. CONSTRUCTION SUBCONTRACTOR SHALL COORDINATE AND PROVIDE ALL REQUIRED WORK.
3. PROVIDE DETAILED SHOP DRAWINGS FOR ALL DUCT WORK PRIOR TO FABRICATION.



COMPLEX "A" KEY PLAN

SCALE: NTS

PROJECT ENGINEERS:

CDM CAMP DRESSER & McKEE

SUB-CONSULTANTS:

PEER CONSULTANTS P.C.

DETROIT, MI. 48226 TEL: (313) 965-1912

CADD-MATE ASSOCIATES 9472 REVERE DRIVE BELLEVILLE MI. 48111 TEL: (734) 697 4646

DJG & ASSOCIATES, Inc. 637 E. BIG BEAVER RD., SUITE 107, TROY, MI 48083 PH: (248) 526-9400 FAX: (248) 526-9406

F				
E				
D	AS BUILT			3/31/06
C	CONSTRUCTION ISSUE			6/16/03
B	ADDENDUM NO. 3			5/22/03
A	BID ISSUE			4/15/03
	DESCRIPTION	CHECKED	APRVD	DATE
	REVISIONS			

DESIGN MJ
DRAFTING MJ/KB
CHECKED MJ
APPROVED CRS

CDM

REHABILITATION OF COMPLEXES A AND B SLUDGE THICKENERS AND ASSOCIATED FACILITIES

COMPLEX A GRADE LEVEL WEST END HVAC NEW WORK PLAN

SCALE: 1/8"=1'-0" DATE: APRIL 15, 2003

detroit wastewater partners

CITY OF DETROIT
WATER AND SEWERAGE DEPARTMENT
ENGINEERING DIVISION

SECTION MAP	TOWN	RANGE	SECTION	PORTION CODE
1 5 - G	2 S	11 E	2 0 0	

M.D.E.Q. PERMIT NO.

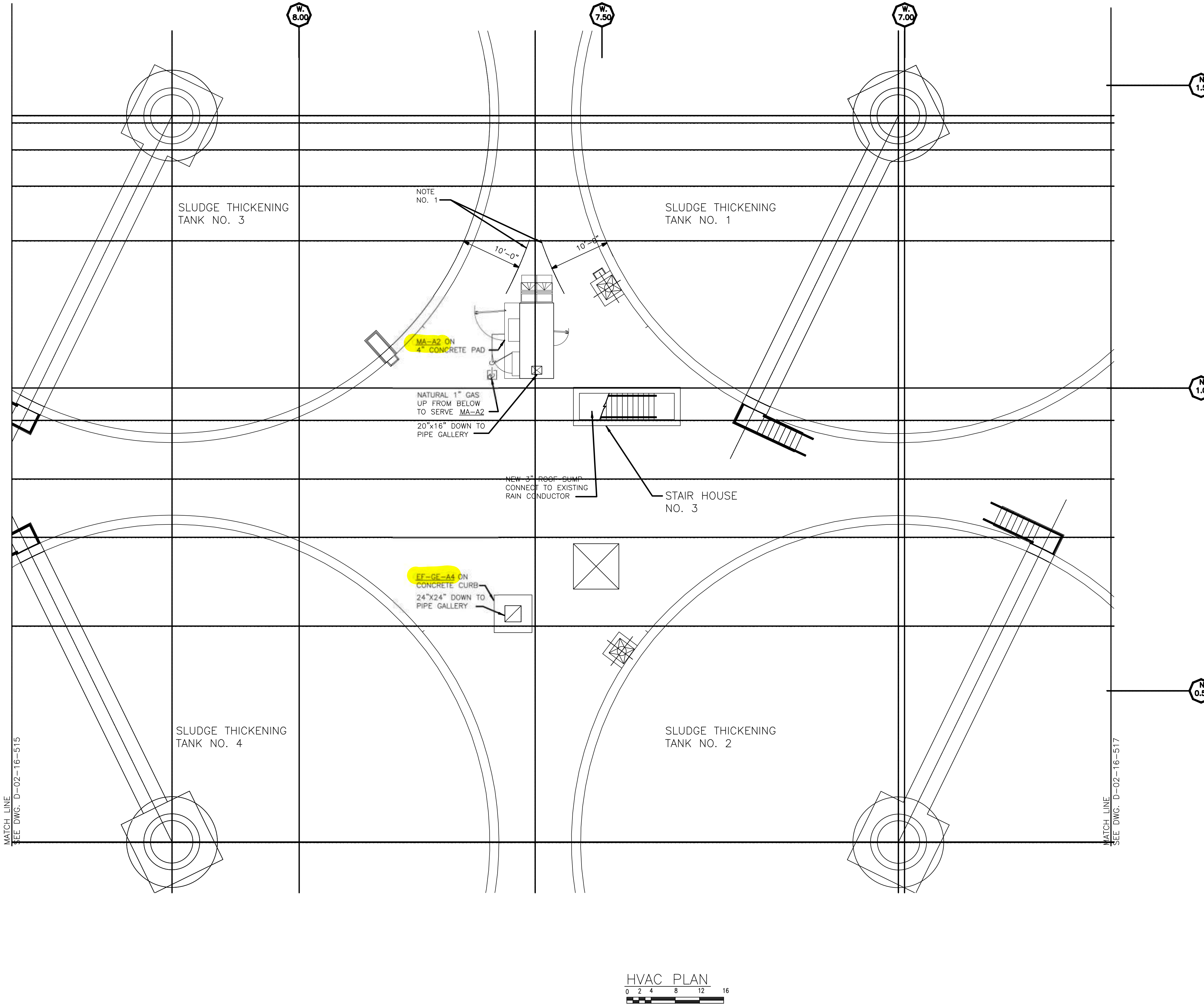
SRF NO.

CONTRACT NO. PC-744

FILE NO. D-02-A-F2-55

PROJECT NO. DWP-1016

DRAWING NO. D-02-16-515



GRILLES REGISTERS & DIFFUSER LEGEND

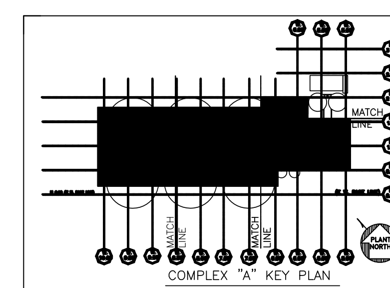
S.A.R. DUCT MOUNTED SUPPLY AIR REGISTER WITH KEY OPERATED OPPOSED BLADE DAMPER
S.A.D. CEILING MOUNTED SUPPLY AIR DIFFUSER WITH OPPOSED BLADE DAMPER
ALL CEILING MOUNTED UNITS SHALL BE 24"x24"
E.A.R. CEILING OR DUCT MOUNTED EXHAUST AIR REGISTER WITH OPPOSED BLADE DAMPERS
R.A.G. CEILING OR DUCT MOUNTED RETURN AIR REGISTER WITH OPPOSED BLADE DAMPERS

KEY NOTES:

1. LOCATE MA-A2 ON NEW CONCRETE CURB LOCATED IN CLEAR SPACE 10'-0" FROM INSIDE WALL OF SLUDGE TANK NO.S 1 AND 3.

GENERAL NOTES:

1. NOT ALL PIPING SHOWN. SEE PROCESS PIPING FOR ALL PIPING.
2. SEE CIVIL/SITE, ARCHITECTURAL, STRUCTURAL, PROCESS, ELECTRICAL, AND INSTRUMENTATION DRAWINGS FOR ADDITIONAL NEW WORK IN THE WORK AREAS SHOWN ON THIS SHEET. CONSTRUCTION SUBCONTRACTOR SHALL COORDINATE AND PROVIDE ALL REQUIRED WORK.
3. PROVIDE DETAILED SHOP DRAWINGS FOR ALL DUCT WORK PRIOR TO FABRICATION.



PROJECT ENGINEERS:
CDM CAMP DRESSER & McKEE
Consulting . Engineering . Construction . Operations

SUB-CONSULTANTS:
SOALES AND ASSOCIATES ENGINEERS & ARCHITECTS
PEER CONSULTANTS P.C.
CADD-MATE ASSOCIATES
DJG & ASSOCIATES, Inc.

	DESCRIPTION	CHECKED	APRVD	DATE
F				
E				
D	AS BUILT			3/31/06
C	CONSTRUCTION ISSUE			6/16/03
B	ADDENDUM NO. 3			5/22/03
A	BID ISSUE			4/15/03

REVISIONS

DESIGN MJ
DRAFTING MJ/KB
CHECKED MJ
APPROVED CRS

CDM

REHABILITATION OF COMPLEXES A AND B
SLUDGE THICKENERS AND ASSOCIATED FACILITIES

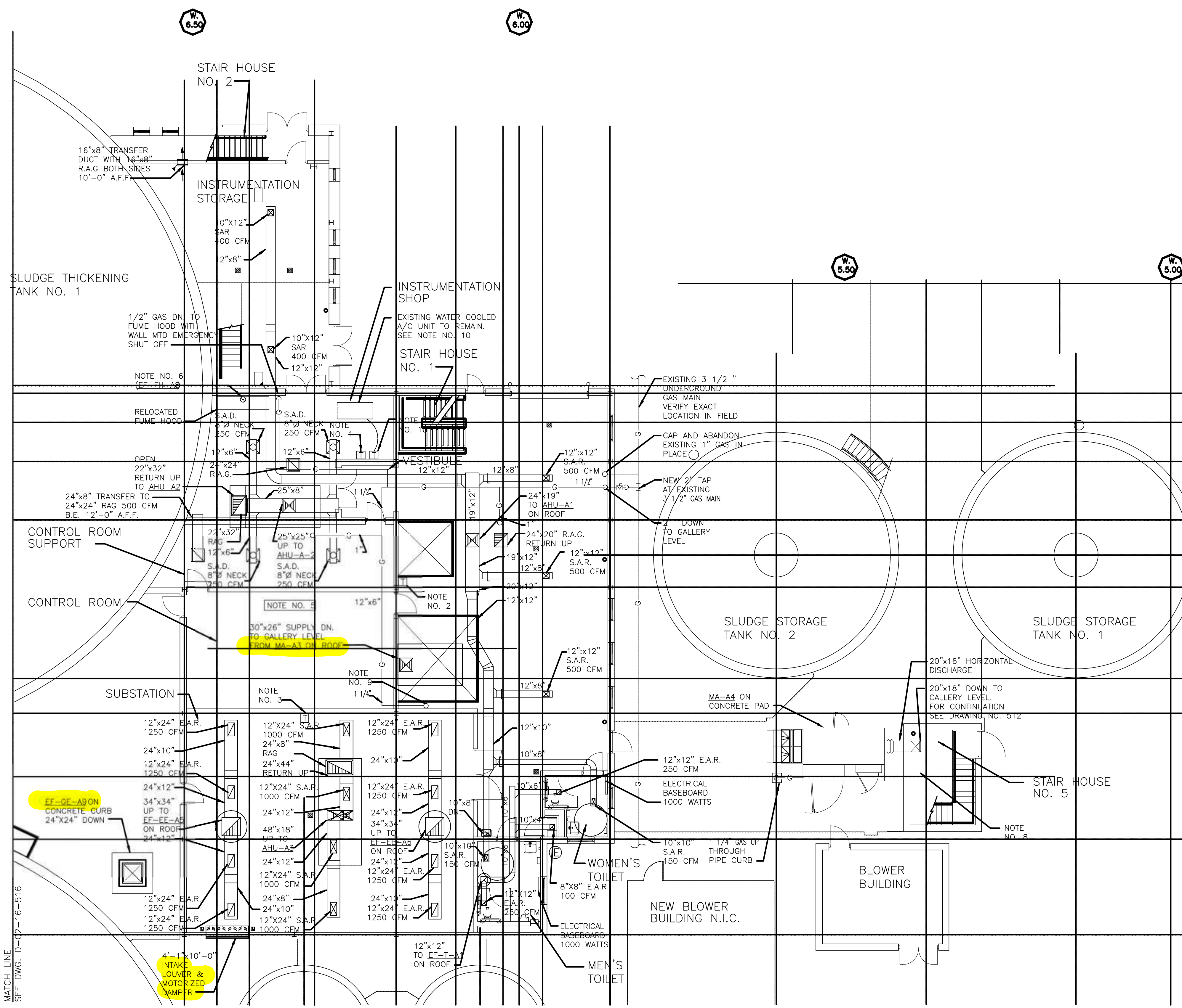
COMPLEX A GRADE LEVEL EAST END HVAC NEW WORK PLAN

SCALE: 1/8"=1'-0"
DATE: APRIL 15, 2003

CITY OF DETROIT
WATER AND SEWERAGE DEPARTMENT
ENGINEERING DIVISION

SECTION MAP	TOWN	RANGE	SECTION	PORTION CODE
1 5 - G	2 S	11 E	2 0 0	

M.D.E.Q. PERMIT NO.
SRF NO.
CONTRACT NO. PC-744
FILE NO. D-02-A-F2-56
PROJECT NO. DWP-1016
DRAWING NO. D-02-16-516



HVAC PLAN

GRAPHIC SCALE 0 2 4 8 12 16

GRILLES REGISTERS & DIFFUSER LEGEND

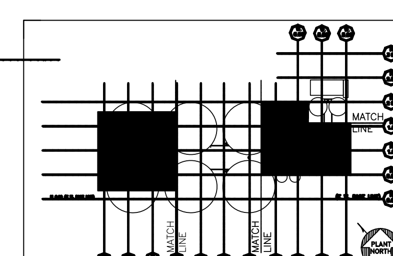
S.A.R. DUCT MOUNTED SUPPLY AIR REGISTER WITH KEY OPERATED OPPOSED BLADE DAMPER
S.A.D. CEILING MOUNTED SUPPLY AIR DIFFUSER WITH OPPOSED BLADE DAMPER. ALL CEILING MOUNTED UNITS SHALL BE 24"x24"
E.A.R. CEILING OR DUCT MOUNTED EXHAUST AIR REGISTER WITH OPPOSED BLADE DAMPERS
R.A.G. CEILING OR DUCT MOUNTED RETURN AIR REGISTER WITH OPPOSED BLADE DAMPERS

KEY NOTES:

1. HEATING / COOLING THERMOSTAT SERVING AHU-A2 ON ROOF
2. SPACE TEMPERATURE SENSOR SERVING AHU-A1 ON ROOF
3. SPACE TEMPERATURE SENSOR SERVING AHU-A3 ON ROOF
4. 24"x24" R.A.G. WITH 24"x8" DUCTED RETURN TRANSFER (500 CFM)
5. CONTROL ROOM HVAC BY OTHERS
6. PROVIDE EXHAUST DUCT CONNECTION FROM RELOCATED FUME HOOD TO EF-FH-A8 ON ROOF. FUME HOOD TESTING AND BALANCING SHALL BE PERFORMED BY AN NEBB OR AABC CERTIFIED CONTRACTOR. REFER TO FUME HOOD DETAIL ON DRAWING NO. 533 FOR MORE INFORMATION
7. REFER TO SEQUENCE OF OPERATIONS ON DRAWING NO.S 538 AND 539 FOR DAMPER CONTROL
8. COORDINATE EXACT LOCATION OF VERTICAL DUCTWORK WITH NEW AND EXISTING ELECTRICAL CONDUIT
9. GAS PIPE UP THROUGH ROOF CURB TO SERVE AIR HANDLING UNIT. (TYPICAL)
10. REFURBISH EXISTING CARRIER WATER COOLED A/C UNIT BY PROVIDING NEW FILTERS, AIR BALANCING, AND NEW TEMPERATURE CONTROL.
11. REFER TO DRAWING 533 FOR FRESH AIR INTAKE UNIT DETAIL.

GENERAL NOTES:

1. LOCATE DIFFUSER IN ROOMS WITH LAY IN CEILINGS PER ARCHITECTURAL REFLECTED CEILING PLAN
2. NOT ALL PIPING SHOWN. SEE PROCESS PIPING FOR ALL PIPING
3. SEE CIVIL/SITE, ARCHITECTURAL, STRUCTURAL, PROCESS, ELECTRICAL AND INSTRUMENTATION DRAWINGS FOR ADDITIONAL NEW WORK IN THE WORK AREAS SHOWN ON THIS SHEET. CONSTRUCTION SUBCONTRACTOR SHALL COORDINATE AND PROVIDE ALL REQUIRED WORK WITH ELECTRICAL TRADE.
4. COORDINATE EXACT LOCATION AND ELEVATION OF DUCTWORK
5. PROVIDE DETAILED SHOP DRAWINGS FOR ALL DUCT WORK PRIOR TO FABRICATION.



COMPLEX "A" KEY PLAN
SCALE: NTS

PROJECT ENGINEERS: CDM CAMP DRESSER & McKEE
SUB-CONSULTANTS: PEER CONSULTANTS P.C.; DJG & ASSOCIATES, Inc.

	DESCRIPTION	CHECKED	APPRVD	DATE
F				
E				
D	AS BUILT			3/31/06
C	CONSTRUCTION ISSUE			6/16/03
B	ADDENDUM No. 3			5/22/03
A	BID ISSUE			4/15/03

REVISIONS

DESIGN MJ
DRAFTING MJ/KB
CHECKED CRS/MJ
APPROVED CRS

REHABILITATION OF COMPLEXES A AND B
SLUDGE THICKENERS AND ASSOCIATED FACILITIES

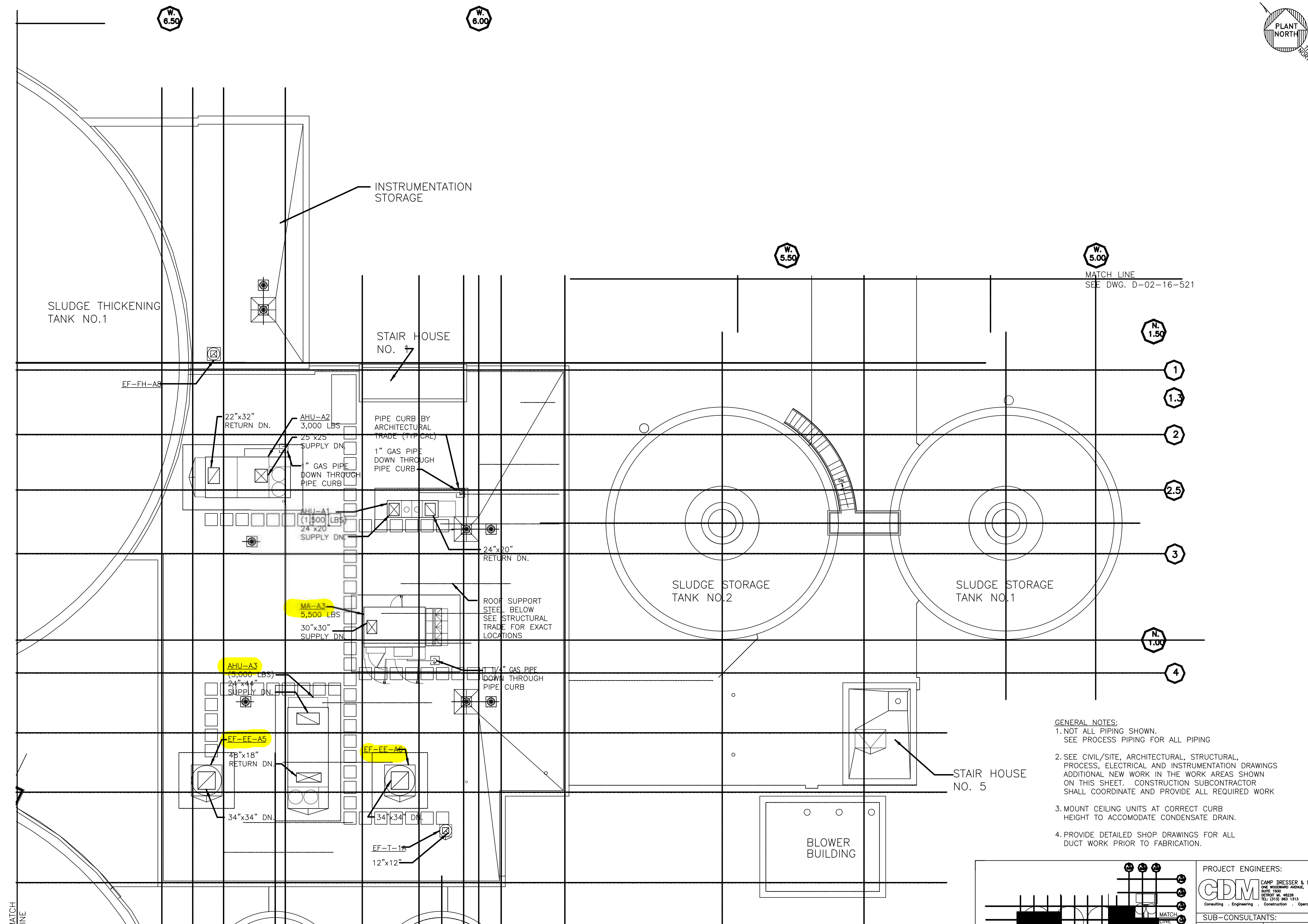
COMPLEX CONTROL BUILDING GRADE LEVEL
HVAC NEW WORK PLAN

SCALE: 1/8"=1'-0"
DATE: APRIL 15, 2003

CITY OF DETROIT
WATER AND SEWERAGE DEPARTMENT
ENGINEERING DIVISION

SECTION MAP	TOWN	RANGE	SECTION	PORTION CODE
1 5 - G	2 S	11 E	2 0 0	

M.D.E.Q. PERMIT NO.
SRF NO.
CONTRACT NO. PC-744
FILE NO. D-02-A-F2-57
PROJECT NO. DWP-1016
DRAWING NO. D-02-16-517

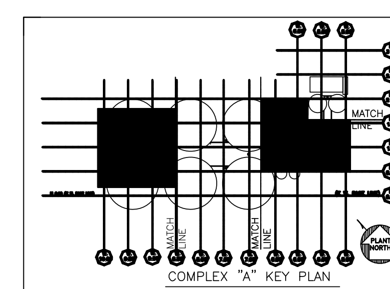


GENERAL NOTES:

1. NOT ALL PIPING SHOWN. SEE PROCESS PIPING FOR ALL PIPING
2. SEE CIVIL/SITE, ARCHITECTURAL, STRUCTURAL, PROCESS, ELECTRICAL AND INSTRUMENTATION DRAWINGS ADDITIONAL NEW WORK IN THE WORK AREAS SHOWN ON THIS SHEET. CONSTRUCTION SUBCONTRACTOR SHALL COORDINATE AND PROVIDE ALL REQUIRED WORK
3. MOUNT CEILING UNITS AT CORRECT CURB HEIGHT TO ACCOMODATE CONDENSATE DRAIN.
4. PROVIDE DETAILED SHOP DRAWINGS FOR ALL DUCT WORK PRIOR TO FABRICATION.

HVAC PLAN

GRAPHIC SCALE 0 2 4 8 12 16



PROJECT ENGINEERS: CDM CAMP DRESSER & McKEE

SUB-CONSULTANTS: PEER CONSULTANTS P.C.; CADD-MATE ASSOCIATES; DJG & ASSOCIATES, Inc.

	DESCRIPTION	CHECKED	APRVD	DATE
F				
E				
D				
C	AS BUILT			3/31/06
B	CONSTRUCTION ISSUE			6/16/03
A	BID ISSUE			4/15/03

REVISIONS

DESIGN MJ
DRAFTING MJ/KB
CHECKED MJ
APPROVED CRS

REHABILITATION OF COMPLEXES A AND B
SLUDGE THICKENERS AND ASSOCIATED FACILITIES

COMPLEX A CONTROL BUILDING ROOF LEVEL
HVAC NEW WORK PLAN

SCALE: 1/8"=1'-0" DATE: APRIL 15, 2003

CITY OF DETROIT
WATER AND SEWERAGE DEPARTMENT
ENGINEERING DIVISION

SECTION MAP	TOWN	RANGE	SECTION	PORTION CODE
1 5 - G	2 S	11 E	2 0 0	

M.D.E.Q. PERMIT NO.

SRF NO.

CONTRACT NO. PC-744

FILE NO. D-02-A-R1 28

PROJECT NO. DWP-1016

DRAWING NO. D-02-16-520

Attachment B

Dewatering Complex I
Sludge Feed Piping

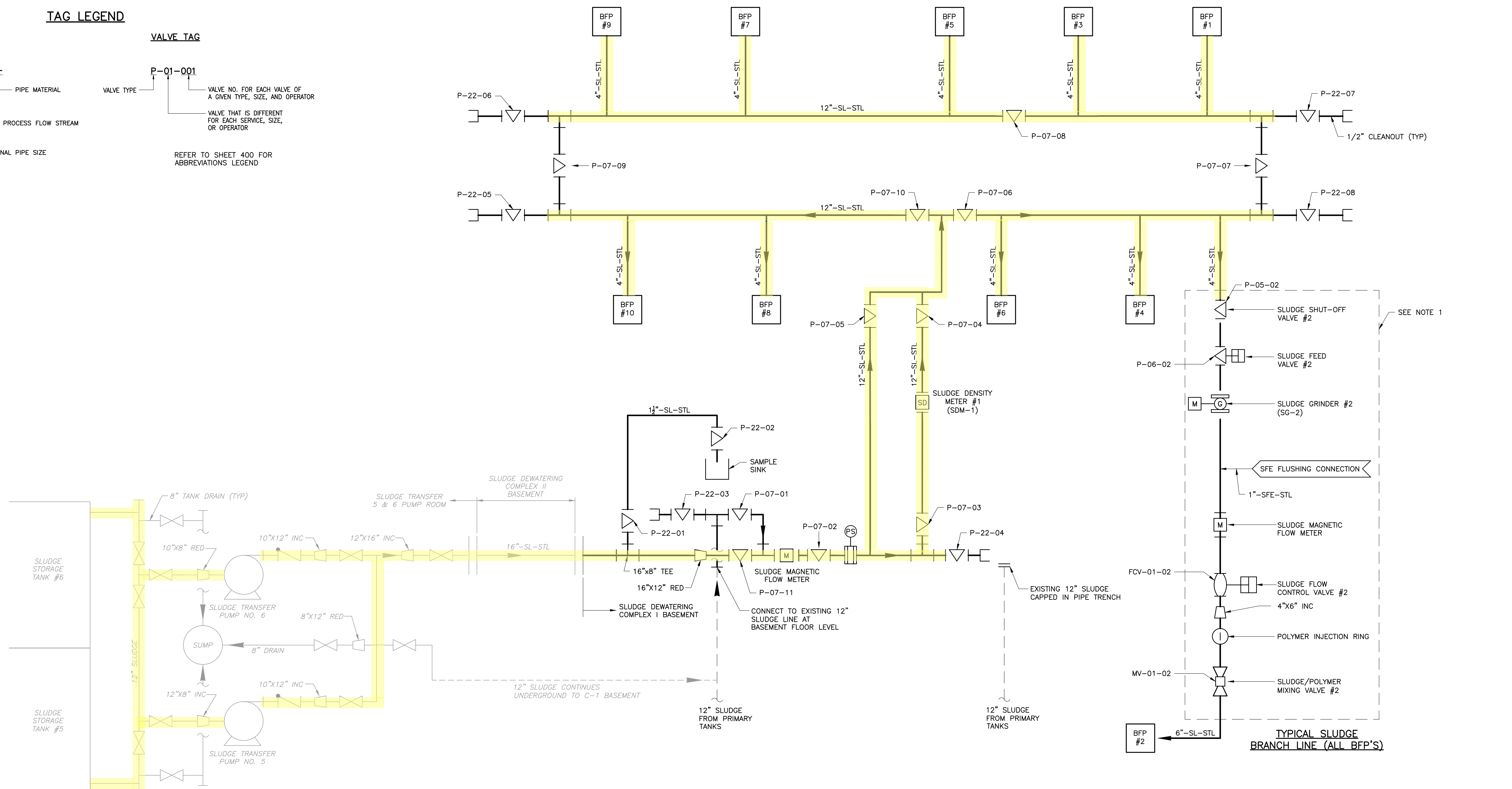
NOTES:

1. EQUIPMENT AND VALVE TAGS SHOWN ARE FOR BFP NO.2 AND TYPICAL FOR EACH BFP. SEE SHEET 436 FOR VALVE SCHEDULE.

TAG LEGEND

PIPE TAG
4"-SL-STL
PIPE MATERIAL
PROCESS FLOW STREAM
NOMINAL PIPE SIZE
VALVE TAG
P-01-001
VALVE TYPE
VALVE NO. FOR EACH VALVE OF A GIVEN TYPE, SIZE, AND OPERATOR
VALVE THAT IS DIFFERENT FOR EACH SERVICE, SIZE, OR OPERATOR

REFER TO SHEET 400 FOR ABBREVIATIONS LEGEND

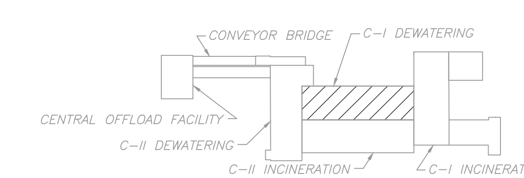


RECORD DRAWING

THIS RECORD DRAWING HAS BEEN PREPARED BASED ON INFORMATION PROVIDED BY OTHERS. THE ENGINEER HAS NOT VERIFIED THE ACCURACY OF THIS INFORMATION AND SHALL NOT BE RESPONSIBLE FOR ERRORS OR OMISSIONS THAT MAY BE INCORPORATED AS A RESULT.

By CARL JOHNSON Date AUGUST 2016

CDM Smith



KEY PLAN

NO.	DESCRIPTION	NO.	DATE	APRVD.
REVISIONS				

DESIGN S. COWBURN
DRAFTING M. STIFF
CHECKED A. KHRAIZAT
APPROVED M. TENBROEK

REPLACEMENT OF BELT FILTER PRESSES FOR COMPLEX I AND UPPER LEVEL COMPLEX II

COMPLEX I SLUDGE SYSTEM PROCESS FLOW DIAGRAM

DATE: AUGUST, 2011

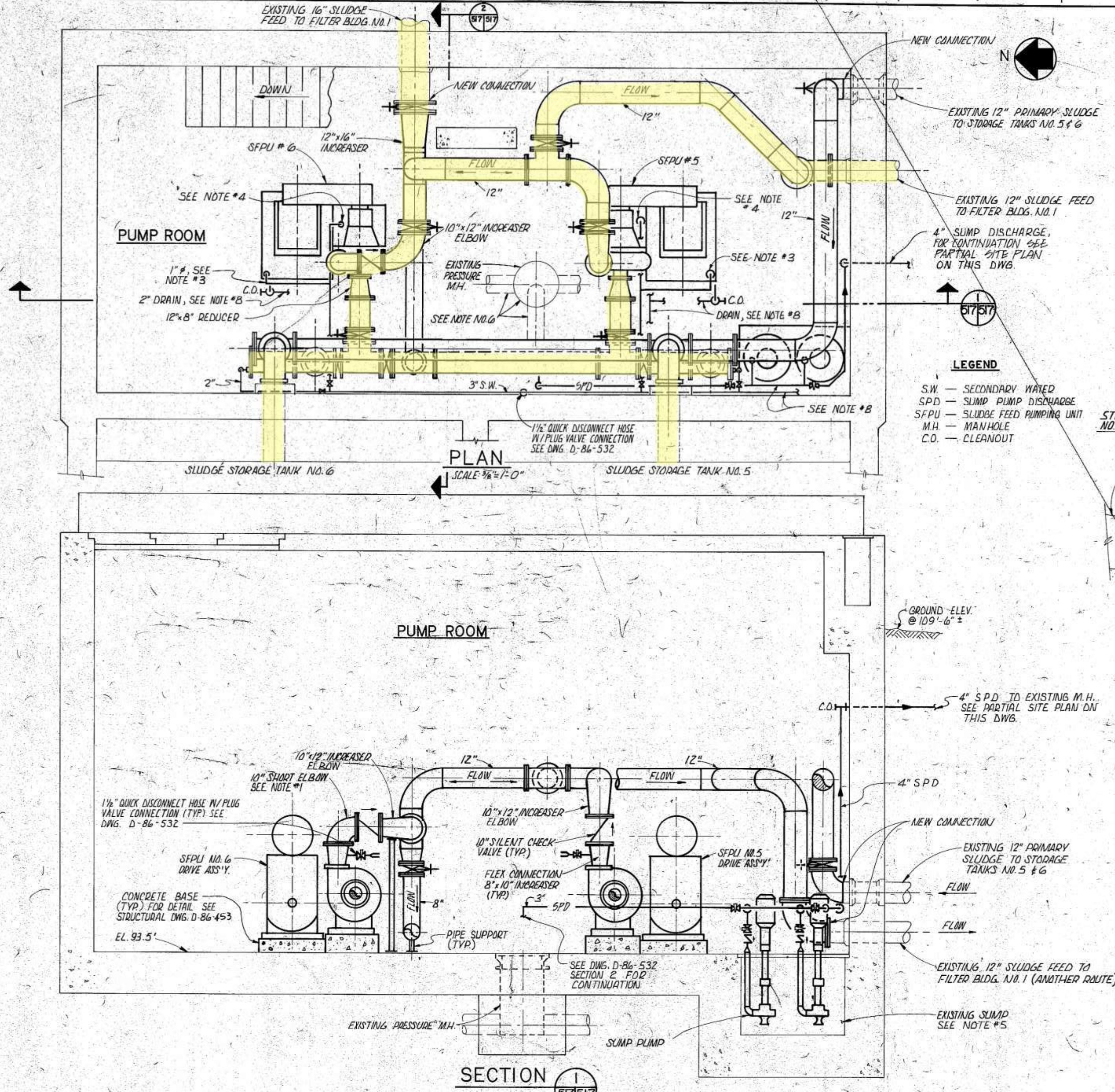
Prime Consultant:
CDM Michigan Inc.
One Woodward Avenue, Suite 1500
Detroit, MI 48226
Tel: (313) 963-1313
consulting • engineering • construction • operations

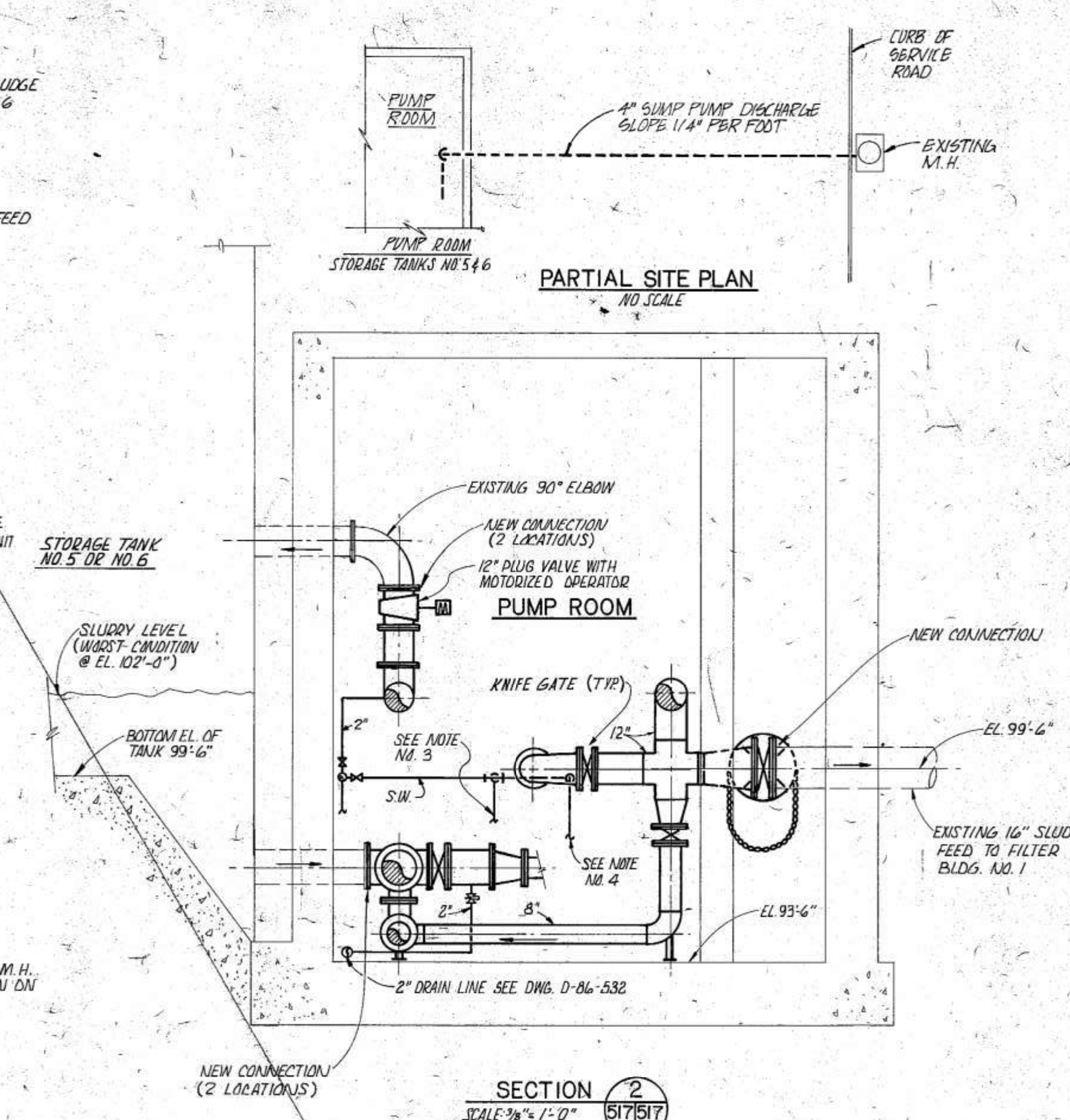
CITY OF DETROIT
WATER AND SEWERAGE DEPARTMENT
ENGINEERING DIVISION

SECTION MAP	TOWN	RANGE	SECTION	PORTION CODE
1 6 - L	2 S	11 E	0 0 2	- - -

MDEQ PERMIT NO.
PERMIT NO. -
CONTRACT NO. PC-787
FILE NO. MCIDI422
DRAWING NO. D-11-01-422

PROCESS





NOTES:

1. THIS DIMENSION DEPENDS ON MANUFACTURER'S PUMP TO ACCOMMODATE 10"-90° SHORT ELBOW, A 10" SILENT CHECK VALVE AND A 10"x12"-90° INCREASER ELBOW.
2. THIS DIMENSION DEPENDS ON MANUFACTURER'S PUMP TO ACCOMMODATE FLEXIBLE CONNECTIONS AND 10"-90° SHORT ELBOW.
3. ONE (1) INCH SECONDARY WATER LINE OR AS RECOMMENDED BY DRIVE MANUFACTURER TO HEAT EXCHANGER FOR EACH PUMP.
4. ONE-HALF (½) INCH SEAL WATER LINE OR AS RECOMMENDED BY PUMP MANUFACTURER TO EACH PUMP. IN-LINE BOOSTER PUMP SHALL BE INSTALLED FOR EACH SLUDGE FEED PUMP.
5. CLEAN EXISTING SUMP BEFORE INSTALLING NEW SUMP PUMP AND ACCESSORIES.
6. CLEAN PRESSURIZE MH 8" INLET CONNECTION AND 12" DISCHARGE AT ELEVATION 89.5' UP TO MH-B3 APPROXIMATELY 75 FEET FROM THE WEST WALL OF EQUIPMENT ROOM.
7. VALVE HANDWHEEL SHALL BE POSITIONED FOR EASE OF OPERATION.
8. FOR SPD, DRAINS FROM HEAT EXCHANGER, PUMP SEAL WATER AND S.W. LINES, REFER TO DWG. D-86-532.
9. SEE DWG. D-86-532
10. FOR CENTERLINE DIMENSIONS, REFER TO STRUCTURAL DWG.

REVISIONS			
DESCRIPTION	CHK'D	APRVD.	DATE
F			
E			
D			
C			
B			
A			

DESIGNED BY V. SOLANO
DRAWN BY J.L. BOURDEAUX
CHECKED BY

APPROVED
HEAD ENGINEER
ASSISTANT DIVISION ENGINEER
DIVISION ENGINEER

INSTALLATION OF BELT FILTER PRESSES IN COMPLEX I

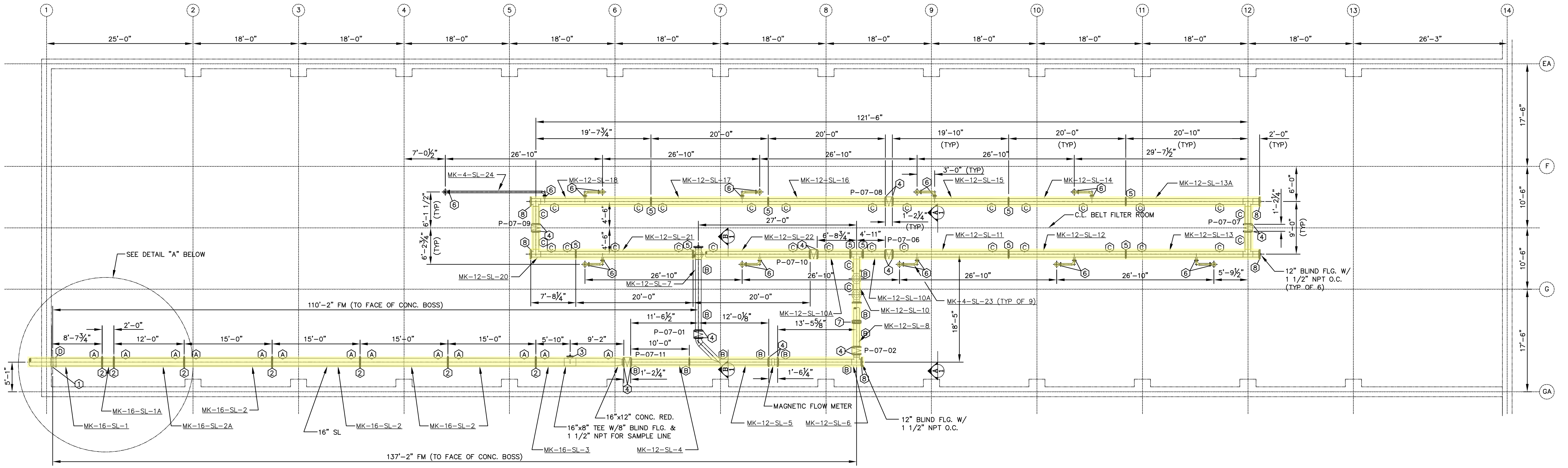
SLUDGE STORAGE TANKS NO. 5 & 6
SLUDGE PUMP ROOM
PLUMBING AND PIPING SYSTEMS - PLAN & SECTIONS

SCALE: AS NOTED DATE MAY, 1987

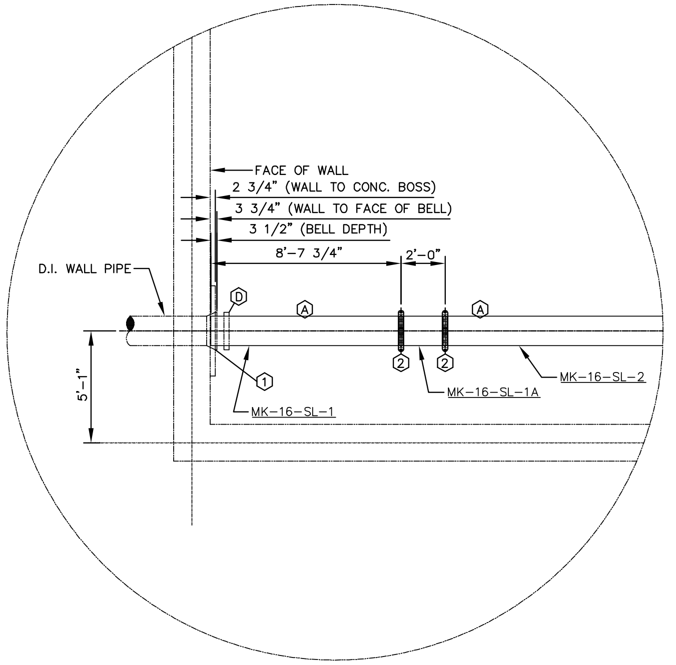
CITY OF DETROIT
WATER AND SEWERAGE DEPARTMENT
ENGINEERING DIVISION
WASTEWATER PLANT

SECTION MAP	TOWN	RANGE	SECTION	PORTION CODE	WORK ORDER NO.
15-G	2 S	11 E	200	527	S-300-957

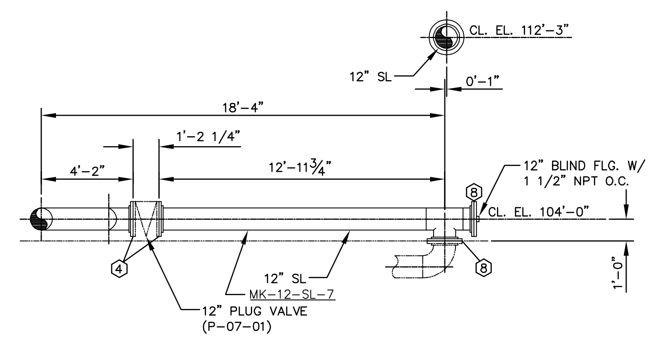
M.D.P.H./D.N.R. PERMIT NO. 879147
FED. REF. NO. C263482-35
CONTRACT NO. PC-616
FILE NO. 5019
D-86-517



COMPLEX 1 SLUDGE PIPING
BASEMENT PLAN EL. 103'-0"

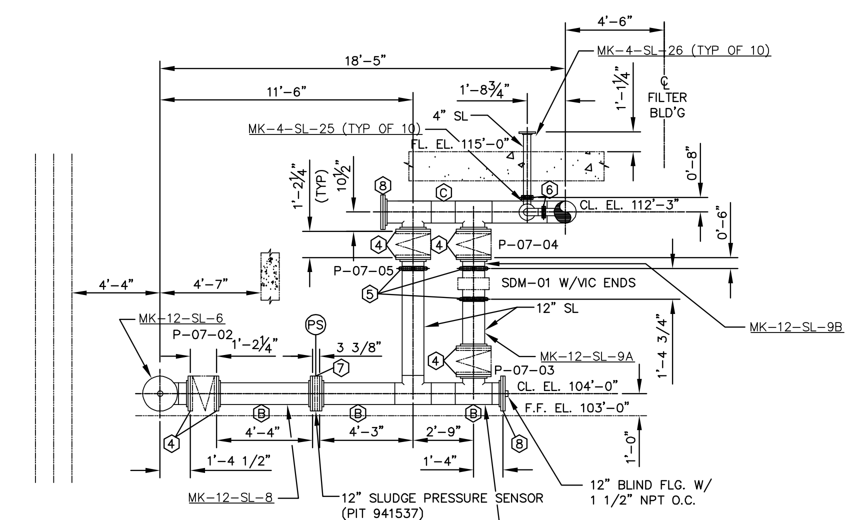


DETAIL "A"



SECTION B/1

SCALE 3/8"=1'



SECTION A/1

SCALE 3/8"=1'

ALL VALVE DIMENSIONS INCLUDE (2) 1/8" GASKETS

*REFERENCE TMF DWG. NO. 11-252 11 & 12 FOR PIPING DETAILS

JOINT ACCESSORIES DESCRIPTION BY WEISS

- (1)– 1 REQ'D. – 16" MJ (EXIST'G TAPPED MJ BELL) D.I./STL. TRANSITION GASKET
- (3)– 1 REQ'D. – 8" STL FLG x STL FLG. JA SET 4
- (4)– 24 REQ'D. – 12" STL-HDG-FLG x PV JA SET 4
- (7)– 1 REQ'D. – 12" FLG. PRESSURE SENSOR 7/8"x10"STUDS W/NUTS
- (8)– 10 REQ'D. – 12" STL. FLG. X STL FLG. HDG-FLG. JA SET 4

JOINT ACCESSORIES DESCRIPTION BY TMF

- (2)– 7 REQ'D. – 16" VICTAULIC STYLE 77 COUPLING 4
- (5)– 14 REQ'D. – 12" VICTAULIC STYLE 77 COUPLINGS
- (6)– 30 REQ'D. – 4" VICTAULIC STYLE 77 COUPLINGS

HANGERS & SUPPORTS BY WEISS

- (A)– 13 REQ'D. – 16" PIPE POURED CONCRETE SADDLE
- (B)– 11 REQ'D. – 4 12" PIPE POURED CONCRETE SADDLE
- (C)– 4 32 REQ'D. – 12" CLEVIS HANGERS
- (D)– 1 –REQ'D. – 16" FRICTION CLAMP

AS BUILT DRAWING

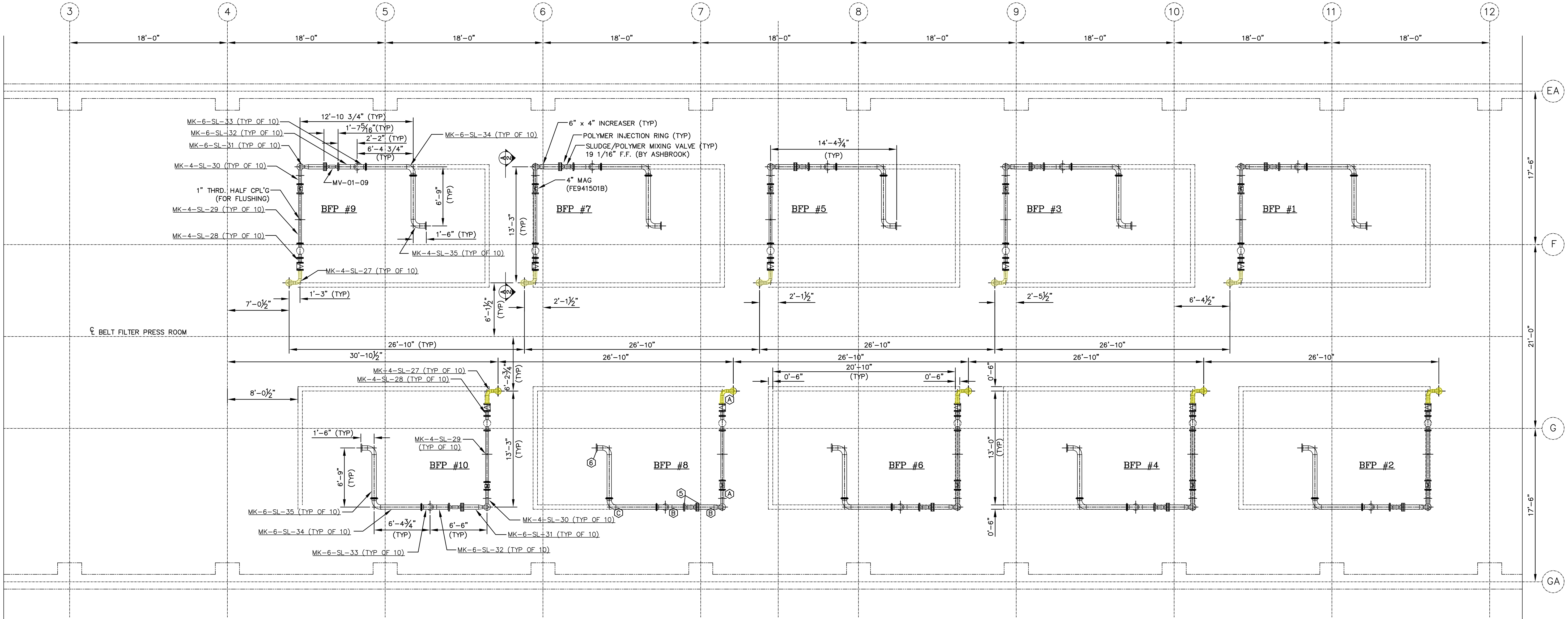
ENGINEER CDM	TENNESSEE METAL FABRICATING CORP. CAMPAIGN, TENNESSEE
CONTRACTOR WEISS CONSTRUCTION CO.	CITY OF DETROIT WATER & SEWER DEPT. PC-787 REPLACEMENT OF BELT FILTER PRESSES

REV.	DATE	REMARKS
1	8-1-12	CHANGED PIPE LENGTHS
2	9-11-12	GENERAL REVISIONS
3	11-6-12	GENERAL REVISIONS
4	11-26-12	GENERAL REVISIONS

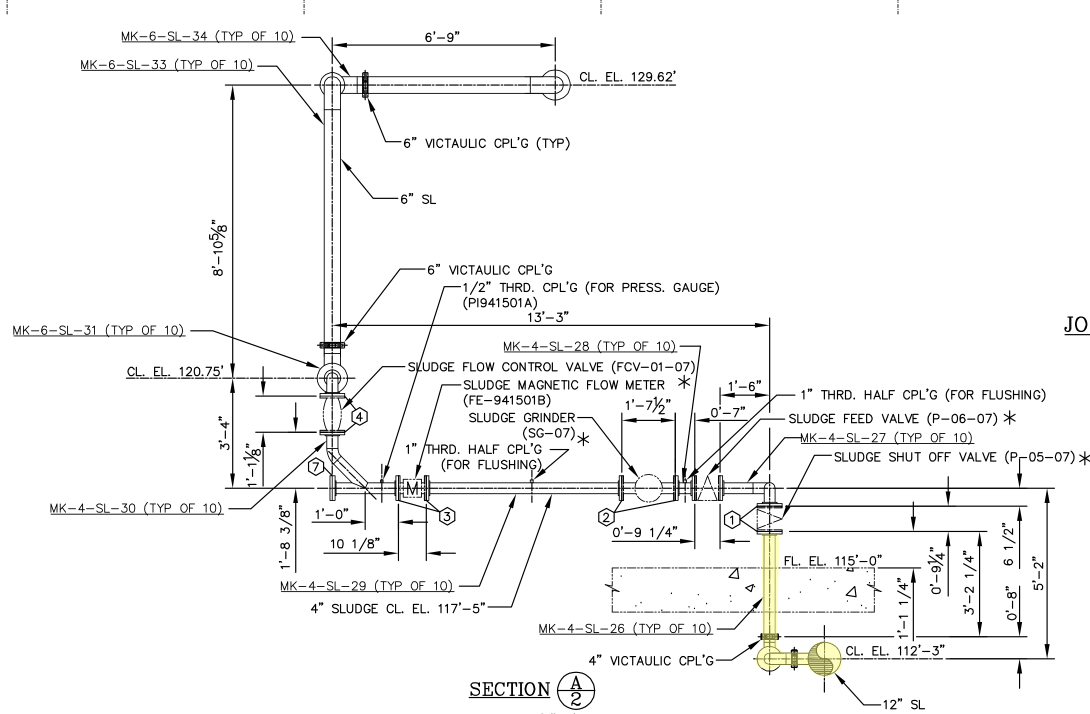
COMPLEX 1 SLUDGE PIPING BASEMENT PLAN

DRAWN BY	SCALE	DATE
B. HEWITT	1/8"=1'	5-4-12
CUSTOMER P.O. NO.	CONTRACT NO.	T.M.F. DRAWING NO.
	PC-787	11-252 1 OF

CAD REF.



SLUDGE PIPING
FIRST FLOOR PLAN EL. 115'-0"



SECTION (A/2)

SCALE 3/8"=1' * =LAST 2 DIGITS MATCH PRESS NO.

HANGERS & SUPPORTS BY WEISS

- (A) – 20 REQ'D. – 4" PIPE SADDLE – TYPE 37
- (B) – 20 REQ'D. – 6" PIPE SADDLE – TYPE 37
- (C) – 10 REQ'D. – 6" PIPE SADDLE – TYPE 37

JOINT ACCESSORIES DESCRIPTION BY WEISS

- (1) – 40 REQ'D. – 4" STL/PV JA SET
- (2) – 20 REQ'D. – 4" STL/GRD JA SET
- (3) – 20 REQ'D. – 4" STL/MAG JA SET
- (4) – 20 REQ'D. – 4" STL/FCV JA SET
- (5) – 20 REQ'D. – 6" STL/PMV JA SET
- (6) – 10 REQ'D. – 6" STL./BPP JA SET
- (7) – 10 REQ'D. – 6" STL/STL JA SET

* ALL VALVE DIMENSIONS INCLUDE (2) ⅛" GASKETS

* REFERENCE TMF DWG. NO. 11-252 11 & 12 FOR PIPING DETAILS

AS BUILT DRAWING

ENGINEER: CDM	TENNESSEE METAL FABRICATING CORP. CAMPAIGN, TENNESSEE
CONTRACTOR: WEISS CONSTRUCTION CO.	CITY OF DETROIT WATER & SEWER DEPT. PC-787 REPLACEMENT OF BELT FILTER PRESSES

REV.	DATE	REMARKS
1	9-11-12	GENERAL REVISIONS
2	11-7-12	GENERAL REVISIONS
3	11-27-12	GENERAL REVISIONS

COMPLEX 1 SLUDGE PIPING PLAN EL. 115'-0"

DRAWN BY	SCALE	DATE
B. HEWITT	3/16"=1'	5-7-12
CUSTOMER P.O. NO.	CONTRACT NO.	T.M.F. DRAWING NO.
	PC-787	11-252 2 OF

CAD REF 11-252

Attachment C

Dewatering Complex II
Sludge Feed Piping

TAG LEGEND

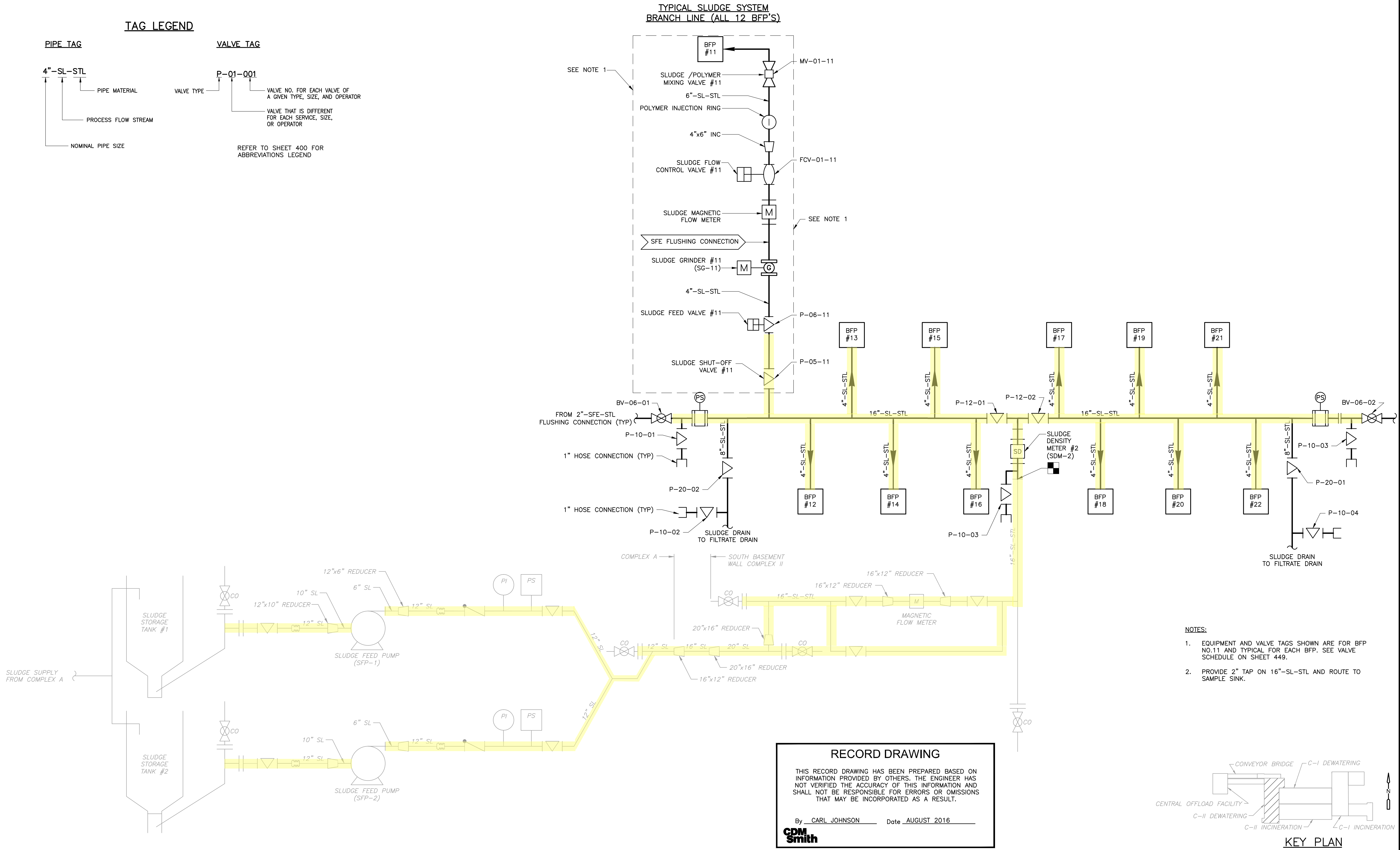
PIPE TAG

4"-SL-STL
- PIPE MATERIAL
- PROCESS FLOW STREAM
- NOMINAL PIPE SIZE

VALVE TAG

P-01-001
- VALVE TYPE
- VALVE NO. FOR EACH VALVE OF A GIVEN TYPE, SIZE, AND OPERATOR
- VALVE THAT IS DIFFERENT FOR EACH SERVICE, SIZE, OR OPERATOR

REFER TO SHEET 400 FOR ABBREVIATIONS LEGEND



NOTES:

1. EQUIPMENT AND VALVE TAGS SHOWN ARE FOR BFP NO.11 AND TYPICAL FOR EACH BFP. SEE VALVE SCHEDULE ON SHEET 449.
2. PROVIDE 2" TAP ON 16"-SL-STL AND ROUTE TO SAMPLE SINK.

RECORD DRAWING

THIS RECORD DRAWING HAS BEEN PREPARED BASED ON INFORMATION PROVIDED BY OTHERS. THE ENGINEER HAS NOT VERIFIED THE ACCURACY OF THIS INFORMATION AND SHALL NOT BE RESPONSIBLE FOR ERRORS OR OMISSIONS THAT MAY BE INCORPORATED AS A RESULT.

By CARL JOHNSON Date AUGUST 2016

CDM Smith

NO.	DESCRIPTION	NO.	DATE	APRVD.
	REVISIONS			

DESIGN S. COWBURN
DRAFTING K. PERRY
CHECKED A. KHRAIZAT
APPROVED M. TENBROEK

REPLACEMENT OF BELT FILTER PRESSES FOR COMPLEX I AND UPPER LEVEL COMPLEX II

COMPLEX II
SLUDGE SYSTEM PROCESS FLOW DIAGRAM

DATE: AUGUST, 2011

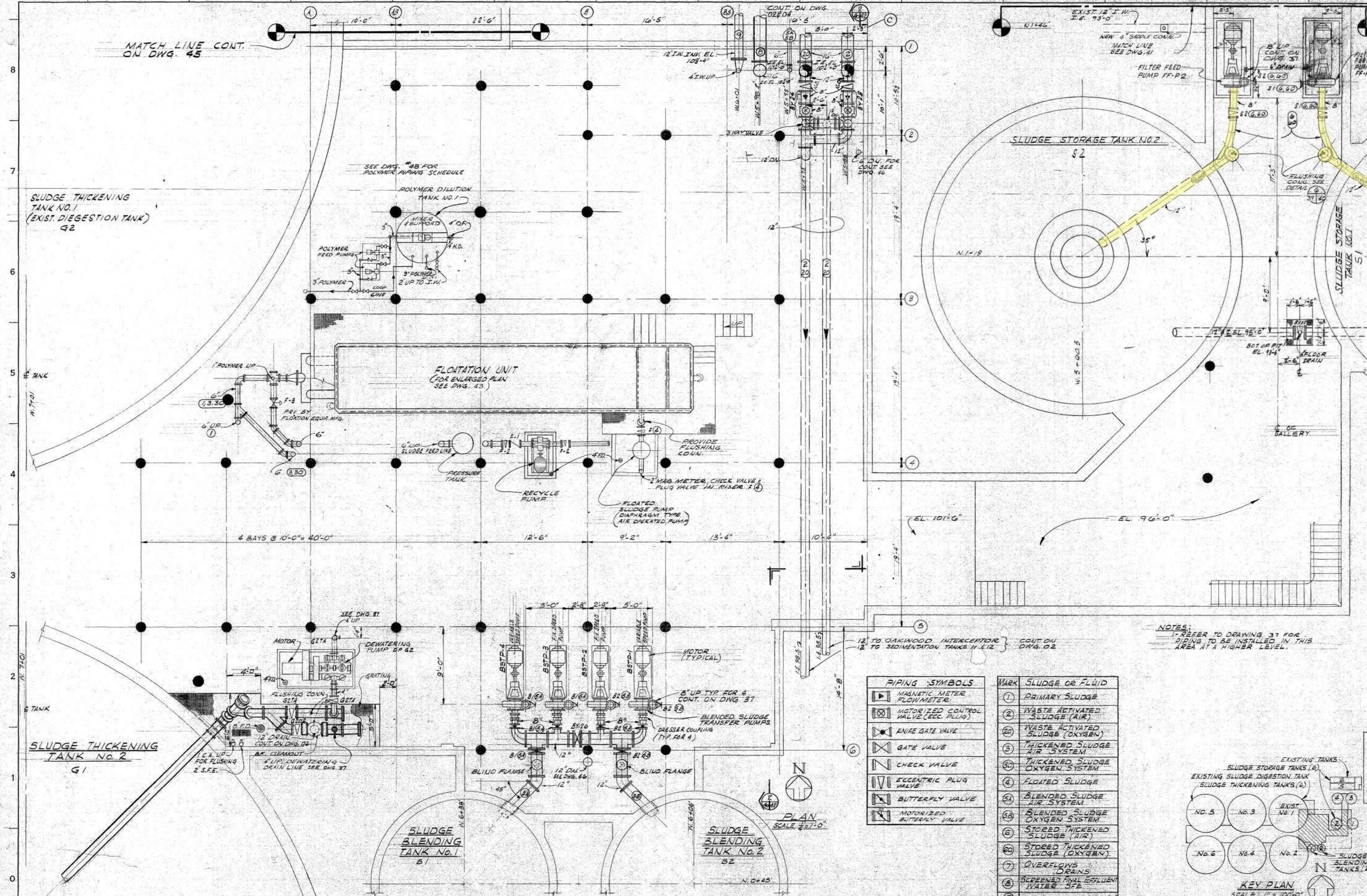
Prime Consultant:
CDM Michigan Inc.
One Woodward Avenue, Suite 1500
Detroit, MI 48226
Tel: (313) 963-1313
consulting • engineering • construction • operations

CITY OF DETROIT
WATER AND SEWERAGE DEPARTMENT
ENGINEERING DIVISION

SECTION MAP	TOWN	RANGE	SECTION	PORTION CODE
1 6 - L	2 S	11 E	0 0 2	- - -

MDEQ PERMIT NO.
PERMIT NO. -
CONTRACT NO. PC-787
FILE NO. MCIIFD425
DRAWING NO. D-11-01-425

PROCESS



PIPING SYMBOLS
MAGNETIC METER FLOWMETER
MOTORIZED CONTROL VALVE (ECC. PLUG)
KNIFE GATE VALVE
GATE VALVE
CHECK VALVE
ECCENTRIC PLUG VALVE
BUTTERFLY VALVE
MOTORIZED BUTTERFLY VALVE

MARK	SLUDGE OR FLUID
1	PRIMARY SLUDGE
2	WASTE ACTIVATED SLUDGE (AIR)
20	WASTE ACTIVATED SLUDGE (OXYGEN)
3	THICKENED SLUDGE AIR SYSTEM
30	THICKENED SLUDGE OXYGEN SYSTEM
4	FLOATED SLUDGE
5A	BLENDED SLUDGE AIR SYSTEM
5B	BLENDED SLUDGE OXYGEN SYSTEM
6	STORED THICKENED SLUDGE (AIR)
60	STORED THICKENED SLUDGE (OXYGEN)
7	OVERFLOWS DRAINS
8	SCREENED FINAL EFFLUENT WATER SFE
9	INDUSTRIAL WATER (IW)

REVISIONS: G F E D C B A — COOR | DESCRIPTION | APRVD. | DATE

DESIGNED BY R. L. HANNIGAN
DRAWN BY R.W. LARKIN
CHECKED BY R.V. CHERUKURI

APPROVED
PROJECT DIRECTOR - HRC
ASS'T. CHIEF ENGINEER - DMWD
CHIEF ENGINEER - DMWD

ACTIVATED SLUDGE THICKENING FACILITIES

PLAN - LOW LEVEL PROCESS PIPING
FLOATATION GALLERY AND SOUTH STORAGE TANK GALLERY

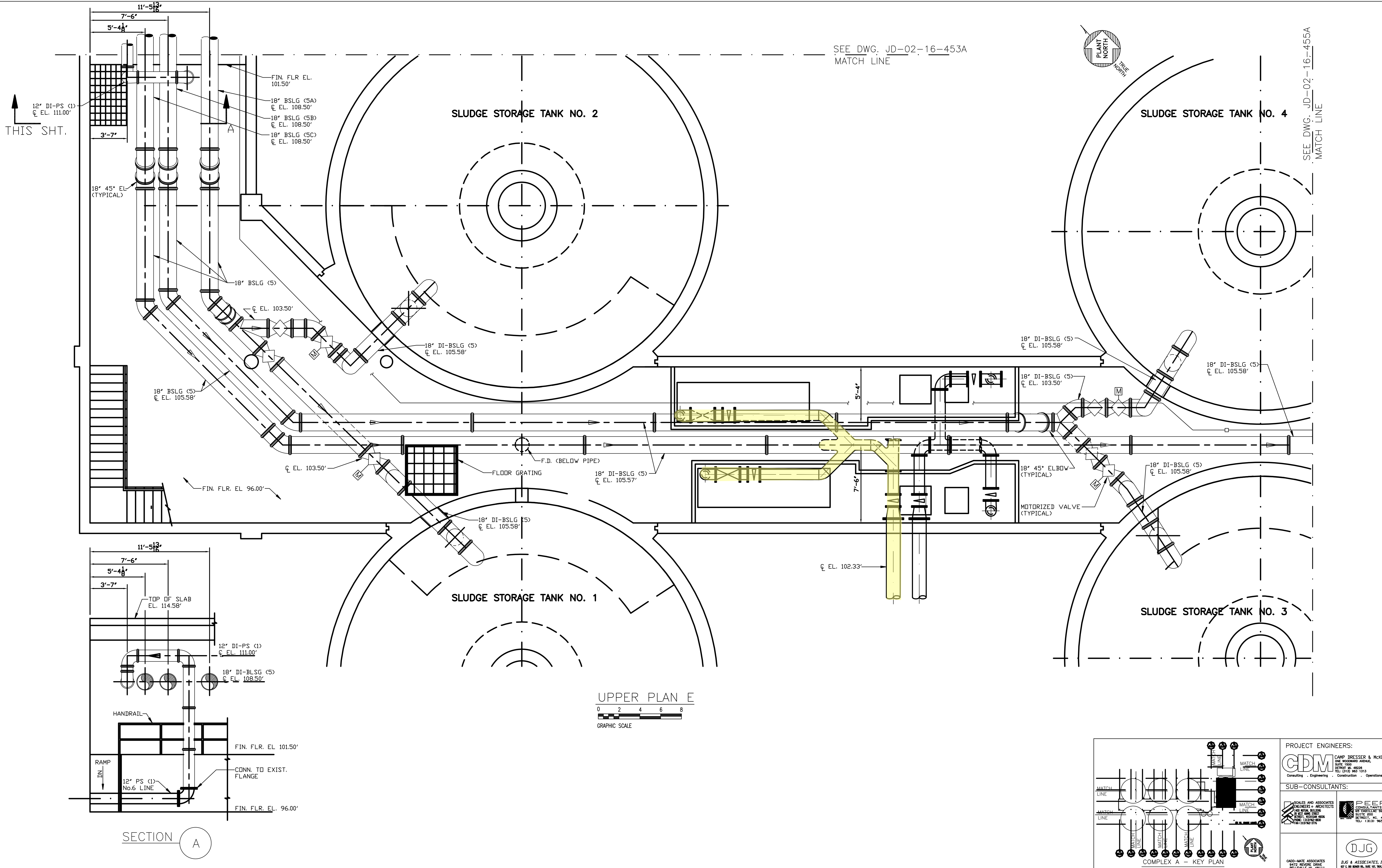
SCALE AS NOTED — DATE DEC. 1971

DETROIT METRO WATER DEPARTMENT
POLLUTION CONTROL PROGRAM
WASTEWATER PLANT

HUBBELL, ROTH & CLARK, INC.
CONSULTING ENGINEERS
BLOOMFIELD HILLS, MICHIGAN

SECTION MAP | TOWN | RANGE | SECTION | PORTION CODE | WORK ORDER NO. | H.R.C. JOB NO. 66111-311

M.D.P.H. PERMIT NO. S-710709
FED. REF. NO. WPC-MICH-1896
CONTRACT NO. PC-241
DRAWING NO. 76640



REV	DESCRIPTION	CHECKED	APRVD	DATE
F				
E				
D				
C	AS BUILT			3/31/06
B	CONSTRUCTION ISSUE			6/16/03
A	BID ISSUE			4/15/03

REVISIONS

DESIGN
DRAFTING JDC
CHECKED JDC
APPROVED JDC

CDM

REHABILITATION OF COMPLEXES A AND B
SLUDGE THICKENERS AND ASSOCIATED FACILITIES

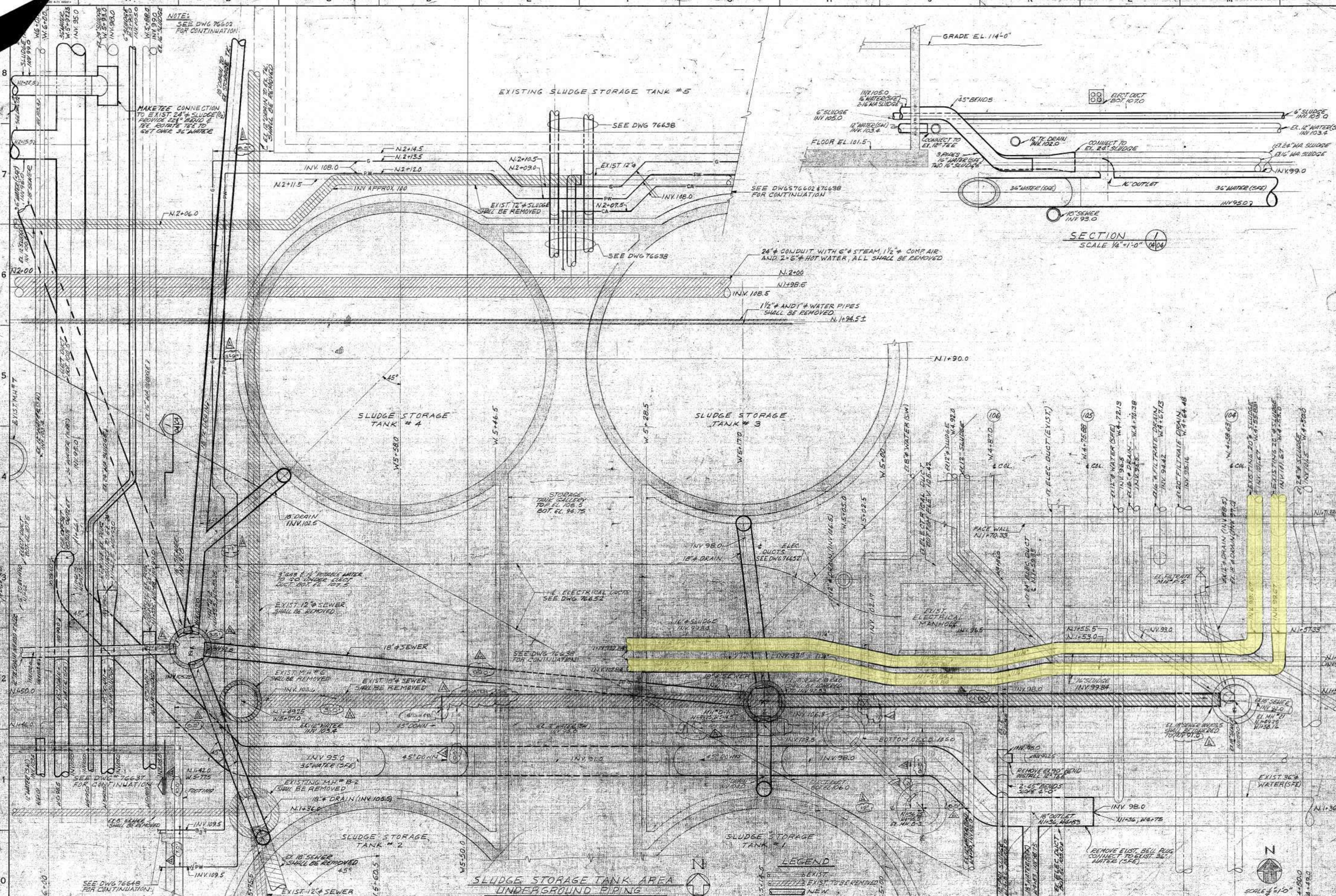
COMPLEX A
PIPE GALLERY SST UPPER LEVEL
PLAN E NEW WORK

SCALE: 1/4"=1'-0"
DATE: MARCH 7, 2005

CITY OF DETROIT
WATER AND SEWERAGE DEPARTMENT
ENGINEERING DIVISION

SECTION MAP | TOWN | RANGE | SECTION | PORTION CODE

M.D.E.Q. PERMIT NO.
SRF NO.
CONTRACT NO. PC-744
FILE NO. D-02-16-454
PROJECT NO. DWP-1016
DRAWING NO. D-02-16-454



DESIGNED BY	T.G. LA VALLEY
DRAWN BY	W.F. RUBARTH
CHECKED BY	R.V. CHERUKURI

REVISIONS: A — AS BUILT CHANGES OF DIMENSIONS

APPROVED: PROJECT DIRECTOR - HRC; ASST. CHIEF ENGINEER - DMWD; CHIEF ENGINEER - DMWD

ACTIVATED SLUDGE THICKENING FACILITIES

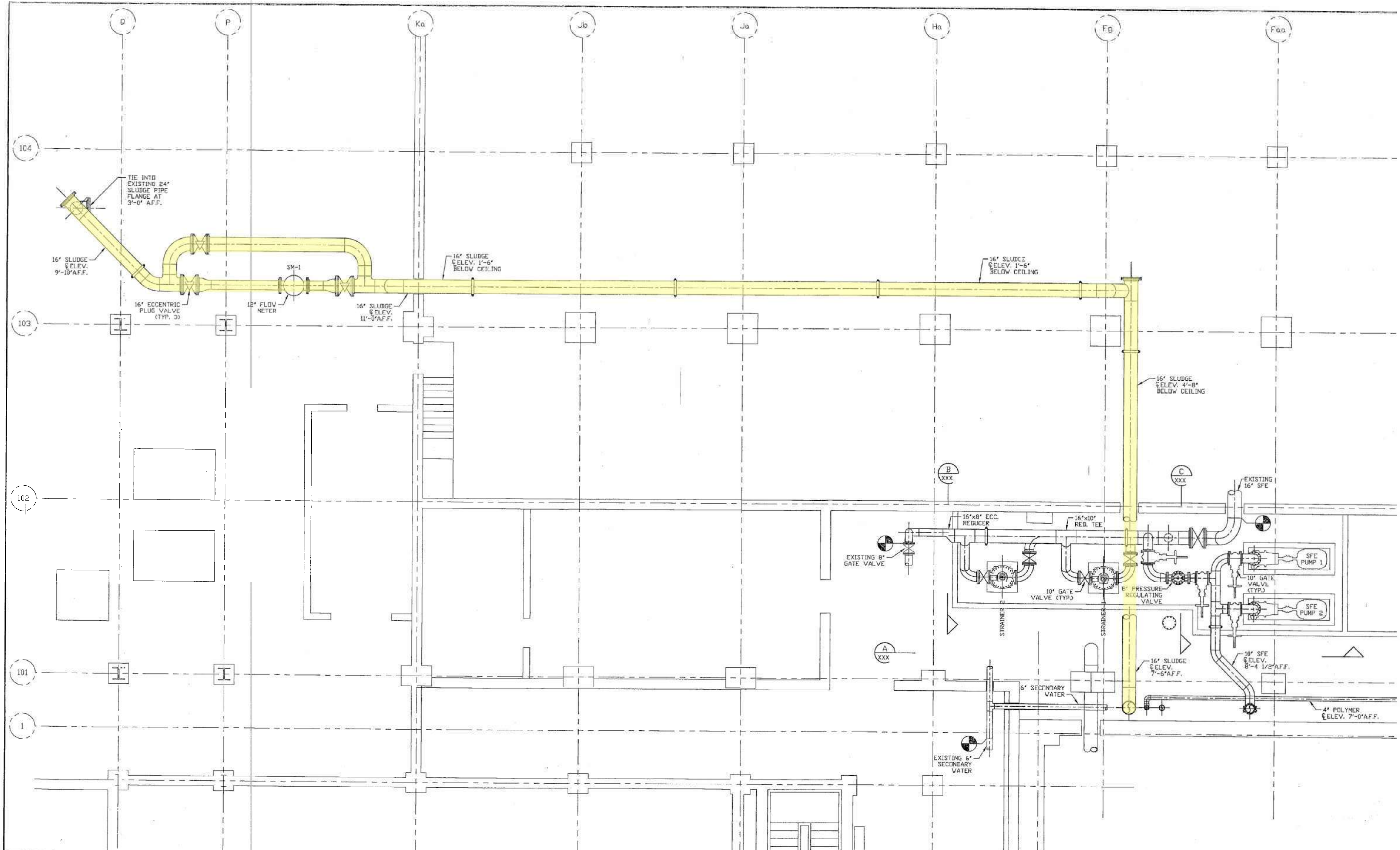
SLUDGE STORAGE TANK AREA
UNDERGROUND PIPING

SCALE 1/4" = 1'-0"   DATE DEC. 1971

DETROIT METRO WATER DEPARTMENT
POLLUTION CONTROL PROGRAM
WASTEWATER PLANT

HUBBELL, ROTH & CLARK, INC.
CONSULTING ENGINEERS
BLOOMFIELD HILLS, MICHIGAN

M.D.P.H. PERMIT NO. S-710709
FED. REF. NO. WPC-MICH-1896
CONTRACT NO. PC-241
DRAWING NO. 76604



REV.	DESCRIPTION	CHK'D	APRVD	DATE
F				
E				
D				
C				
B				
A				

REVISIONS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

COMPLEX II - UPPER LEVEL - BELT FILTER PRESSES

SFE & SLUDGE PIPING

XXXXXX
XXXXXX
XXXXXX

SCALE:
DATE:

CITY OF DETROIT
WATER AND SEWERAGE DEPARTMENT
ENGINEERING DIVISION

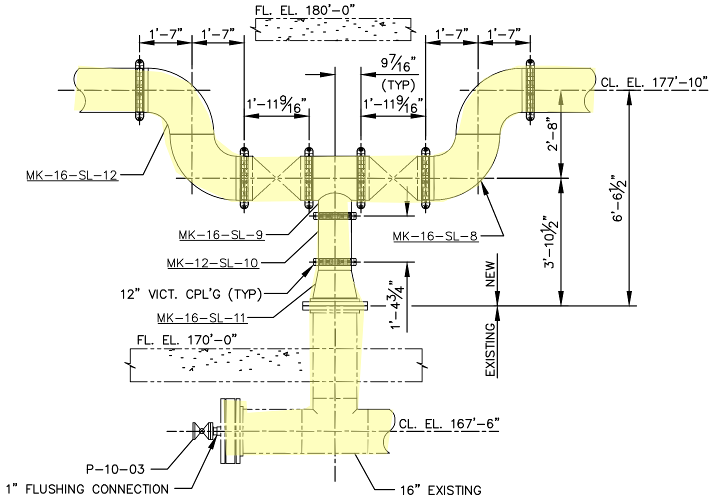
E.L. PIPE, INC.
18637 Mt. Elliot
Detroit, Michigan 48234

PROJECT MGR.	DESIGNED BY	DRAWING FILE	
GOLD	XXX	P:\9812\PROD\MP-XXX.DWG	
DRAWN BY	CHECKED BY	JOB NO.	ELP DRAWING NO.
XXX	XXX	9812	MP-XXX

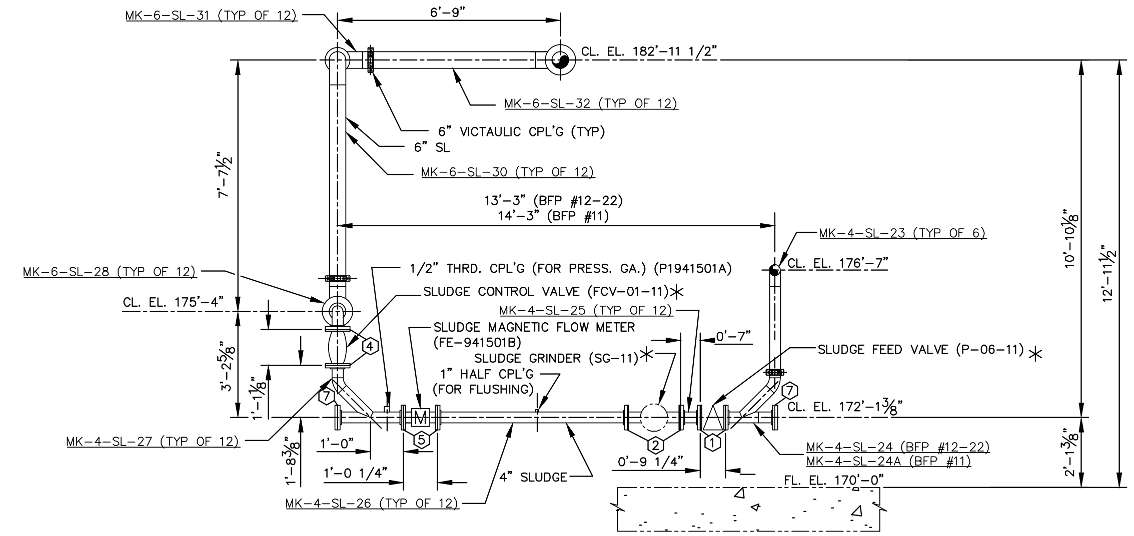
SECTION MAP | TOWN | RANGE | SECTION | PORTION CODE | WORK ORDER NO.

WORK ORDER NO.
FED. REF. NO.
CONTRACT NO. PC-691
FILE NO.

D - 92 - 05 -

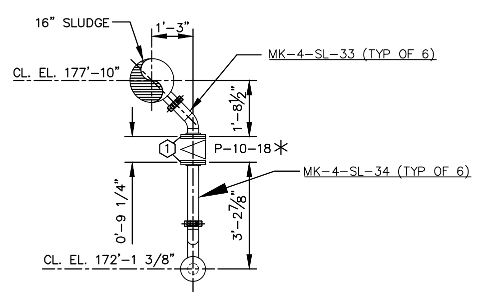


SECTION (A/21)

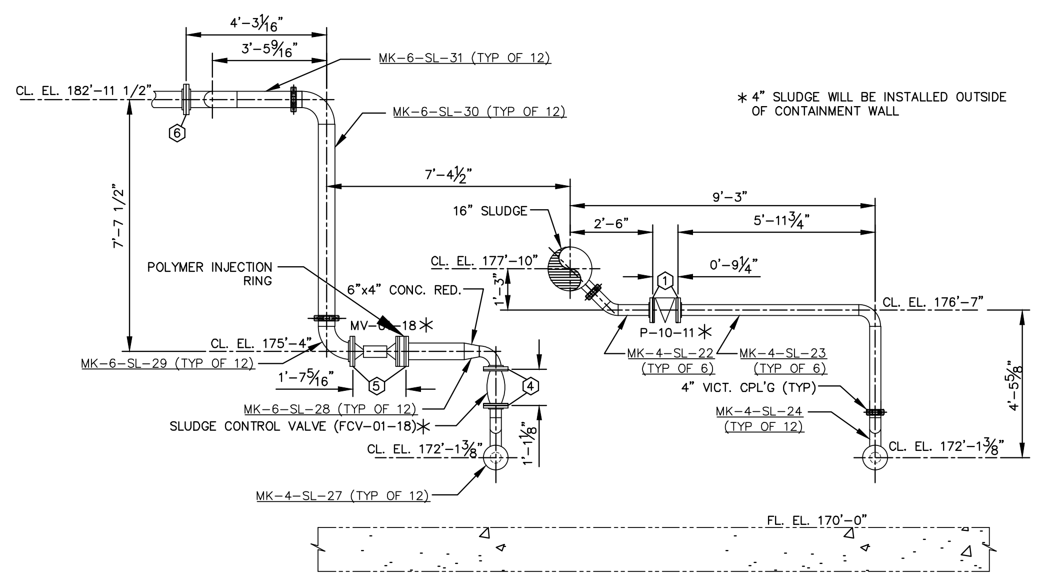


SECTION (B/22)

*=LAST 2 DIGITS MATCH PRESS NO.



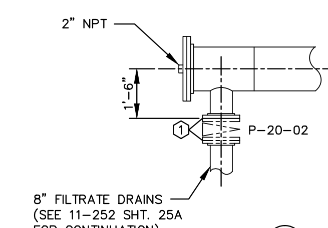
SECTION (C/22)



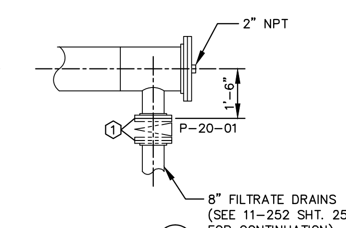
*4" SLUDGE WILL BE INSTALLED OUTSIDE OF CONTAINMENT WALL

SECTION (D/22)

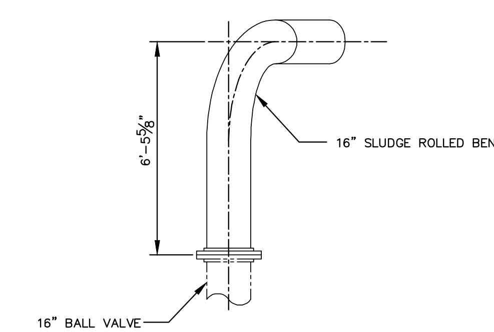
*=LAST 2 DIGITS MATCH PRESS NO.



SECTION (F/22)



SECTION (G/22)



SECTION (E/22)

JOINT ACCESSORIES DESCRIPTION BY WEISS

(1)- 48 REQ'D. - 4" STL/PV JA SET
(2)- 24 REQ'D. - 4" STL/GRD JA SET
(3)- 24 REQ'D. - 4" STL/MAG JA SET
(4)- 24 REQ'D. - 4" STL/FCV JA SET
(5)- 24 REQ'D. - 4" STL/PMV JA SET
(6)- 12 REQ'D. - 6" STL./BPP JA SET
(7)- 24 REQ'D. - 4" STL/STL JA SET

GENERAL NOTES FOR COMPLEX II SLUDGE PIPING

1. ALL PIPE WILL BE XS A-53 GR. B ERW.
2. ALL FITTINGS WILL BE XS ASTM A-234.
3. FLANGES WILL 150# RAISED FACE SLIP-ON.
4. FLANGE BOLT HOLES SHALL STRADDLE PIPE CENTER LINES.
5. PIPE WILL BE SANDBLASTED TO SSPC-SP 10 NEAR WHITE PROFILE I.D. AND O.D. BEFORE COATING.
6. FINISH: INTERIOR-(1) COAT TNEMEC N140 POTA-POX PLUS 4-6 DRY MILS INTERIOR-(2) COATS TNEMEC N140 POTA-POX PLUS 5-7 DRY MILS PER COAT EXTERIOR-(1) COATS TNEMEC 37H CHEM-PRIME H.S. 2.5-3.5 DRY MILS PER COAT

AS BUILT DRAWING

ENGINEER: CDM		
CONTRACTOR: WEISS CONSTRUCTION CO.		
REV.	DATE	REMARKS
1	3-26-14	GENERAL CORRECTIONS
2	8-13-14	GENERAL CORRECTIONS

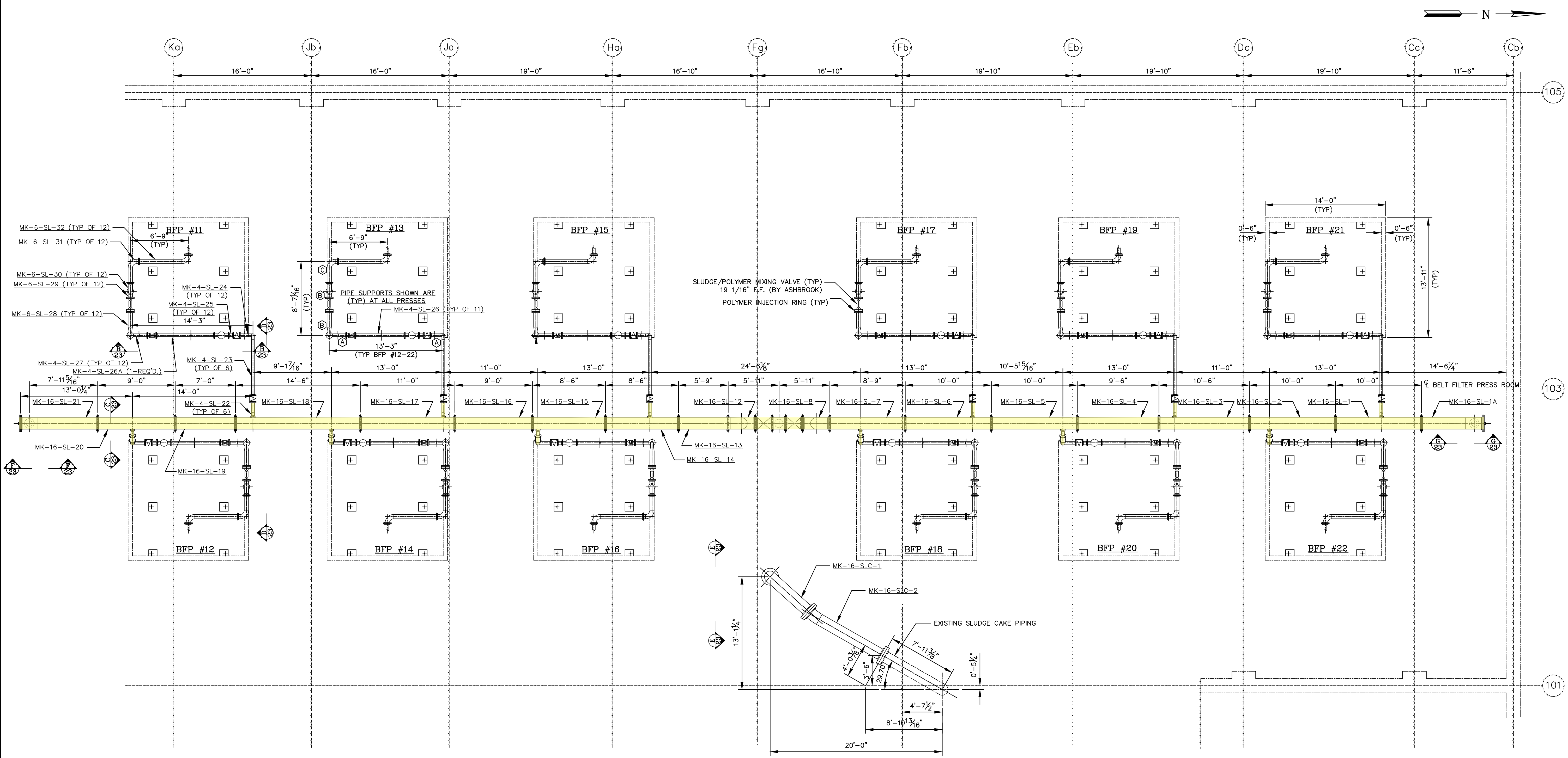
TENNESSEE METAL FABRICATING CORP.
CAMPAIGN, TENNESSEE

CITY OF DETROIT WATER & SEWER DEPT.
PC-787 REPLACEMENT OF BELT FILTER PRESSES

COMPLEX II SLUDGE PIPING SECTION VIEWS

DRAWN BY	SCALE	DATE
B. HEWITT	3/8"=1'	8-23-13
CUSTOMER P.O. NO.	CONTRACT NO.	T.M.F. DRAWING NO.
	PC-787	11-252 23 OF

CAD REF. 11-252



COMPLEX II SLUDGE PIPING
THIRD FLOOR PLAN OF 4" & 6" SLUDGE PIPING

* ALL VALVE DIMENSIONS INCLUDE (2) 1/8" GASKETS

* REFERENCE TMF DWG. NO. 11-252 23, 24 & 25 FOR PIPING DETAILS

HANGERS & SUPPORTS BY WEISS

Ⓐ - 24 REQ'D. - 4" PIPE SADDLE - TYPE 37
Ⓑ - 24 REQ'D. - 6" PIPE SADDLE - TYPE 37
Ⓒ - 12 REQ'D. - 6" PIPE SADDLE - TYPE 37

AS BUILT DRAWING

ENGINEER: CDM
CONTRACTOR: WEISS CONSTRUCTION CO.

REV.	DATE	REMARKS
1	3-26-14	GENERAL CORRECTIONS
2	3-28-14	GENERAL CORRECTIONS
3	8-13-14	GENERAL CORRECTIONS
4	8-21-14	GENERAL CORRECTIONS
5	10-1-14	GENERAL CORRECTIONS

TENNESSEE METAL FABRICATING CORP.
CAMPAIGN, TENNESSEE

CITY OF DETROIT WATER & SEWER DEPT.
PC-787 REPLACEMENT OF BELT FILTER PRESSES

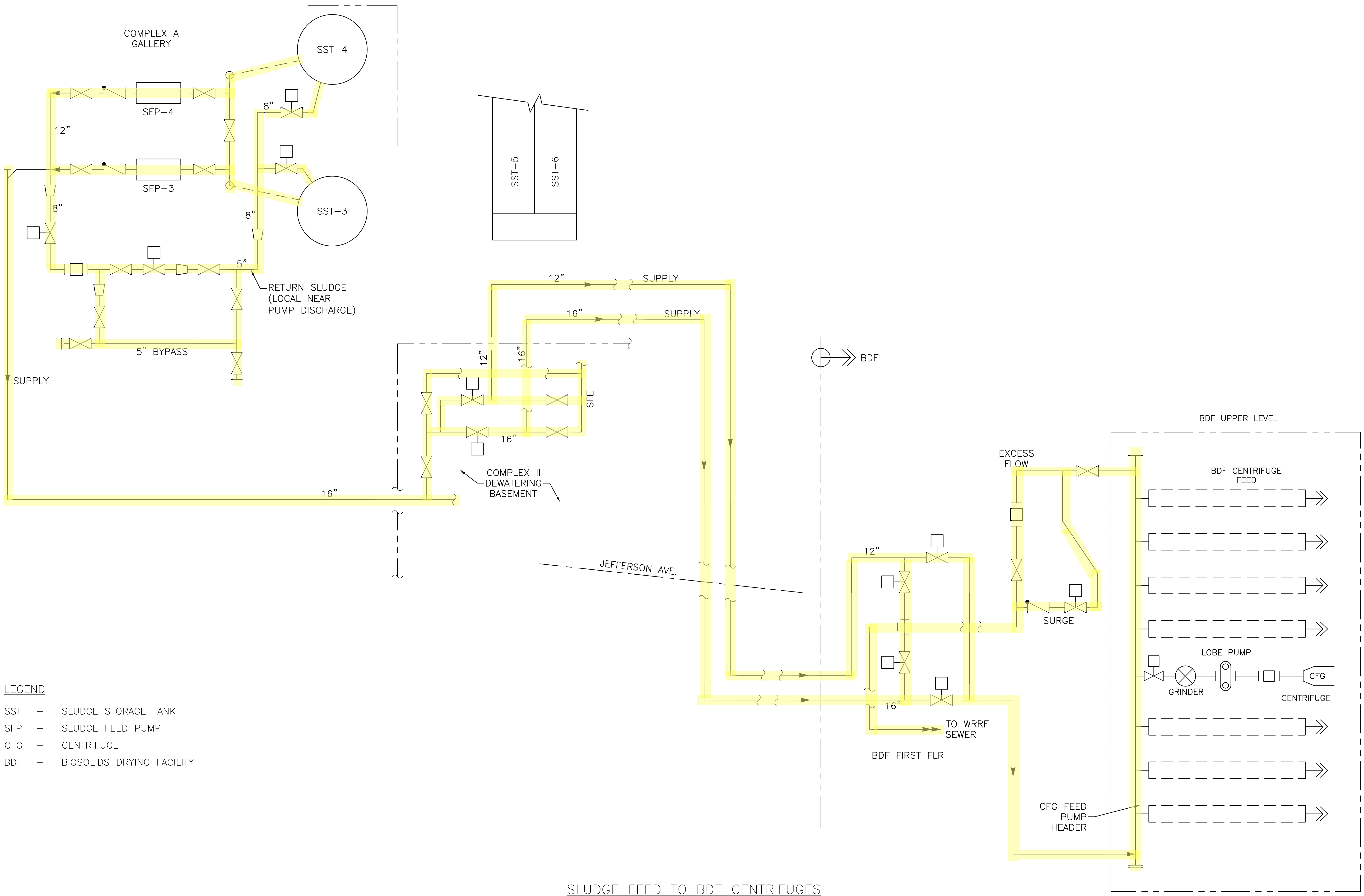
COMPLEX II SLUDGE PIPING PLAN EL. 170'-0"

DRAWN BY	SCALE	DATE
B. HEWITT	3/16"=1'	8-29-13
CUSTOMER P.O. NO.	CONTRACT NO.	T.M.F. DRAWING NO.
	PC-787	11-252 22 OF

CAD REF. 11-252

Attachment D

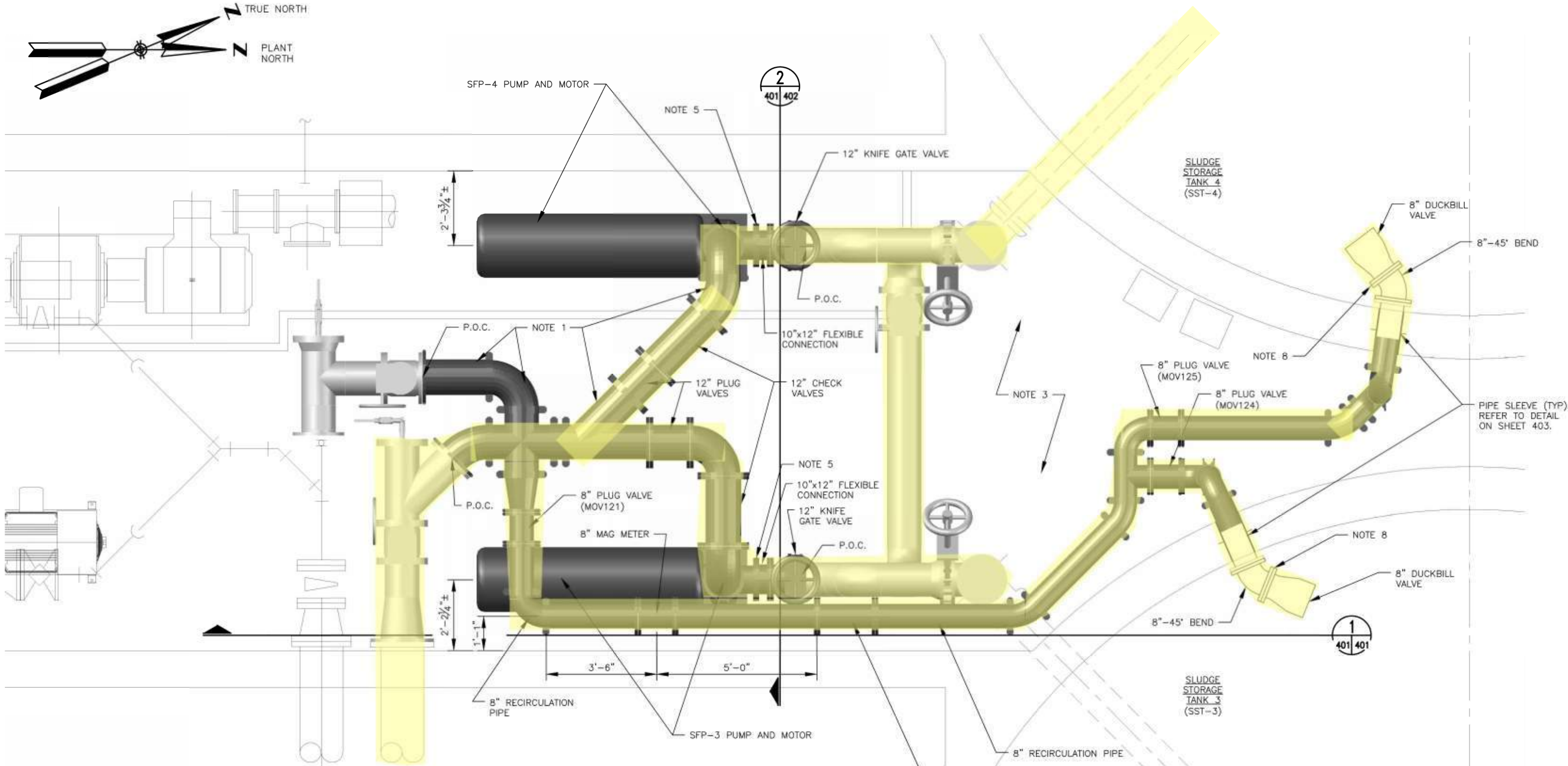
Biosolids Dryer Facility
Sludge Feed Piping



LEGEND

SST – SLUDGE STORAGE TANK
SFP – SLUDGE FEED PUMP
CFG – CENTRIFUGE
BDF – BIOSOLIDS DRYING FACILITY

SLUDGE FEED TO BDF CENTRIFUGES
PROCESS FLOW DIAGRAM – EXISTING
(NOT ALL VALVES OR FEATURES SHOWN)



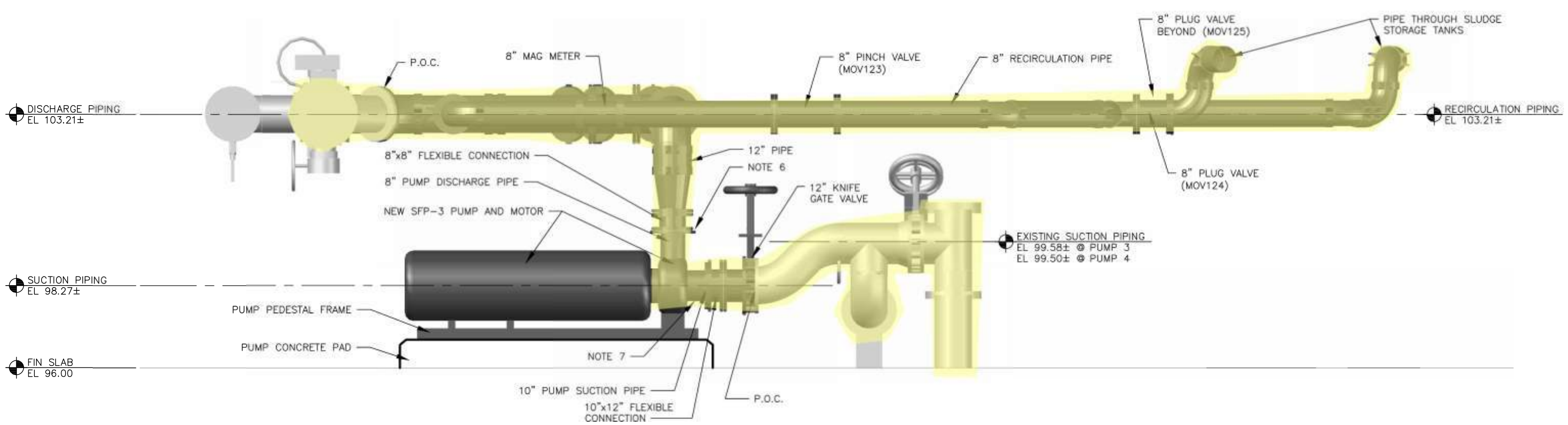
MECHANICAL FLOOR PLAN
SCALE: 1/2"=1'-0"

LEGEND:

- DARK LINE WEIGHT WORK INSIDE THE SLUDGE TANK INDICATES NEW WORK
- DARK SHADED PIPING IN THE PUMP GALLERY INDICATES NEW WORK
- LIGHT SHADED PIPING IN THE GALLERY INDICATES WORK TO REMAIN
- LIGHT LINE WEIGHT WORK INDICATES EXISTING WORK TO REMAIN
- P.O.C. = POINT OF CONNECTION

NOTES:

1. FABRICATE FITTINGS AS NECESSARY TO CONNECT TO EXISTING FITTINGS BASED ON FIELD CONDITIONS.
2. USE FLANGED OR GROOVED COUPLINGS FOR PIPING AND FITTINGS AS NECESSARY.
3. EXISTING SLUDGE FEED PIPING TO SLUDGE STORAGE TANKS 3 THROUGH 6 NOT SHOWN FOR CLARITY.
4. PROVIDE PIPE SUPPORTS AS NECESSARY IN ACCORDANCE WITH DWSD MASTER SPECIFICATION SECTION 15140.
5. INSTALL PRESSURE GAUGE AT THE ¼" NPT PUMP SUCTION PRESSURE GAUGE TAP (BOTH PUMPS). REFER TO DRAWING 403 FOR INSTALLATION DETAILS.
6. INSTALL PRESSURE GAUGE AT THE ¼" NPT PUMP DISCHARGE PRESSURE GAUGE TAP (BOTH PUMPS). REFER TO DRAWING 403 FOR INSTALLATION DETAILS.
7. INSTALL DRAIN CONNECTION AT THE 1" NPT DRAIN ON THE PUMP SUCTION SIDE (BOTH PUMPS). REFER TO DRAWING 403 FOR INSTALLATION DETAILS.
8. PROVIDE VALVE/FLANGE STAINLESS STEEL SUPPORT CONNECTED TO THE SLUDGE STORAGE TANK WALL.
9. REFER TO SPECIFICATION SECTION 01014(S) "CONSTRUCTION SEQUENCE" FOR DETAILS OF CONSTRUCTION CONSTRAINTS AND SEQUENCING.



1 401 401 SECTION
SCALE: 1/2"=1'-0"

	DESCRIPTIONS / REVISIONS	CHK'D	APPR.	DATE
F				
E				
D	RECORD DRAWING			11-02-15
C	ISSUED FOR CONSTRUCTION			
B	100% DESIGN SUBMITTAL			
A	95% REVIEW SUBMITTAL			

DESIGNED BY: WA
DRAWN BY: WC
CHECKED BY: WA
MANAGER: DP

SEAL / STAMP: STATE OF MICHIGAN — WALID ALAILI — ENGINEER — No. 44967 — LICENSED PROFESSIONAL ENGINEER

DETROIT WASTEWATER TREATMENT PLANT
REPLACEMENT OF SLUDGE FEED PUMPS
SFP-3 AND SFP-4

MECHANICAL PLAN AND SECTIONS

SCALE AS NOTED
DATE 01-23-15

NEFCO Recycle, Renew, Restore

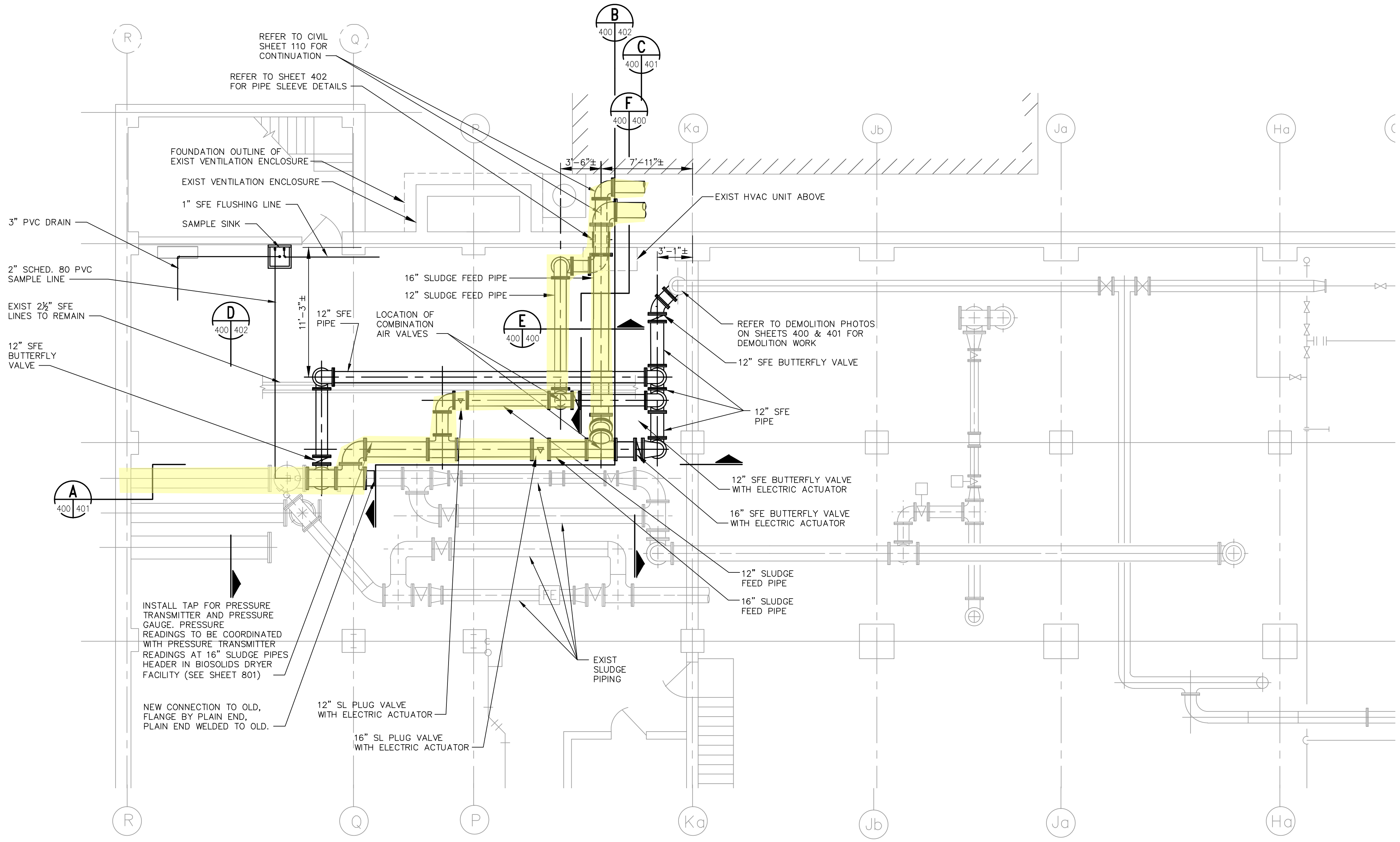
DOC ESTABLISHED 1879

WADETRIM
500 GRISWOLD, SUITE 2500, Detroit, MI 48226
TEL: 313-961-3650 - FAX: 313-961-0898

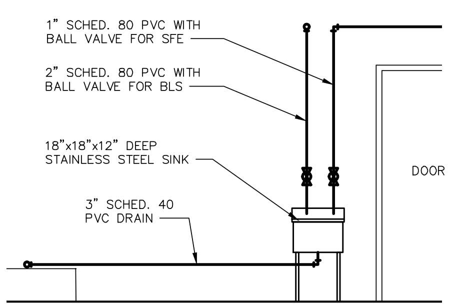
CITY OF DETROIT
WATER AND SEWERAGE DEPARTMENT
ENGINEERING DIVISION

SECTION MAP			TOWN			RANGE			SECTION		PORTION CODE		
1	5	G	0	2	S	1	1	E	20	0	-	-	-

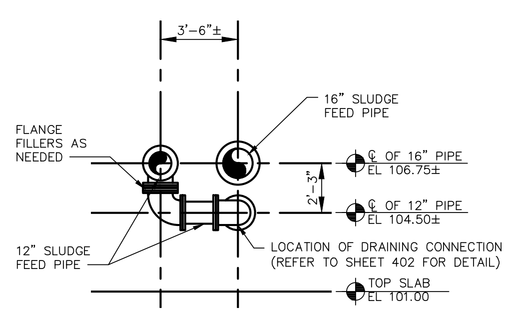
M.D.E.Q. PERMIT No.
DRMS. No.
DWSD CONTRACT No. PC-792
FILE No. SAME AS DWG
DRAWING No. D-13-02-401PKG4



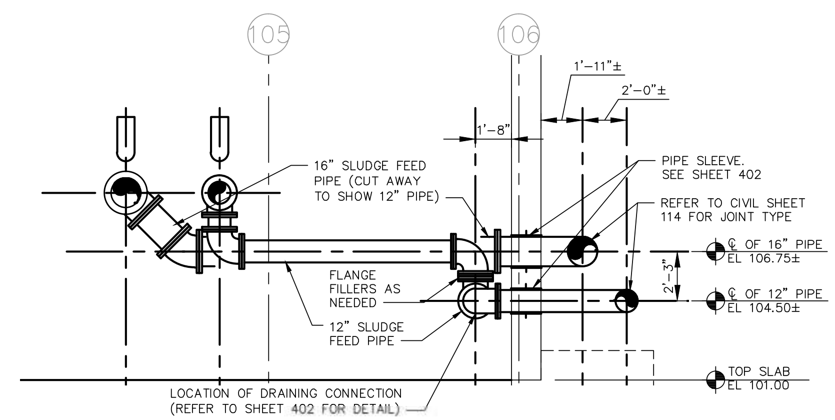
SLUDGE PLAN – BASEMENT
SCALE: 3/16"=1'-0"



G 400 400 SAMPLE SINK DETAIL
SCALE: NONE
CCD "N"



E 400 400 SLUDGE PIPING SECTION
SCALE: 1/4"=1'-0"



F 400 400 SLUDGE PIPING SECTION
SCALE: 1/4"=1'-0"

SAMPLE SINK PHOTO

	DESCRIPTIONS / REVISIONS	CHK'D	APPR.	DATE
	RECORD DRAWING - UPDATED PER GLWA COMMENTS	SD	DP	02-09-16
	RECORD DRAWING	SD	DP	10-29-15
F	3 BULLETIN 3	BW	DP	09-09-14
E	1 BULLETIN 1	BW	DP	02-10-14
D	ISSUED FOR CONSTRUCTION	BW	DP	11-15-13
C	100% DESIGN	BW	DP	10-22-13
B	100% DRAFT DESIGN	BW	DP	09-24-13
A	100% REVIEW SUBMITTAL	BW	DP	9-13-13

DESIGNED BY: WA
DRAWN BY: AS
CHECKED BY: DP
MANAGER: DP

SEAL / STAMP
STATE OF MICHIGAN WALID AL-AHI ENGINEER No. 44957 LICENSED PROFESSIONAL ENGINEER

BIOSOLIDS DRYER FACILITY
PACKAGE 1
SLUDGE PIPING PLAN

SCALE AS NOTED
DATE

NEFCO Recycle, Renew, Restore
DOC ESTABLISHED 1879
WADETRIM 500 GRISWOLD, SUITE 2500, Detroit, MI 48226 TEL: 313-961-3650 - FAX: 313-961-0898
SOMAT Engineering, Inc.

CITY OF DETROIT
WATER AND SEWERAGE DEPARTMENT
ENGINEERING DIVISION

SECTION MAP			TOWN			RANGE			SECTION		PORTION CODE		
1	5	G	0	2	S	1	1	E	20	0	-	-	-

M.D.E.Q. PERMIT No.
DRMS. No.
DWSD CONTRACT No. PC-792
FILE No. SAME AS DWG
DRAWING No. D-13-02-400PKG1

LEGEND

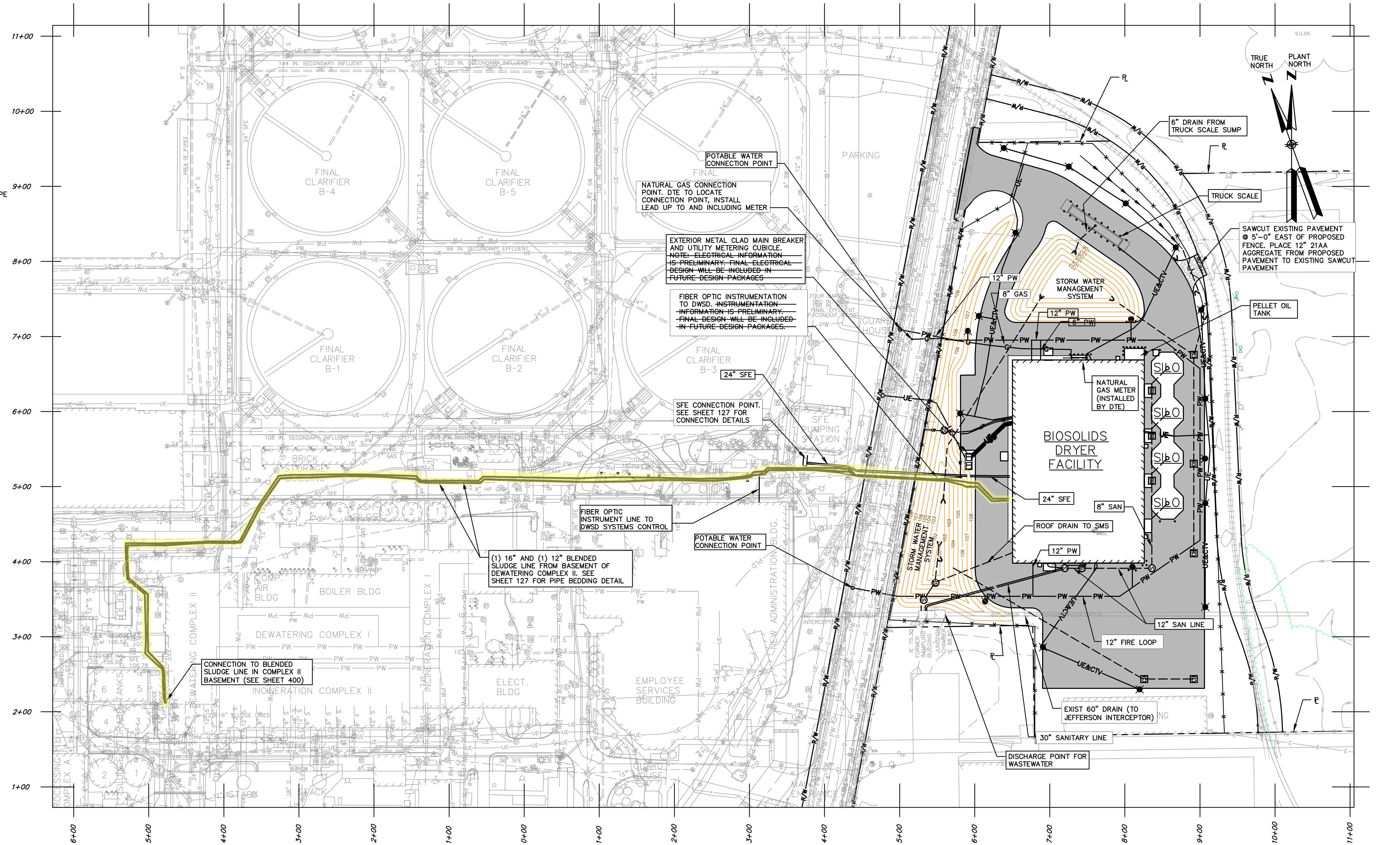
- FIRE HYDRANT
- CATCH BASIN
- STORM MANHOLE
- SANITARY MANHOLE
- LIGHT POLE

UTILITY ABBREVIATIONS

CB	CATCH BASIN
FO	FIBER OPTIC CABLE
G	NATURAL GAS PIPE
IE	INVERT ELEVATION
OH	OVERHEAD UTILITY
PW	POTABLE WATER PIPE
S	SEWER
SFE	SCREENED FINAL EFFLUENT PIPE
BLS	BLENDED SLUDGE PIPE
SW	SECONDARY WATER PIPE
STM	STORM PIPE
UE	UNDERGROUND ELECTRIC

NOTES:

1. ELECTRICAL AND INSTRUMENTATION INFORMATION IS PRELIMINARY. FINAL ELECTRICAL WILL BE INCLUDED IN FUTURE DESIGN PACKAGE.
2. SEE DRAWINGS 127, 130 AND 131 FOR MANHOLE, INLET STRUCTURES AND RIGID PIPE BEDDING STANDARD DETAILS.
3. SEE DRAWING 101 FOR OUTSIDE PIPING NOTES.
4. ALL PIPING REMOVED AS REQUIRED BY DRAWINGS.
5. NATURAL GAS SERVICE, INCLUDING OUTSIDE PIPING AND GAS METERS SHALL BE INSTALLED BY DTE WHERE INDICATED. INSTALLATION SHALL BE COORDINATED BY THE CONTRACTOR.
6. UNLESS OTHERWISE INDICATED, TAPPING SLEEVES AND VALVES SHALL BE USED FOR ALL CONNECTIONS TO PRESSURE MAINS. EXISTING PIPE SIZES AND MATERIALS SHALL BE FIELD VERIFIED BY THE CONTRACTOR.
7. SEE DRAWINGS 117, 120 AND 121 FOR DRAINAGE STRUCTURE AND MANHOLE INFORMATION.
8. SEE DRAWING 114 FOR BLS CLEANOUT DETAIL.
9. THE TWO NEW BLS LINES ARE TO BE PLACED IN THE SAME TRENCH. SEE DRAWING 127 FOR BLS BEDDING DETAIL.
10. SEE DRAWING 132 FOR FIRE HYDRANT DETAIL.
11. USE LONG RADIUS ELBOWS FOR BLS 90° BENDS.
12. NEW BLS LINES SHALL HAVE RESTRAINED JOINTS.
13. NEW 24" SFE LINE SHALL HAVE RESTRAINED JOINTS FROM THE EXISTING SFE PUMP STATION TO THE BIOSOLIDS DRYER FACILITY.



OVERALL UTILITY SITE PLAN

SCALE: 1"=60'

	DESCRIPTIONS / REVISIONS	CHK'D	APPR.	DATE
	RECORD DRAWING - UPDATED PER GLWA COMMENTS	SD	DP	02-09-16
F	RECORD DRAWING	SD	DP	10-29-15
E	BULLETIN 1	BW	DP	02-10-14
D	ISSUED FOR CONSTRUCTION	BW	DP	11-15-13
C	100% DESIGN	BW	DP	10-22-13
B	100% DRAFT DESIGN	BW	DP	09-24-13
A	100% REVIEW SUBMITTAL	BW	DP	9-13-13

DESIGNED BY: BW
DRAWN BY: AS
CHECKED BY: DP
MANAGER: DP

SEAL / STAMP: STATE OF MICHIGAN — BRIAN WOODWORTH — ENGINEER — No. 52609 — LICENSED PROFESSIONAL ENGINEER

BIOSOLIDS DRYER FACILITY
PACKAGE 1

OVERALL UTILITY SITE PLAN

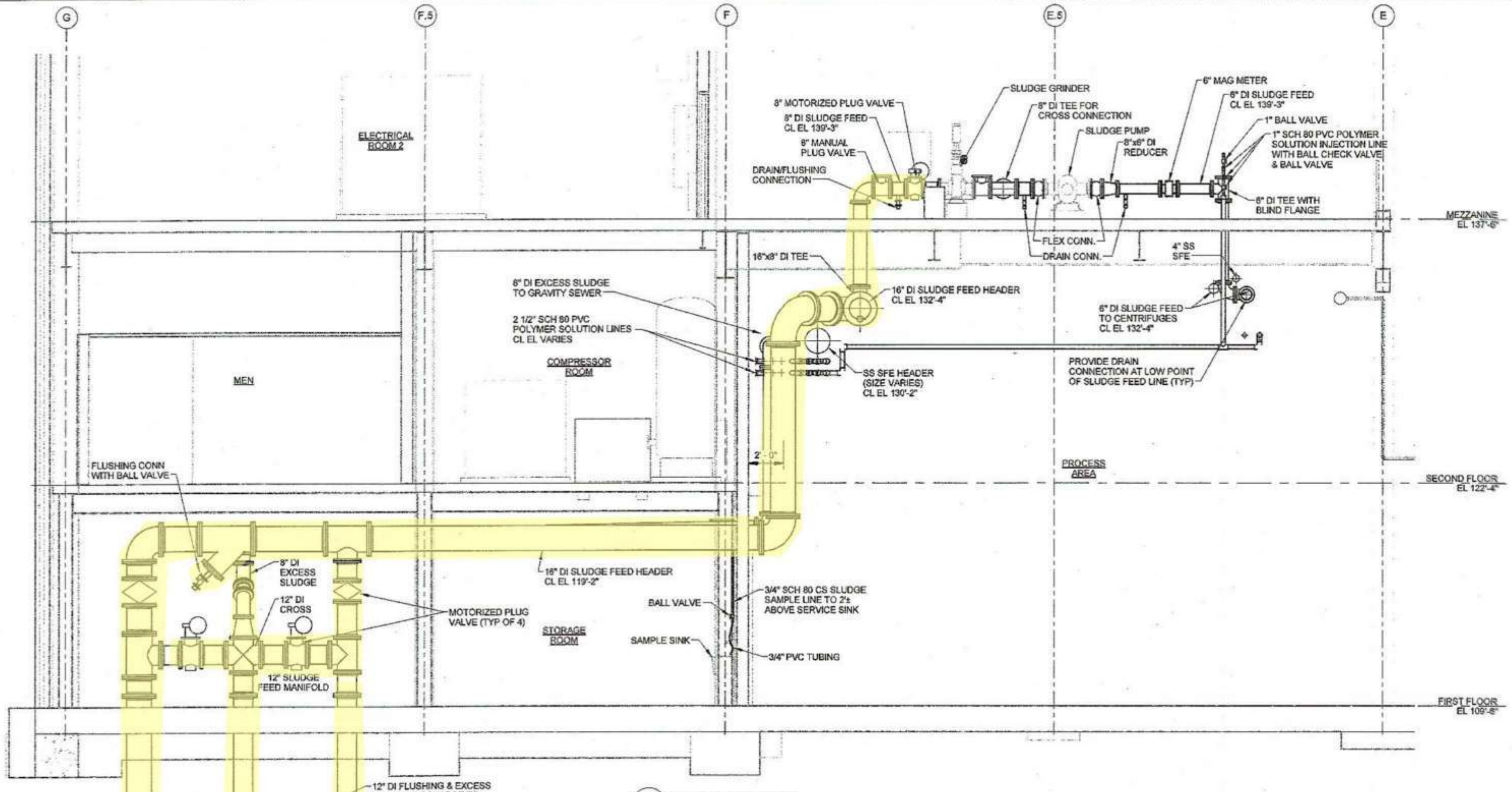
SCALE 1"=60'
DATE

NEFCO — Recycle, Renew, Restore
DOC — ESTABLISHED 1879
WADETRIM — 500 GRISWOLD, SUITE 2500, Detroit, MI 48226 — TEL: 313-961-3650 - FAX: 313-961-0898
SOMAT Engineering, Inc.

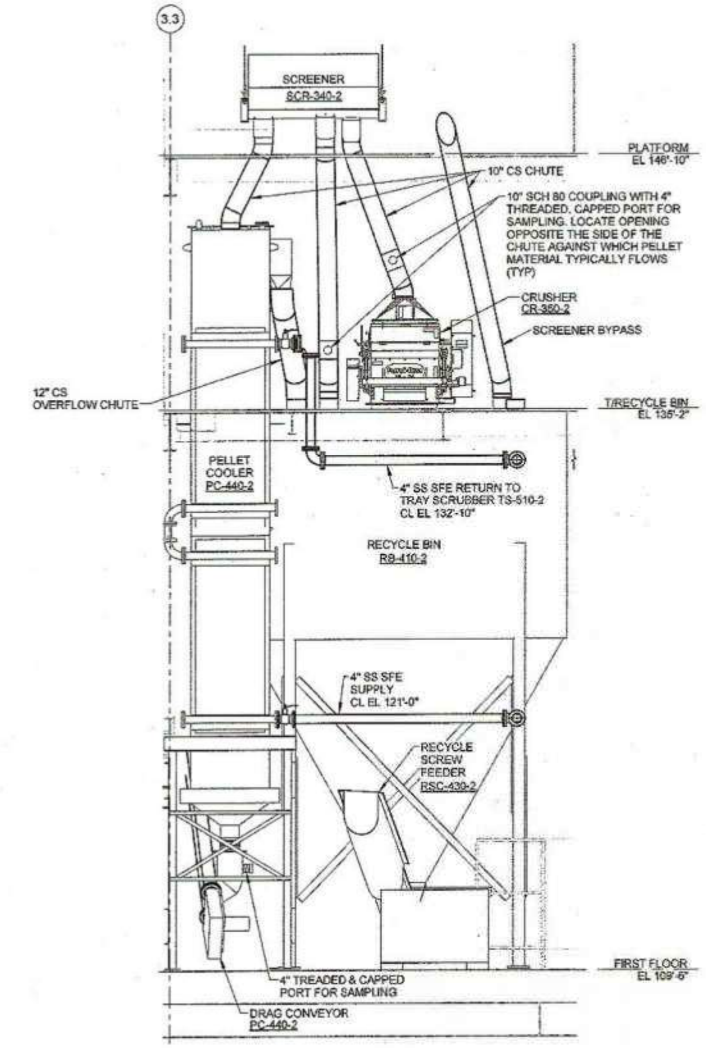
CITY OF DETROIT
WATER AND SEWERAGE DEPARTMENT
ENGINEERING DIVISION

SECTION MAP			TOWN			RANGE			SECTION		PORTION CODE		
1	5	G	0	2	S	1	1	E	20	0	-	-	-

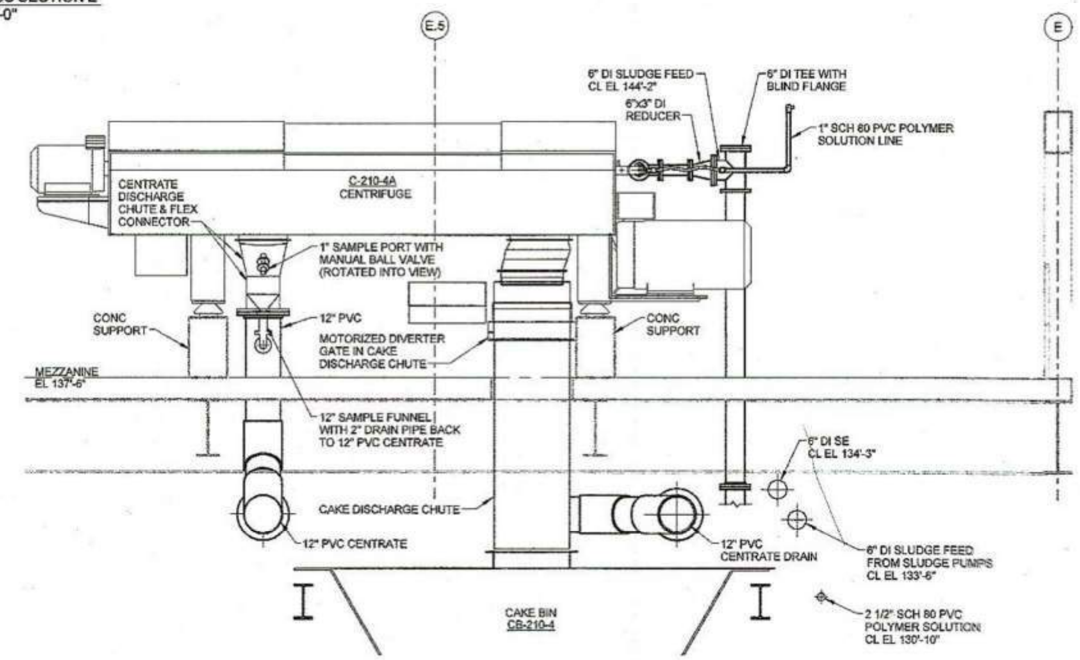
M.D.E.Q. PERMIT No.
DRMS. No.
DWSD CONTRACT No. PC-792
FILE No. VSP-Plts-109_PROPSitePlan
DRAWING No. D-13-02-110PKG1



E 404/419 PROCESS SECTION E
1/4" = 1'-0"



G 402/419 PROCESS SECTION G
1/4" = 1'-0"



F 408/419 PROCESS SECTION F
3/8" = 1'-0"

NOTES:

1. ALL PROCESS & RELATED PIPING IS SHOWN DIAGRAMMATICALLY. EXACT LOCATION & CONFIGURATION TO BE DETERMINED IN THE FIELD. VERIFY ALL PIPE LOCATIONS AND PIPE FIT-UP IN THE FIELD. REFER TO P&ID FOR VALVING ARRANGEMENTS AND OTHER MISCELLANEOUS PIPING APPURTENANCES.

NOTE:
REFER TO DE-CAL, INC. FINAL AS-BUILT DRAWINGS FOR ADDITIONAL INFORMATION.

	DESCRIPTION / REVISIONS	CHK'D	APPR.	DATE
F				
E				
D				
C	RECORD DRAWING	RLS	MJH	10-15
B	ISSUED FOR CONSTRUCTION	RLS	MJH	4-30-14
A	100% DESIGN	CCB	MJH	3-6-14

DESIGNED BY: RLS
DRAWN BY: RWK
CHECKED BY: CCB
MANAGER: MJH

SEAL / STAMP: STATE OF MICHIGAN, MARK J. HOEY, ENGINEER, No. 59976, LICENSED PROFESSIONAL ENGINEER

BIOSOLIDS DRYER FACILITY
PACKAGE 2A
PROCESS SECTIONS - 3

SCALE: As indicated
DATE: 1/14

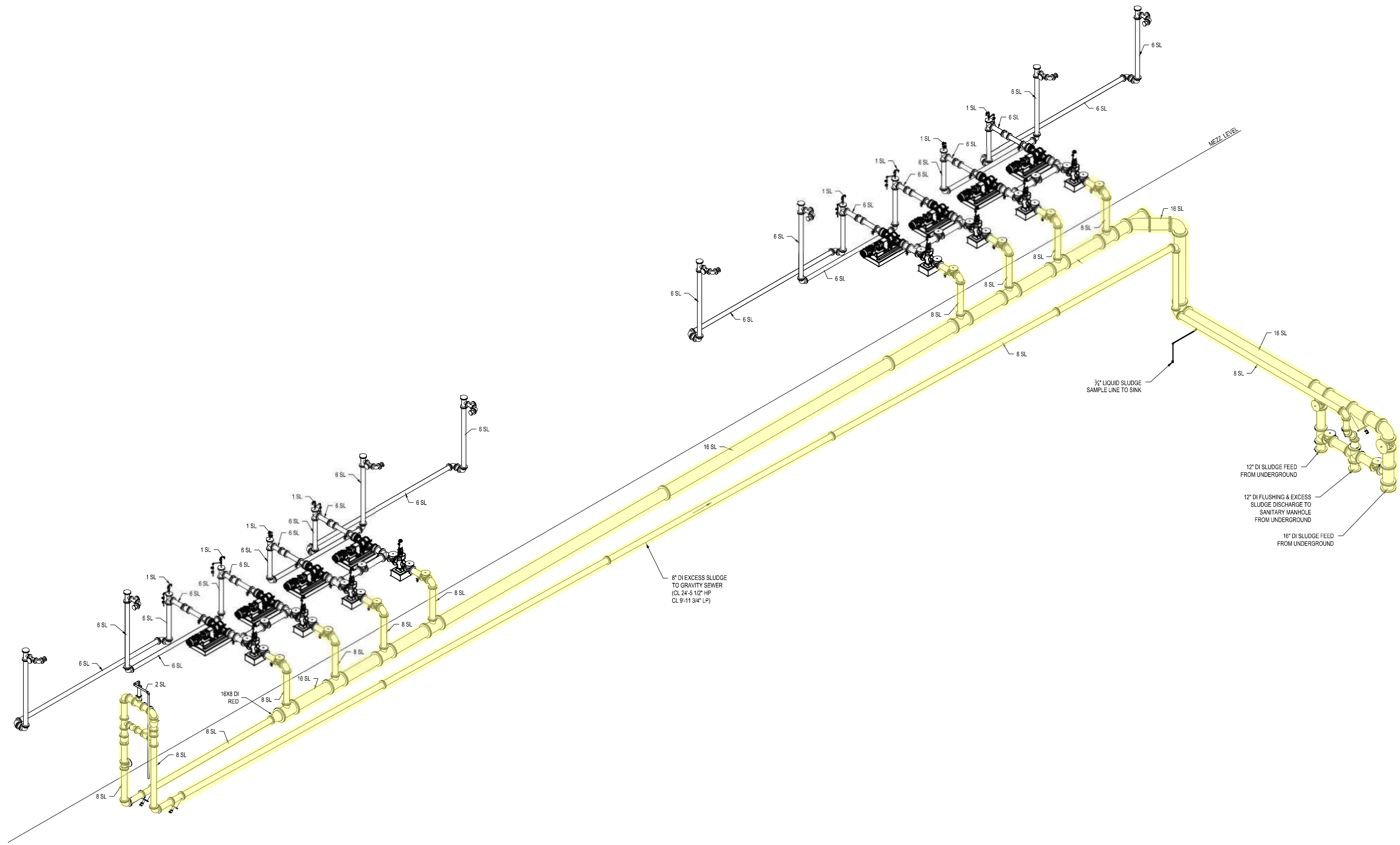
NEFCO — Recycle, Renew, Restore
DOC — ESTABLISHED 1979
Tighe&Bond Consulting Engineers www.tighebond.com

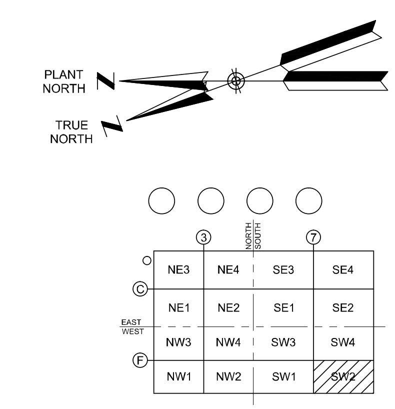
RECORD DRAWING
THIS RECORD DRAWING WAS PREPARED BASED ON AS-BUILT INFORMATION PROVIDED BY THE CONTRACTOR AND INDICATES ONLY SIGNIFICANT CHANGES MADE FROM THE DESIGN DRAWINGS DURING CONSTRUCTION.

CITY OF DETROIT
WATER & SEWERAGE DEPARTMENT
ENGINEERING DIVISION

SECTION MAP			TOWN			RANGE			SECTION	PORTION CODE		
1	5	G	0	2	S	1	1	E	20 0	-	-	-

M.D.E.Q. PERMIT No.
DRMS. No.
DWSD CONTRACT No. PC-792
FILE No. DWSD BUILDING MODEL
DRAWING No. D-13-02-419PKG2A





KEY PLAN

NO SCALE

ISOMETRIC VIEW
SLUDGE PIPING LAYOUT

SCALE: NTS

REVIEWED

To the best of our knowledge, the attached as-built documents are consistent with as-built conditions observed on this project.

Tighe & Bond, Inc.

NUMBER	REVISION	DATE
0	ISSUED FOR REVIEW	10/02/14

JOB: CITY OF DETROIT
WATER & SEWERAGE DEPARTMENT
PC792 - BIOSOLIDS DRYER FACILITY
ISOMETRIC VIEW

FOR: BIOSOLIDS DRYER FACILITY
9125 W. Jefferson Ave.
Detroit, MI, 48209

GC: Daniel O' Connell's Sons
480 Hampden Street
Holyoke, MA, 01040

DE-CAL, INC.
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Detroit, MI ~ Warren, MI ~ Pittsburgh, PA ~ Youngstown, OH
www.de-cal.com

DATE:	11APR14
SCALE:	AS NOTED
DRAWN:	SM
CHECKED:	JS
JOB No.:	114002
SHEET No.:	SL-ISO

Appendix E: TM-4 Dewatering System Sludge Demands

CDM Smith

Technical Memorandum 4

To: *Jared Buzo, METCO*
Sham Sihabdeen, AECOM
Chris Wilson, GLWA

From: *Steve Wyman, CDM Smith*
Mohsen Sadatiyan, CDM Smith

Date: *September 15, 2023*

Subject: *Great Lakes Water Authority (GLWA)*
Contract No. 2202790 – Water Resource Recovery Facility (WRRF) Improvements to the Sludge Feed System for Solids Processing
TM-4 Dewatering Systems Sludge Demands

1.0 Purpose and Background

Great Lakes Water Authority (GLWA) owns and operates the Water Resource Recovery Facility (WRRF) located at 9300 W. Jefferson, Detroit, MI 48209. WRRF is a conventional activated sludge plant with a wet weather design capacity of 1,444 million gallons per day (MGD) and serves approximately one-third of the State of Michigan's population. This facility is one of the largest wastewater treatment plants in the world, with the capacity to treat up to 1,700 MGD through primary treatment and 930 MGD through secondary treatment.

Many of the components of the facility are 80 years old. In service for about 50 years, the majority of the process units were built and expanded in the 1970s. Influent pumping and a large portion of preliminary and primary treatment facilities went online in 1940, sludge incineration went online in the 1950s and 1970s, and secondary treatment was started in the 1970s with the advent of the Clean Water Act. The facility was expanded in the 1990s to treat flow from the Northern Interceptor–East Arm, with the construction of Pump Station No. 2 and associated preliminary treatment and optimized for wet weather flow in the early 2000s. The Biosolids Drying Facility went online in 2016, allowing the decommissioning of the Complex I incinerators. Disinfection of primary effluent was implemented in 2019.

WRRF generates solids through primary and secondary clarification. Solids handling processes include gravity thickening, blending, storage, dewatering, incineration, and drying treatment processes. Thickened primary sludge (TPS) and thickened waste activated sludge (TWAS) is blended prior to being discharged into six sludge storage tanks (SSTs). The sludge feed system, comprised of sludge feed pumps (SFPs), sludge piping, and flow control equipment, supplies thickened blended sludges from the SSTs to sludge dewatering equipment at three different dewatering facilities. These dewatering facilities include belt filter presses (BFPs) located in Sludge Dewatering Complex I (C-I); BFPs in Sludge Dewatering Complex II (C-II); and centrifuges (CFGs) in the Biosolids Drying Facility (BDF). Under normal operating conditions, BDF CFGs process 60 to 70 percent of WRRF's solids. BFPs in C-I and C-II are used to dewater the remaining sludge not processed by the BDF or when the BDF equipment is offline for maintenance. C-II is also equipped with CFGs which were discontinued by GLWA prior to 2018 in favor of utilizing the C-I and C-II BFPs to supplement dewatering at the BDF. Dewatered sludge from C-I and C-II is incinerated onsite and dried sludge from BDF is land-applied offsite.

The service life of many of the existing SFPs has been exceeded, and all SFP equipment and piping are understood to be oversized for the feed rates required at the dewatering facilities. Additionally, sludge feed piping "dead ends" at each of the dewatering facilities result in sludge feed header pressures that are difficult to maintain within the operating range required for the sludge flow control equipment at each piece of dewatering equipment. The end result of the aged pumping equipment, oversized sludge feed components, dewatering facility locations, and piping configurations is a sludge feed system that is difficult to operate and maintain.

This project, WRRF Improvements to the Sludge Feed System for Solids Processing (the Project), involves making improvements to the dewatering sludge feed pumping systems, improving drainage of SSTs 1-4, and mitigating flooding of the Sludge Processing Complex A basement. The scope includes conducting discipline-specific condition assessments and evaluations in order to recommend cost-effective upgrades and improvements to achieve robust, sustainable, and long-term upgrades while reducing maintenance efforts, improving operational flexibility, and maintaining treatment operations at all times. This assessment and evaluation work will be documented in technical memoranda (TMs). This document is Technical Memorandum 4 (TM-4) and covers the development of the dewatering systems sludge demands for the Project.

The purpose of this TM-4 is to evaluate and recommend the dewatering system sludge demands for each dewatering facility (i.e., BDF CFGs, C-I BFPs, and C-II BFPs). The sludge demands as determined by this TM will be used to evaluate and select the improvements for implementation on the Project.

2.0 Sludge Demand Analysis

A detailed analysis of the dewatering system sludge demands at each dewatering facility was performed to assist in the rightsizing of the sludge feed systems. Multiple sources of information were analyzed to define a comprehensive set of parameters that will allow WRRF to meet regulatory and contractual requirements as well as plant operational needs. WRRF's National Pollutant Discharge Elimination System (NPDES) permit, BDF contractual requirements, design parameters of the existing sludge feed and dewatering systems, and historical operational data were all considered in this analysis.

2.1 NPDES Permit Requirements

WRRF's NPDES permit (Permit No. MI0022802 dated July 2019) is issued and administered by the Michigan Department of Environment, Great Lakes, and Energy (EGLE). The current permit requires the plant's solids handling processes to meet the following capacity requirements:

- Average capacity of 500 dry tons per day (dtpd), calculated as a calendar monthly average.
- Peak capacity of 850 dtpd, calculated as a 10-day average.

There are no specific requirements on the flow rates or percent solids of the feed sludge to the dewatering facilities. The NPDES permit requires WRRF to:

- Maintain a monthly average solids inventory of less than 750 dtpd, when there are less than 5 days of discharge from the Detroit River outfall (Point 049A) during the month and maintain a calendar quarterly average solids inventory not to exceed 1,000 dtpd. Solids inventory is defined as the total solids in the Complex A and B gravity thickeners, determined daily in dtpd.
- Notify EGLE within one business day if solids are recycled from the gravity thickeners to the head of the WRRF for more than 72 hours and provide an explanation for the recycled solids. Recycled solids are defined as a total suspended solids (TSS) overflow concentration of 1,000 mg/l or greater from the Complex A thickeners.
- At least 10 days in advance of scheduled maintenance and within 24 hours after initiation of diversion due to emergency conditions, the permittees shall notify EGLE of the reason for the diversion and the expected duration of the diversion.

CDM Smith is aware that GLWA is currently negotiating a new NPDES permit. Final recommendations of this TM-4 will be confirmed with the new permit when received.

2.2 BDF Contract Requirements

New England Fertilizer Company (NEFCO) operates and maintains the BDF as required by Contract PC-792 dated March 2013. Per Contract, NEFCO is required to:

- Maintain the facilities so as to keep the rated firm dewatering, drying and processing capacity continuously available for use, with excess capacity also available to the extent feasible while complying with Contract maintenance requirements.
- Each and every day of the year, maintain a continuous capability for dewatering, drying, processing, removing, transporting, and beneficially re-using not less than 316 dtpd of biosolids received at 2.5% to 6% solids, or equivalent water evaporation capacity for drying if biosolids are dewatered to a solids percentage greater than 25%.

- Operate the facilities around the clock, every day of the year to dry and process up to 316 dtpd of biosolids provided by GLWA, or a greater daily quantity to the extent excess capacity is from time to time available and required by GLWA.
- Communicate daily with GLWA regarding the quantity of biosolids to be processed each day by the facilities. NEFCO shall keep GLWA informed of any planned maintenance or operational changes that could affect facilities processing capacity and shall immediately notify GLWA of any facilities capacity reductions below the specified firm capacity, including the reason, and the anticipated time when full capacity will be restored.
- Quantities of GLWA biosolids to be provided to the facilities are generally anticipated to average in the range from 225 dry tons per day (dtpd) to 440 dtpd, with a projected annual total of 115,000 to 135,000 dry tons and a guaranteed annual minimum of not less than 73,000 dry tons per year. Annual quantities could equal 140,000 dry tons if use of the Dryer Facility above its firm capacity is available and proves economical and remains feasible on a year- round basis. GLWA does not guarantee the quantities of biosolids to be provided to the Dryer Facility daily or monthly. GLWA will provide biosolids to the facilities that are typically a blend of Primary Sludge and Secondary Waste Activated Sludge (but may from time to time include only one or the other). The blend may vary from time to time depending on WRRF operational requirements.

It is understood that maximizing the solids processed at the BDF to the extent allowed by the Contract is beneficial for GLWA.

2.3 Dewatering Facility Original Design Criteria

The dewatering facilities include centrifuges (CFGs) in the Biosolids Dryer Facility (BDF), belt filter presses (BFPs) in Sludge Dewatering Complex I (C-I), and BFPs in Sludge Dewatering Complex II (C-II). The C-II CFGs have been decommissioned and are not being considered in this evaluation. Each dewatering facility was analyzed to determine its original design criteria and the system throughput capacity based on the original design. It is understood that the current required throughput at C-I and C-II is much lower than the originally designed capacities as the result of the BDF addition. During normal operations, the BDF processes approximately 70 percent of the plant's solids with C-I and C-II processing the balance.

2.3.1 Biosolids Dryer Facility

The BDF is equipped with four dryer trains of equal capacity, each provided with two CFGs **(Figure 2-1)**. The facility has a firm capacity of 316 dtpd while processing thickened sludge between 2.5 to 6.0 percent solids. The firm capacity is based on one dryer train out of service. The facility has a maximum capacity of 420 dptd while processing thickened sludge between 3.0 to 6.0 percent solids with all trains in operation. Plant staff have indicated that the sludge feed system to the BDF needs to remain capable of supplying the facility's maximum capacity scenario (four dryer trains in operation). The minimum and maximum original design sludge flows to the facility are shown in **Table 2-1**.

Figure 2-1: BDF Centrifuge

Table 2-1: BDF Sludge Feed Flow Range Based on Original Facility Design

Flow Scenario	Dryer Trains	Centrifuges	Feed Solids (%)	Feed Flow (gpm)	Header Pressure Range (psi)
Minimum	1	2	6.0	350	5-25
Maximum	4	8	3.0	2,400	5-25

At a meeting with NEFCO on April 25, 2023, it was determined that the required pressure range of the sludge feed header upstream of the centrifuges is 5 to 25 psi with a 10-psi target value. The pressure is continuously monitored by a sensor located on the downstream end of the sludge feed header on the blow-off manifold at the centrifuge mezzanine **(Figure 2-2 and Figure 2-5)**. The manifold tap is located on the upper portion of the manifold loop and is piped down to the sensor which is located approximately 3 feet higher than the elevation of the centrifuge feed pump suction piping and appurtenances. A sludge header pressure rising above 25 psi results in a pressure relief valve opening on the blow-off manifold and sludge being discharged through drain piping to a manhole. A sludge header pressure drop below 5 psi will cause the sludge feed system and centrifuges to shut down if the pressure is not restored above the limit within a specified time interval (typically set at 1 minute).

Figure 2-2: BDF Sludge Header Blow-off Manifold (left), Pressure Sensor on Manifold (right)

2.3.2 Dewatering Complex I

C-I is equipped with 10 BFPs and has a firm capacity of 312 dtpd while processing thickened sludge between 3.0 to 7.0 percent solids **(Figure 2-3)**. The firm capacity is based on 6.5 BFPs in service per the Contract CS-1483 project's basis of design report. Each BFP is designed for a sludge feed rate of 100 to 270 gpm with peak capacity of 48 dtpd. The minimum and maximum design sludge flows to the facility (original design) are shown in **Table 2-2**.

The BFP O&M Manual (dated August 2016) indicates a pressure of 25 to 30 psi required at the sludge header upstream of the BFP feed branch locations. It is noted that pressures less than 25 psi will not allow the BFP sludge control valves to operate properly.

Figure 2-3: C-I BFPs

Table 2-2: C-I Sludge Feed Flow Range Based on Original Facility Design

Flow Scenario	BFPs	Feed Solids (%)	Feed Flow (gpm)	Header Pressure (psi)
Minimum	1	7.0	100	25-30
Maximum	6.5	3.0	1,755	25-30

It is understood that C-I's role has changed from a primary dewatering facility at WRRF to a facility used to supplement the BDF (along with C-II). As a result, providing adequate sludge feed to meet the facility's original firm capacity is no longer needed and if provided would result in an oversized sludge feed system.

2.3.3 Dewatering Complex II

C-II is equipped with 12 BFPs and has a firm capacity of 384 dtpd while processing thickened sludge between 3.0 to 7.0 percent solids **(Figure 2-4)**. The firm capacity is based on 8 BFPs in service per the Contract CS-1483 project's basis of design report. Each BFP is designed for a sludge feed rate of 100 to 270 gpm with peak capacity of 48 dtpd. The minimum and maximum design sludge flows (original design) to the facility are shown in **Table 2-3**.

The BFP O&M Manual (dated August 2016) indicates a pressure of 25 to 30 psi is required at the sludge header BFP feed branch locations. It is noted that pressures less than 25 psi will not allow the BFP sludge control valves to operate properly.

Figure 2-4: C-II BFPs

Table 2-3: C-II Sludge Feed Flow Range Based on Original Facility Design

Flow Scenario	BFPs	Feed Solids (%)	Feed Flow (gpm)	Header Pressure (psi)
Minimum	1	7.0	100	25-30
Maximum	8	3.0	2,160	25-30

It is understood that C-II's role has changed from a primary dewatering facility at WRRF to a facility used to supplement the BDF (along with C-I). As a result, providing adequate sludge feed to meet the facility's original firm capacity is no longer needed and if provided would result in an oversized sludge feed system.

2.4 Operational Data

The sludge feed systems are equipped with flow meters, level sensors, pressure sensors, and density meters that collect real time operational data. This data is accessed via the plant distributed control system (DCS) via OVATION workstations and historian. Manual pressure gauges are provided on the suction and discharge piping of the sludge feed pumps (SFPs) to provide additional information on the operational condition of each pump. **Tables 2-4** and **2-5** provide information on the sludge feed system instruments that were used to collect the data used for this analysis. Schematic locations of these instruments are shown in **Figures 2-5** to **2-7.**

Table 2-4: Sludge Feed System Pressure Instruments

Type	Name	Location	OVATION Point	Status	Elev.
Pressure Indicator	SFP 1 Suction	SSTs 1-4 Pipe Gallery	NA	Out of Service	98.7’
	SFP 1 Discharge	SSTs 1-4 Pipe Gallery	NA	Out of Service	102.0’
	SFP 2 Suction	SSTs 1-4 Pipe Gallery	NA	Out of Service	98.7’
	SFP 2 Discharge	SSTs 1-4 Pipe Gallery	NA	Out of Service	102.0’
	SFP 3 Suction	SSTs 1-4 Pipe Gallery	NA	In Service	98.3’
	SFP 3 Discharge	SSTs 1-4 Pipe Gallery	NA	In Service	99.5’
	SFP 4 Suction	SSTs 1-4 Pipe Gallery	NA	In Service	98.3’
	SFP 4 Discharge	SSTs 1-4 Pipe Gallery	NA	In Service	99.5’
	SFP 5 Suction	SSTs 5/6 Pump Building	NA	Out of Service	96.3’
	SFP 5 Discharge	SSTs 5/6 Pump Building	NA	Out of Service	98.0’
	SFP 6 Suction	SSTs 5/6 Pump Building	NA	In Service	96.3’
	SFP 6 Discharge	SSTs 5/6 Pump Building	NA	In Service	98.0’
Pressure Indicating Transmitter	BDF Force Main Inlet	C-II Basement	P905650.ACC4@W3	In Service	109.5’
	BDF Feed Force Main Discharge	BDF Dewatering Mezzanine	P985110.PCC@W3	In Service	142.5’
	SFPs 3/4 Recirculation Line Differential Pressure	SSTs 1-4 Pipe Gallery	MOV-123_DP.ACC3@W3	In Service	103.2’
	C-I Sludge Header	C-I Basement	P941537.ACC4@W#	In Service	104.0’
	C-II North Sludge Header	C-II Fifth Floor	P966545A.ACC4@W3	In Service	177.8’
	C-II South Sludge Header	C-II Fifth Floor	P966545B.ACC4@W3	In Service	177.8’

Table 2-5: Sludge Feed System Flow Meters, Level Sensors, and Density Meters

Type	Name	Location	OVATION Point	Status	Size
Flow Indicating Transmitter	BDF (one on each centrifuge feed line)	BDF Dewatering Mezzanine	BDF-TOTAL-FLOW.ACC@W3	In Service	8”
	SFP 3/4 Recirculation Line	SSTs 1-4 Pipe Gallery	F905649.ACC@W3	In Service	8”
	C-I Sludge Header	C-I Basement	F900667.ACC4@W3	In Service	14”
	C-II Sludge Header	C-II Basement	F966550.ACC4@W3	In Service	10”
	SSTs 1/2 TPS	Complex A Basement	F905610.ACC3@W3	In Service	14”
	SSTs 1/2 TWAS	Complex A Basement	F905630.ACC3@W3	In Service	10”
	SSTs 3/4 TPS	Complex A Basement	F905611.ACC3@W3	In Service	14”
	SSTs 3/4 TWAS	Complex A Basement	F905631.ACC3@W3	In Service	10”
	SSTs 5/6 TPS	Complex A Basement	F905612.ACC3@W3	In Service	14”
	SSTs 5/6 TWAS	Complex A Basement	F905632.ACC3@W3	In Service	10”
Density Indicating Transmitter	BDF	BDF Lower Level	D982500.PCC@W3	In Service	16”
	C-I Sludge Header	C-I Basement	D900668.ACC4@W3	In Service	12”
	C-II Sludge Header	C-II Fifth Floor	D966550.ACC4@W3	In Service	12”
Level Indicating Transmitter	SST-1	SST-1	L905783.ACC3@W3	In Service	NA
	SST-2	SST-2	L905781.ACC3@W3	In Service	NA
	SST-3	SST-3	L905779.ACC3@W3	In Service	NA
	SST-4	SST-4	L905777.ACC3@W3	In Service	NA
	SST-5	SST-5	L965750.ACC3@W3	Out of Service	NA
	SST-6	SST-6	L965751.ACC3@W3	In Service	NA

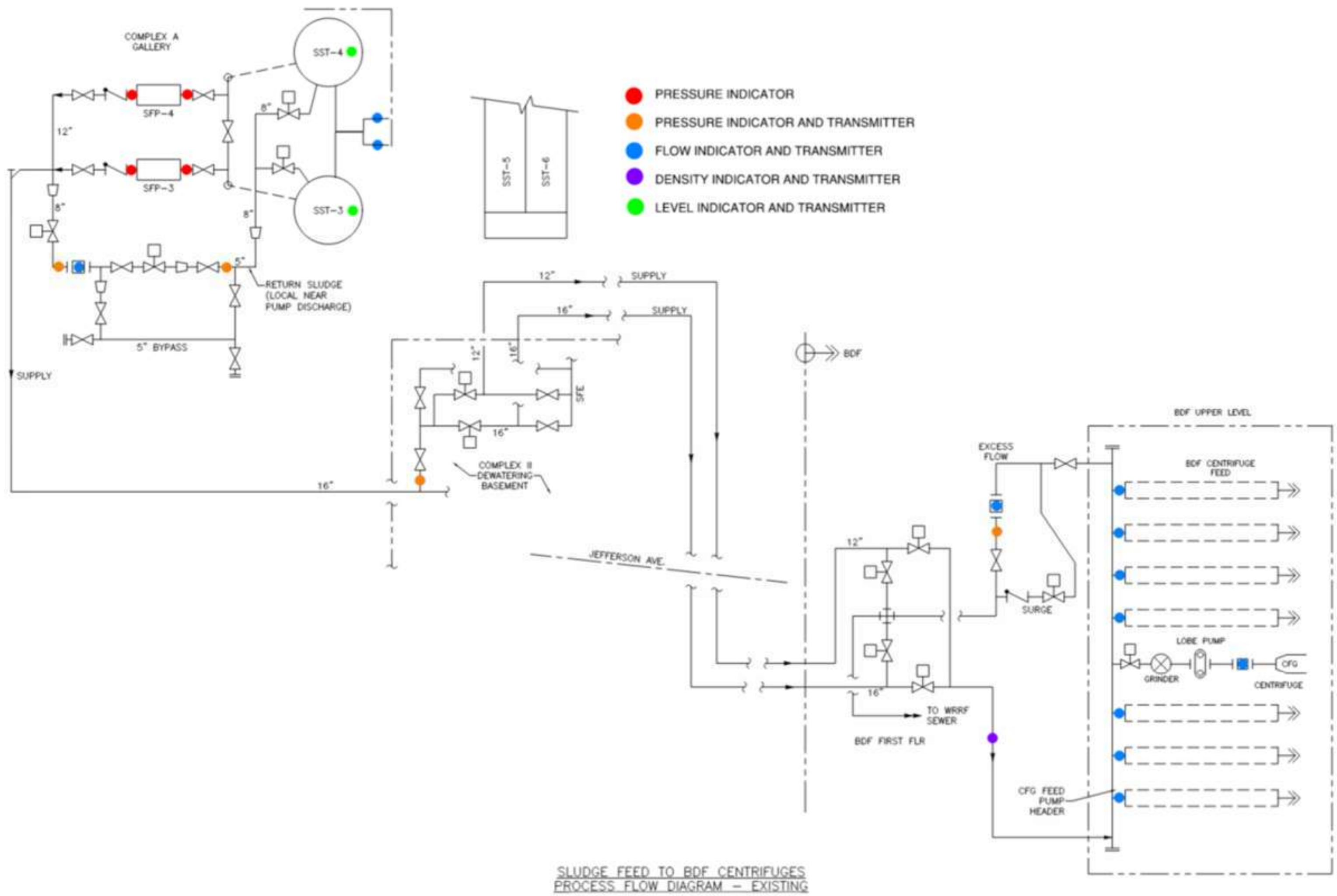

Figure 2-5: BDF Sludge Feed System Schematic – Instrument Locations

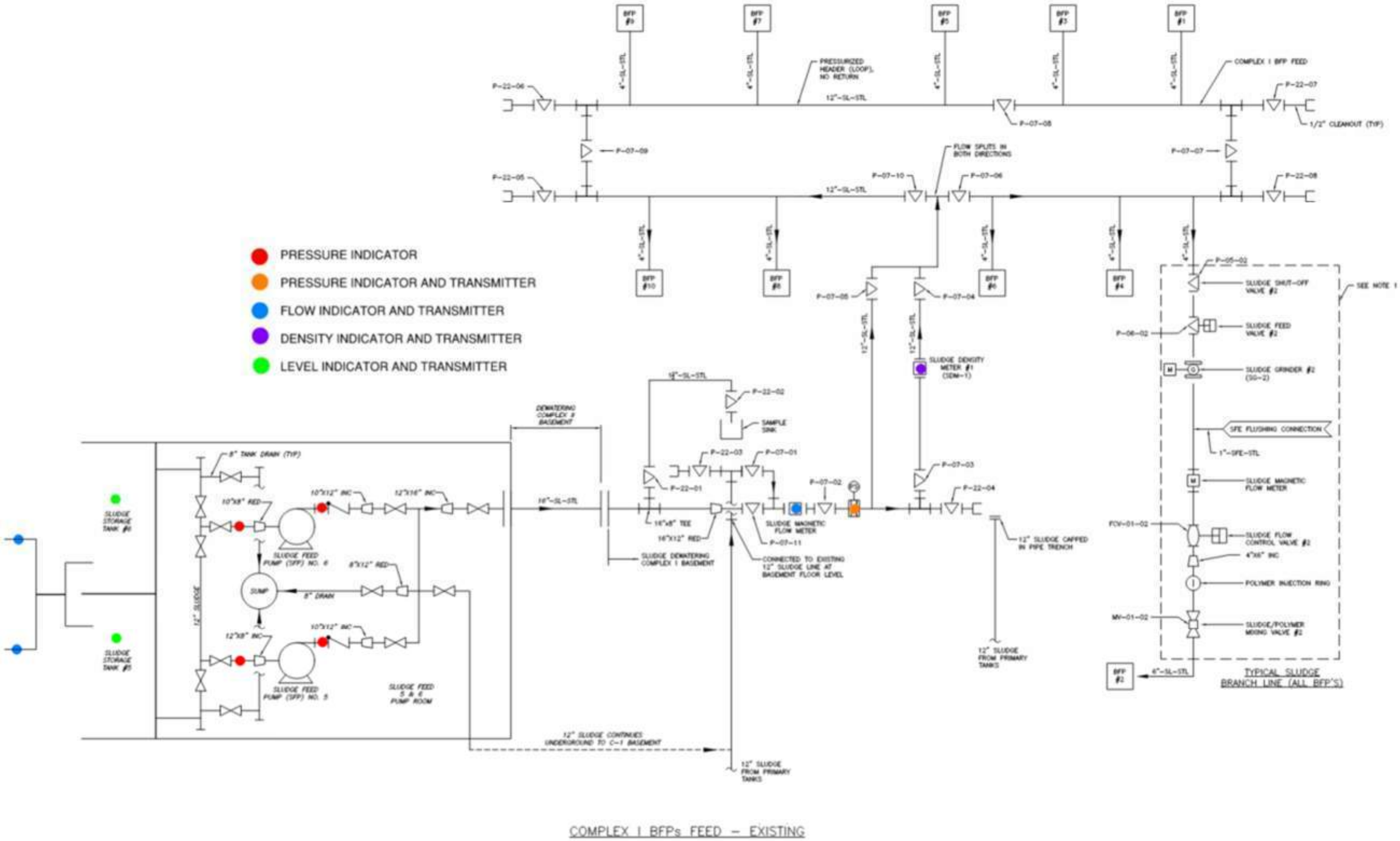

Figure 2-6: C-I Sludge Feed System Schematic – Instrument Locations

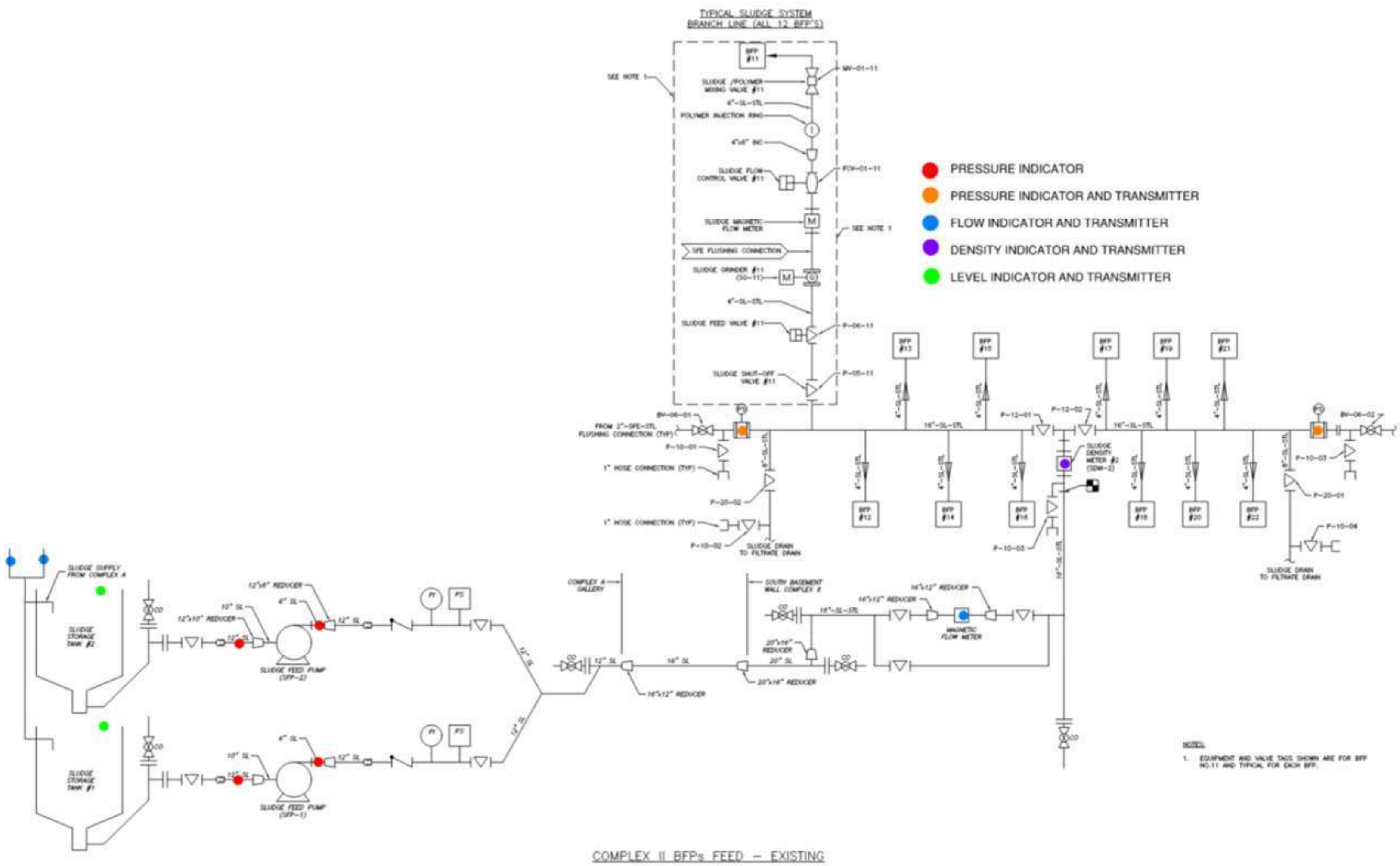

Figure 2-7: C-II Sludge Feed System Schematic - Instrument Locations

In addition to the operational information collected by the system instruments, laboratory data for total solids (TS) from the WRRF and BDF sludge sampling and testing programs were obtained. Laboratory and DCS historian data for the past three years (5/2020 – 5/2023) were collected and analyzed. The laboratory data was analyzed using daily values and the historian data was analyzed using hourly values.

2.4.1 Sludge Feed - Blending Ratio

Historian data from the six flow meters located on the TPS and TWAS lines upstream of the SSTs was used to calculate the blending ratio of the sludge going to each dewatering facility. The calculated average sludge blend ratios are displayed in **Table 2-6**.

Table 2-6: Dewatering Facility Sludge Blending Ratios

Dewatering Facility	TPS (%)	TWAS (%)	Time Facility in Operation During Data Period (%)
BDF	39	61	97
C-I	51	49	6
C-II	60	40	76

The blending ratios calculated are consistent with feedback provided by plant staff. During the data period the BDF served as the primary dewatering facility and received a secondary heavy blend of sludge (BDF prefers a blend with more secondary per input from plant staff). C-II served as the primary supplemental dewatering facility to BDF and received a primary heavy blend of sludge.

2.4.2 Sludge Feed - Total Solids

Laboratory and DCS historian data for total solids were collected and analyzed for each of the dewatering facilitates. Comparison of this data displayed major differences between the total solids values collected from the two data sources (lab and historian). During the Project Quality Management Meeting on April 14, 2023, plant staff indicated that the density meter readings are often inaccurate and that they rely on the laboratory data when making operational adjustments and decisions. Sludge conveyed to the BDF is tested for total solids by both WRRF and BDF laboratories. Comparison of the data from the two labs showed that the results matched closely, indicating that the data is likely accurate. As a result, the laboratory data was used for this analysis and the DCS total solids historian data was omitted.

The total solids laboratory data was analyzed and is displayed in **Figure 2-8**. The 5^{th} to 95^{th} percentile of the data for the BDF and combined data for C-I and C-II are shown in the colored portions of the chart with a line indicating the average values. Absolute minimums and maximums are displayed as leader lines above and below the 5^{th} to 95^{th} percentile range.

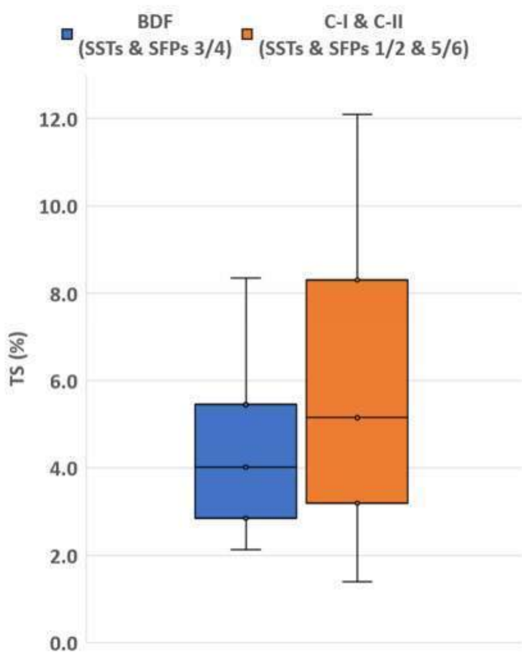

Figure 2-8: Sludge Feed – Total Solids

The 5th to 95th percentile totals solids range for the BDF feed sludge was 2.9% to 5.5%. This range is within the 2.5% to 6.0% total solids range required per GLWA's contract with NEFCO. The total solids range of the feed sludge to C-I and C-II was 3.2% to 8.3% which is slightly wider than the 3.0% to 7.0% range indicated in the facilities' design documents. The wider range of total solids to C-I and C-II is likely the result of the higher percentage of TPS in the C-I and C-II blending ratios. TPS experiences greater fluctuations in solids concentrations than TWAS after wet weather events which would attribute to the wider range of total solids to these facilities.

2.4.3 Sludge Feed – Flow

Historian data from the eight flow meters located on the centrifuge feed lines was used to determine the sludge feed flow rate to the BDF. A flow meter on each of the C-I and C-II feed headers was used to determine the sludge feed flow rate to the C-I and C-II facilities. The sludge feed flow data was analyzed and is displayed in **Figure 2-9**. The 5th to 95th percentile of the data for the BDF and combined data for C-I and C-II are shown in the colored portions of the chart with a line indicating the average values. Absolute minimums and maximums are displayed as leader lines above and below the 5th to 95th percentile range.

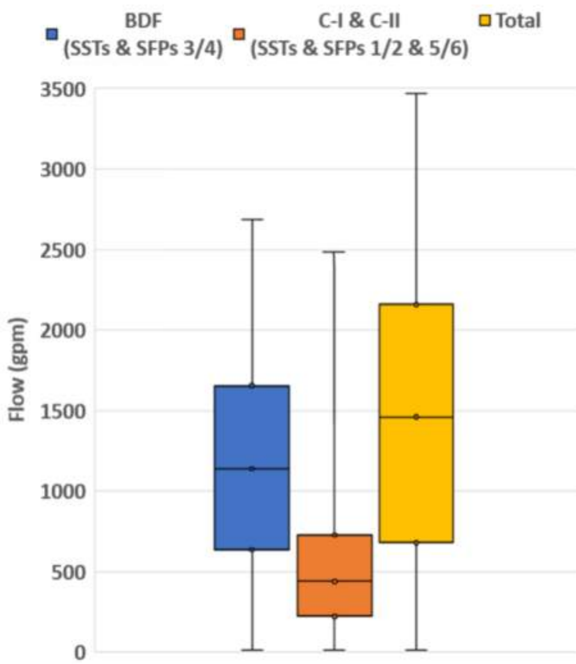

Figure 2-9: Sludge Feed – Flow

The 5th to 95th percentile flow range for the BDF feed sludge was 635 to 1,653 gpm. These values are within the expected flow range with 1 to 3 BDF dryer trains in operation. The flow range for the feed sludge to C-I and C-II was 221 to 726 gpm.

2.4.4 Sludge Feed - Solids Loading

Laboratory data for total solids and historian data for flow was used to calculate the solids loading to the dewatering facilities. The resultant sludge feed solids loading data is displayed in **Figure 2-10**. The 5th to 95th percentile of the data for the BDF and combined data for C-I and C-II are shown in the colored portions of the chart with a line indicating the average values. Absolute minimums and maximums are displayed as leader lines above and below the 5th to 95th percentile range.

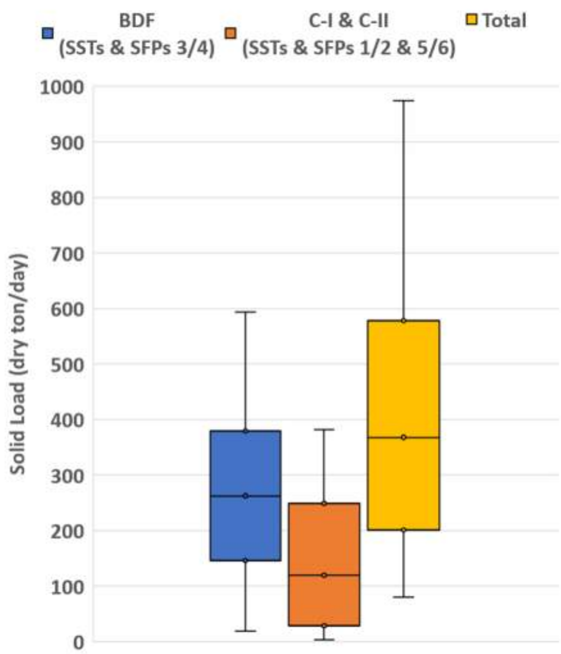

Figure 2-10: Sludge Feed – Solids Loading

The 5th to 95th percentile solids loading range for the past three years was 146 to 379 dtpd to the BDF, and 28 to 248 dtpd to C-I and C-II combined.

2.4.5 Sludge Feed - Header Pressure

Historian data from pressure transmitters located on the sludge headers upstream of the dewatering feed branches was used to determine the sludge feed pressures at each dewatering facility. The sludge feed pressure data was analyzed and is displayed in **Figure 2-11**. The 5th to 95th percentile of the data for each facility is shown in the colored portion of the chart with a line indicating the average value. Absolute minimums and maximums are displayed as leader lines above and below the 5th to 95th percentile range.

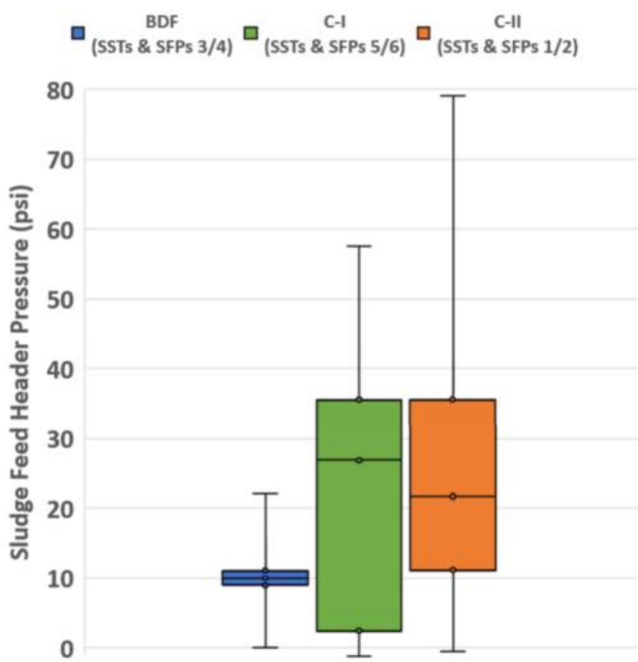

Figure 2-11: Sludge Feed – Header Pressure

The BDF sludge header pressure was normally at or near the 10-psi pressure desired by NEFCO. The 5th to 95th percentile sludge header pressures for C-I and C-II were 2 to 36 psi and 11 to 36 psi respectively.

2.4.6 Operational Data Summary

Laboratory and DCS historian data for the past three years (5/2020 – 5/2023) were collected and analyzed. The 5th to 95th percentile data ranges for each parameter are summarized in **Table 2-7**.

Table 2-7: Operational Data Summary (5/2020 – 5/2023)

Parameter	BDF (Min[1] – Max[2])	C-I and C-II (Min[1] – Max[2])
Feed Sludge Total Solids (%)	2.9 – 5.5	3.2 – 8.3
Feed Sludge Flow (gpm)	635 – 1,653	221 – 726
Feed Sludge Solids Loading (dtpd)	146 – 379	28 – 248
Feed Sludge Header Pressure (psi)	9.6 – 10.4	2 – 36 for C-I 11 – 36 for C-II

[1] Minimum values are based on 5th percentile of data.
[2] Maximum values are based on 95th percentile of data.

3.0 Analysis Summary and Recommendations

The dewatering systems sludge demand analysis was performed to assist in the rightsizing of the sludge feed systems for each dewatering facility. Minimum and maximum values for the feed sludge total solids, flow, solids loading, and header pressures are required to establish the design criteria for the improvements being considered as part of the Project. **Table 3-1** summarizes the data analysis performed. Data values in bold were used as the basis for developing the design criteria recommendations.

Table 3-1: Summary of Data Analysis

Parameter	Data Source	BDF (Min/Avg/ Max)	C-I (Min/Avg/ Max)	C-II (Min/Avg/ Max)
Total Solids (%)	NPDES Permit	No Requirement	No Requirement	No Requirement
	Original Design Criteria	**2.5**/--/**6.0**	**3.0**/--/7.0	**3.0**/--/7.0
	Operational Data	2.9/**4.0**/5.5	3.2/**5.2**/**8.3**	3.2/**5.2**/**8.3**
Flow (gpm)	NPDES Permit	No Requirement	No Requirement	No Requirement
	Original Design Criteria	**350/--/2,400**	100/--/2,160	100/--/2,160
	Operational Data	635/**1,137**/1,653	**221/439/726**	**221/439/726**
Solids Loading (dtpd)	NPDES Permit	--/500/850 (total)	--/500/850 (total)	--/500/850 (total)
	Original Design Criteria	**105**/316[1]/**420**[2]	18/--/312[3]	18/--/384[3]
	Operational Data	146/**262**/379	**28**/119/**248**	**28**/119/**248**
Feed Header Pressure (psi)	NPDES Permit	No Requirement	No Requirement	No Requirement
	Original Design Criteria	**5/10/25**	**25**/--/**30**	**25**/--/**30**
	Operational Data	9.6/10.0/10.4	2/**27**/36	11/**22**/36

[1]Based on firm capacity (3 dryer trains in operation).
[2]Based on all 4 dryer trains in operation.
[3]Based on original design firm capacity.

Each data source of information was analyzed to recommend a comprehensive set of parameters that will allow WRRF to meet regulatory requirements, contractual requirements, and plant operational needs while rightsizing the equipment. It is noted that the recommended design criteria values were determined based on what is required at each dewatering facility to process the WRRF's solids. Inclusion of return flows associated with the sludge header return loops will be addressed as part of the pumping system analysis. CDM Smith's recommended design criteria for the sludge feed systems based on the data analysis performed is presented in **Table 3-2**.

Table 3-2: Summary of Recommended Design Criteria

Parameter	BDF (Min/Avg/Max)	C-I (Min/Avg/Max)	C-II (Min/Avg/Max)
Feed Sludge Total Solids (%)	2.5/4.0/6.0	3.0/5.2/8.3	3.0/5.2/8.3
Feed Sludge Flow (gpm)	350/1,137/2,400	221/439/726	221/439/726
Feed Sludge Solids Loading (dtpd)	105/262/420	28/119/248	28/119/248
Feed Sludge Header Pressure (psi)	5/10/25	25/27/30	25/27/30

Table 3-3 displays that the recommended sludge feed system design criteria and resultant total solids loading capacity meets the NPDES Permit requirements.

Table 3-3: Solids Loading Recommendation vs NPDES Permit Requirements

Facility/Permit Requirement	Average Solids Loading (dtpd)	Maximum Solids Loading (dtpd)
BDF	262	420
C-I	119	248
C-II	119	248
WRRF Total	**500**	**916**
NPDES Permit Requirements	500	850

Table 3-4 displays that the recommended sludge feed system design criteria and resultant solids loading capacity at the BDF meets the BDF Contract requirements.

Table 3-4: Solids Loading Recommendation vs BDF Contract Requirements

Parameter	Contract Value (dtpy)	Contract Value (dtpd)	Recommended BDF Solids Loading (dtpd) (Min/Avg/Max)
Guaranteed Annual Minimum Solids (Contract Requirement)	73,000	200	105/262[1]/420
Projected Annual Solids Range (Contract Projection)	115,000 – 135,000	315 - 369	105/262[1]/420
Project Maximum Annual Solids (Contract Projection)	140,000	383	105/262[1]/420

[1]262 dtpd is the average solids processed by BDF based on the operational data analyzed. NEFCO is required per Contract to have the BDF's firm capacity of 316 dtpd available daily. Project improvements will be designed to accommodate the BDF's firm capacity.

4.0 Workshop 1 and Additional Analysis

On August 11, 2023, CDM Smith, GLWA, and NEFCO participated in a workshop (Workshop 1) to review TM-4 and to establish dewatering systems sludge demands to be used for the Project. CDM Smith was tasked with reviewing the practicality of providing provisions to feed all C-I and C-II BFPs (22 total) in the scenario of a total BDF outage. Additional feedback received during Workshop 1 for analysis included the following:

- Preference is for the pumps dedicated to BDF to not be used as backup to feed C-I or C-II during a BDF outage.
- C-I and C-II minimum sludge header pressure requirement (25 psi) is based on the O&M document which indicates this pressure is required for proper flow control valve operation. Additional data analysis and GLWA input is needed to determine if this value can be lowered.

4.1 C-I and C-II BFP Sludge Feed – Total Flow Required to Feed All 22 BFPs

Historian data from the 22 flow meters located on the BFP feed lines was used to determine the operational flow range to each BFP over the past three years (5/2020 – 5/2023). **Figure 4-1** presents this data in a histogram. The blue bars indicate the total hours that a BFP was operating at a given flow. The orange line indicates the cumulative percentage of time that the BFPs were operating at or below a given flow value. The 5th to 95th percentile flow range for the feed sludge to each BFP was 95 gpm to 160 gpm with an average flow of 127 gpm.

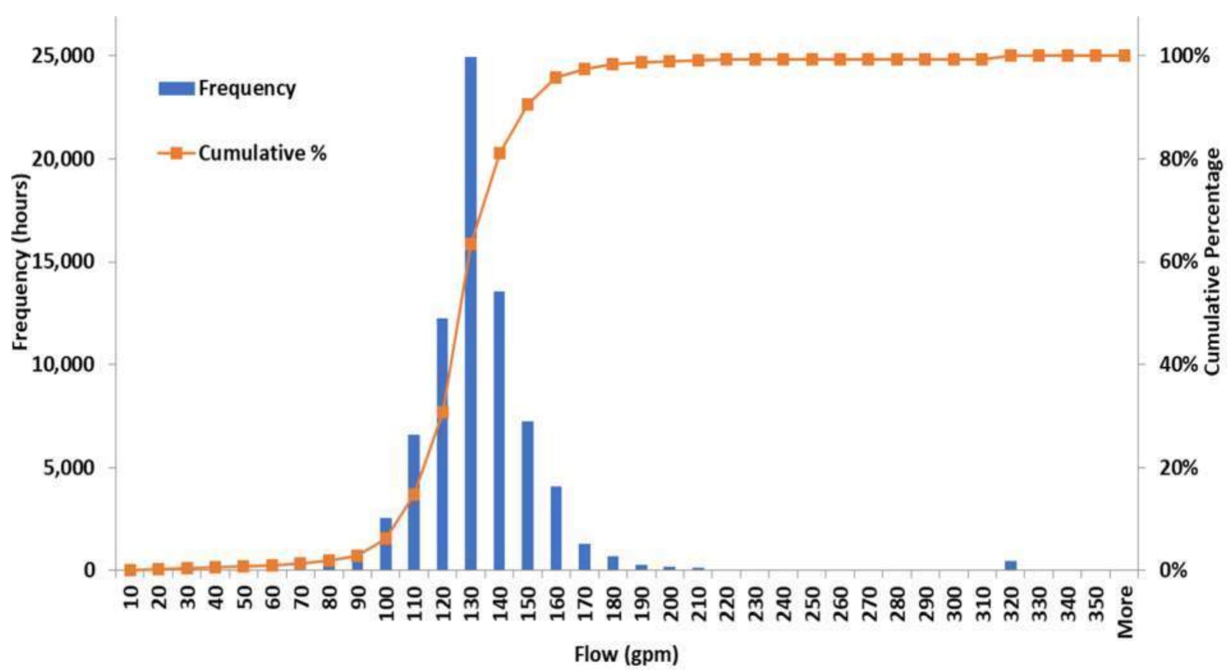

Figure 4-1: Histogram of Sludge Feed Flow to the C-I & C-II BFPs

CDM Smith selected the 90th percentile (150 gpm) as a conservative and practical basis for feeding each of the 22 BFPs in the scenario of a BDF outage occurring during maximum sludge loading conditions at the WRRF. This feed rate results in a total required flow of 3,300 gpm with all BFPs in operation (1,500 gpm for C-I, 1,800 gpm for C-II).

C-I and C-II typically process thicker sludge (5.2% average) than the BDF (4.0% average). The C-I and C-II BFPs will need to dewater all the WRRF sludge during a BDF outage. Analysis of the laboratory data determined that the combined average of the feed sludge total solids is 4.3%. 3,300 gpm of 4.3% sludge results in a combined solids loading capacity of 859 dtpd for the C-I and C-II facilities. This capacity, with BDF out of service, exceeds the required plant peak capacity of 850 dtpd included in the NPDES permit.

4.1.1 BDF Outage – Pumping Considerations

CDM Smith was tasked with determining the feasibility of dedicating the BDF pumps to feed the BDF only and for them not be used as backup to feed C-I or C-II during a BDF outage. This constraint is being considered as part of TM-5B Pumping Systems Evaluation. Preliminary results indicate that dedicating all of these pumps to BDF will greatly reduce the sludge feed pump system's operational flexibility and require larger duty pumps to be provided for the pumps feeding C-I and C-II during normal operating conditions. These larger pumps will likely require additional building expansion(s) and result in an increase in constructability challenges.

Dedicating some of the BDF pumps to feed the BDF, and allowing others to be used as backup to feed C-I or C-II during a BDF outage is also being considered. This alternative will allow for the right sizing of the C-I and C-II pumps, require the least amount of building expansion(s), and provide the most operational flexibility. This discussion will be expanded on in TM-5B.

4.2 C-I and C-II BFP Sludge Feed – Required Header Pressures

CDM Smith performed additional analysis of the C-I and C-II sludge header pressures to determine if lowering the 25 psi minimum requirement would be appropriate. **Figure 4-2** displays the C-I and C-II operating header pressures for the past three years (5/2020 – 5/2023) in a histogram. The bars indicate the total hours that the sludge header was operating at a given pressure. The lines indicate the cumulative percentage of time that the sludge headers were operating at or below a given pressure value.

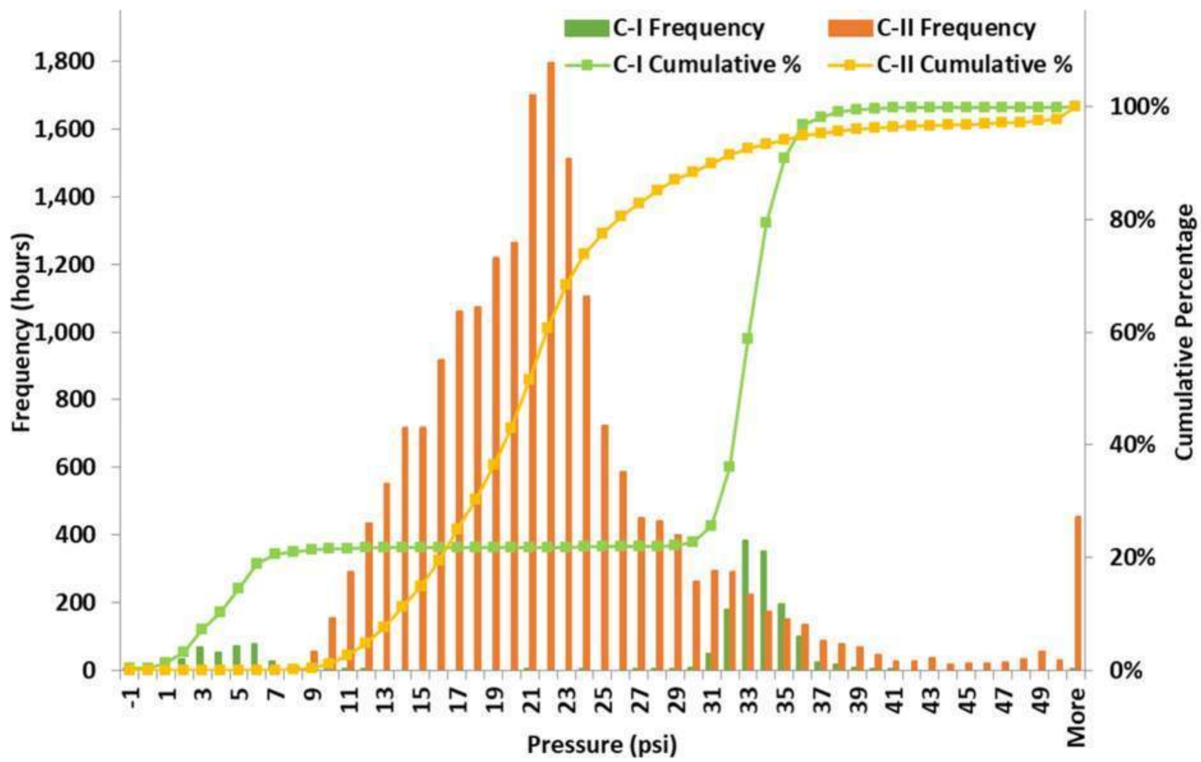

Figure 4-2: Histogram of C-I and C-II Sludge Header Pressures

4.2.1 C-II Sludge Header - Pressure Requirement

The originally recommended 25 psi minimum sludge header pressure requirement was based on information in the C-II O&M Manual. This document states that 25 psi is required for the flow control equipment to operate properly (including the flow control valves). Further analysis of the operating data determined that the C-II BFPs were in operation with sludge header pressures lower than 25 psi 80 percent of the time. The 5th to 95th percentile sludge header pressure for C-II was 11 to 36 psi with an average of 22 psi. In addition to this, plant staff have indicated that 15 to 20 psi is required to begin placing BFPs in service without experiencing flow control issues.

Based on this additional analysis and plant staff input, CDM Smith recommends using the operational data as a basis for selecting the required C-II sludge header pressure in lieu of the O&M information. 15 psi minimum, 22 psi average, and 30 psi maximum are the updated recommended values. It is noted that these pressure requirements are based on the existing sludge header pressure sensor locations as shown in **Figure 4-3**.

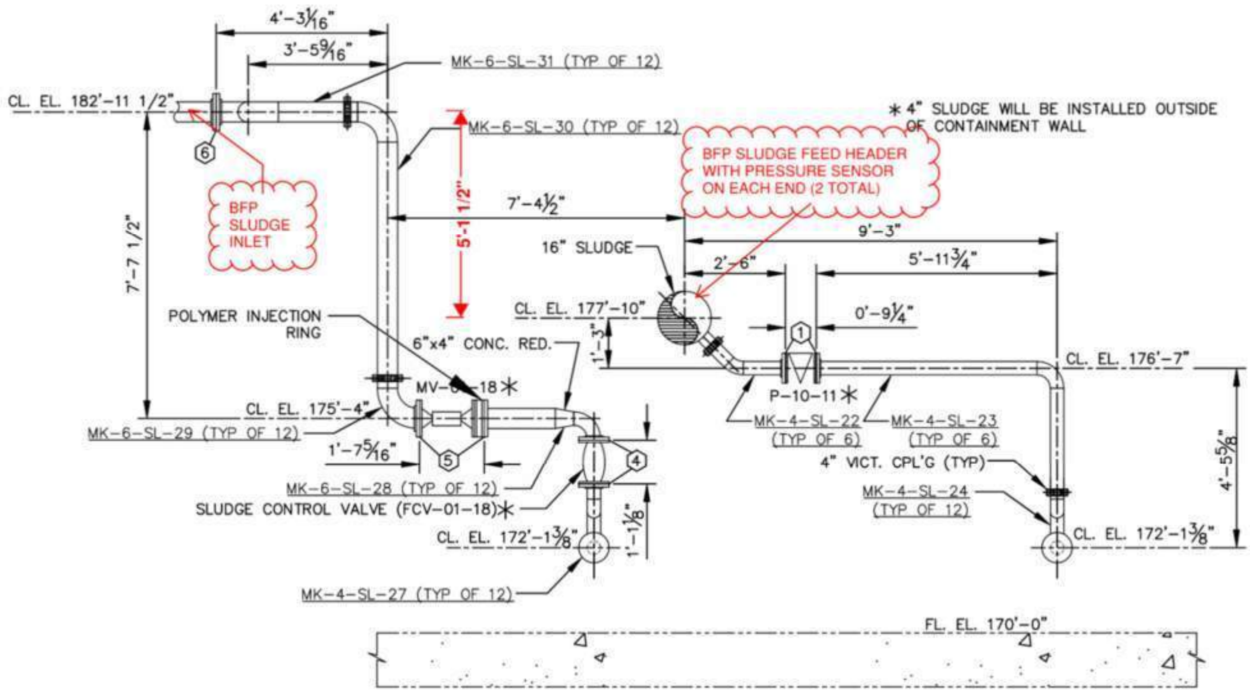

Figure 4-3: C-II Sludge Header Pressure Sensor Location in Relation to BFP Inlet (Static Head Difference)

4.2.2 C-I Sludge Header - Pressure Requirement

The originally recommended 25 psi minimum sludge header pressure requirement for C-I was based on information in the C-II O&M Manual. This info was assumed to be applicable to C-I as the BFP feed branches (piping, equipment, and layouts) are very similar between the two facilities. This document states that 25 psi is required for the flow control equipment to operate properly (including the flow control valves). Further analysis has determined that although the BFP feed branches are similar, the sludge header and pressure sensor elevations relative to the BFP inlets are significantly different for C-I as shown in **Figure 4-4**.

The elevation difference between the sludge header pressure sensor and the BFP feed inlet is 25.6 feet for C-I and 5.1 feet for C-II. This 20.5 feet difference between the C-I and C-II facilities is equivalent to 9 psi of additional static head required at the C-I sludge header when compared to C-II. The C-I and C-II BFP feed branches (including isolation valves, flow control valve, grinder, and piping layout) are relatively similar and expected to have similar dynamic head losses. Based on this physical data, the C-I sludge header pressure requirements are expected to be 9-10 psi higher than the C-II requirements.

Adding this 10 psi to the C-II pressure requirements results in C-I pressure requirements of 25 psi minimum, 32 psi average, and 40 psi maximum. These values align with the limited C-I operational data available as displayed in the **Figure 4-2** histogram. This recommended pressure range covers 99% of the operational data range for the past three years. It is noted that these pressure requirements are based on the existing sludge header pressure sensor location for C-I.

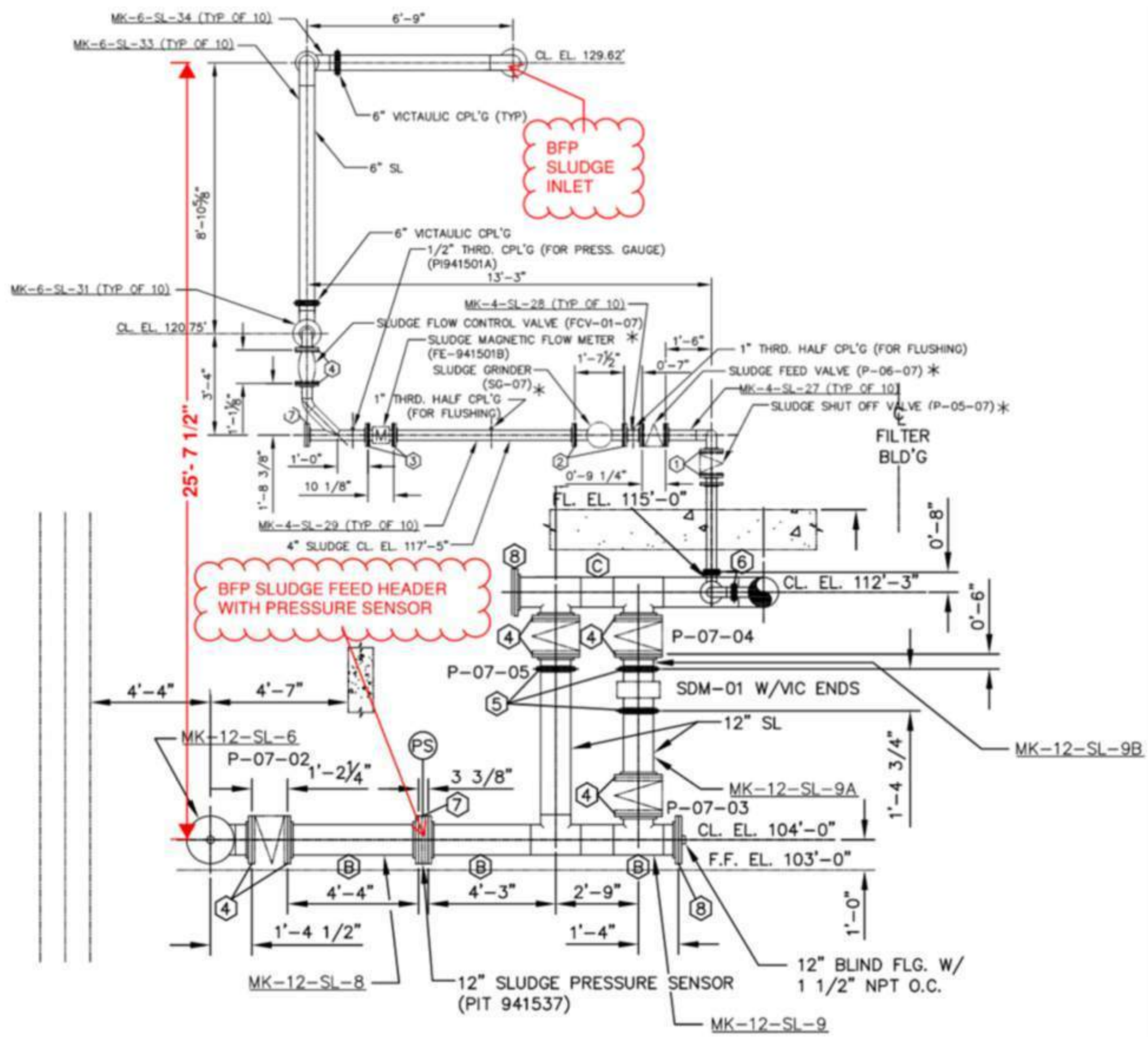

Figure 4-4: C-I Sludge Header Pressure Sensor Location in Relation to BFP Inlet (Static Head Difference)

5.0 Additional Analysis Summary and Updated Recommendations

Additional analysis was performed to address GLWA's input received during Workshop 1. Recommendations were modified to display both a normal operating condition scenario as well as a BDF outage scenario. CDM Smith's updated recommended design criteria for the sludge feed systems is presented in **Table 5-1** and **Table 5-2**.

Table 5-1: Updated Recommended Design Criteria (Normal Operation)

Parameter	BDF (Min/Avg/Max)	C-I (Min/Avg/Max)	C-II (Min/Avg/Max)
Feed Sludge Total Solids (%)	2.5/4.0/6.0	3.0/5.2/8.3	3.0/5.2/8.3
Feed Sludge Flow (gpm)	350/1,137/2,400	221/439/726	221/439/726
Feed Sludge Solids Loading (dtpd)	105/262/420	28/119/248	28/119/248
Feed Sludge Header Pressure (psi)	5/10/25	25/32/40	15/22/30

Table 5-2: Updated Recommended Design Criteria (BDF Outage)

Parameter	BDF (Min/Avg/Max)	C-I (Min/Avg/Max)	C-II (Min/Avg/Max)
Feed Sludge Total Solids (%)	-	3.0/4.3/8.3	3.0/4.3/8.3
Feed Sludge Flow (gpm)	-	221/439/1,500[1]	221/439/1,800[1]
Feed Sludge Solids Loading (dtpd)	-	28/119/390[1]	28/119/469[1]
Feed Sludge Header Pressure (psi)	-	25/32/40	15/22/30

[1]Values based on using 2 of the 4 BDF feed pumps to supply sludge to C-I or C-II during a BDF outage.

Table 5-3 displays that the updated recommended sludge feed system design criteria result in total solids loading capacities that meet the NPDES Permit requirements during normal operation as well as BDF outage scenarios.

Table 5-3: Updated Solids Loading Recommendation vs NPDES Permit Requirements

Facility/Permit Requirement	Average Solids Loading (dtpd)	Maximum Solids Loading (Normal Operation) (dtpd)	Maximum Solids Loading (BDF Outage) (dtpd)
BDF	262	420	0
C-I	119	248	390
C-II	119	248	469
WRRF Total	**500**	**916**	**859**
NPDES Permit Requirements	500	850	

cc: File

Appendix F: Alternative Evaluation Technical Memorandums

Technical Memorandum 5A

To: *Jared Buzo, METCO*
Sham Sihabdeen, AECOM
Chris Wilson, GLWA

From: *Steve Wyman, CDM Smith*
Mohsen Sadatiyan, CDM Smith

Date: *November 7, 2023*

Subject: *Great Lakes Water Authority (GLWA)*
Contract No. 2202790 – Water Resource Recovery Facility (WRRF) Improvements to the Sludge Feed System for Solids Processing
TM-5A Pumping Technology Evaluation and Shortlisting

1.0 Purpose and Background

Great Lakes Water Authority (GLWA) owns and operates the Water Resource Recovery Facility (WRRF) located at 9300 W. Jefferson, Detroit, MI 48209. WRRF is a conventional activated sludge plant with a wet weather design capacity of 1,444 million gallons per day (MGD) and serves approximately one-third of the State of Michigan's population. This facility is one of the largest wastewater treatment plants in the world, with the capacity to treat up to 1,700 MGD through primary treatment and 930 MGD through secondary treatment.

Many of the components of the facility are 80 years old. In service for about 50 years, the majority of the process units were built and expanded in the 1970s. Influent pumping and a large portion of preliminary and primary treatment facilities went online in 1940, sludge incineration went online in the 1950s and 1970s, and secondary treatment was started in the 1970s with the advent of the Clean Water Act. The facility was expanded in the 1990s to treat flow from the Northern Interceptor–East Arm, with the construction of Pump Station No. 2 and associated preliminary treatment and optimized for wet weather flow in the early 2000s. The Biosolids Drying Facility went online in 2016, allowing the decommissioning of the Complex I incinerators. Disinfection of primary effluent was implemented in 2019.

WRRF generates solids through primary and secondary clarification. Solids handling processes include gravity thickening, blending, storage, dewatering, incineration, and drying treatment processes. Thickened primary sludge (TPS) and thickened waste activated sludge (TWAS) is blended prior to being discharged into six sludge storage tanks (SSTs). The sludge feed system, comprised of sludge feed pumps (SFPs), sludge piping, and flow control equipment, supplies thickened blended sludges from the SSTs to sludge dewatering equipment at three different dewatering facilities. These dewatering facilities include belt filter presses (BFPs) located in Sludge Dewatering Complex I (C-I); BFPs in Sludge Dewatering Complex II (C-II); and centrifuges (CFGs) in the Biosolids Drying Facility (BDF). Under normal operating conditions, BDF CFGs process 60 to 70 percent of WRRF's solids. BFPs in C-I and C-II are used to dewater the balance of sludge not processed by the BDF or when the BDF equipment is offline for maintenance. C-II is also equipped with CFGs which were discontinued by GLWA prior to 2018 in favor of utilizing the C-I and C-II BFPs to supplement dewatering at the BDF. Dewatered sludge from C-I and C-II is incinerated onsite and dried sludge from BDF is land-applied offsite.

The service life of many of the existing SFPs has been exceeded, and all SFP equipment and piping are understood to be oversized for the feed rates required at the dewatering facilities. Additionally, sludge feed piping "dead ends" at each of the dewatering facilities result in sludge feed header pressures that are difficult to maintain within the operating range required for the sludge flow control equipment at each piece of dewatering equipment. The end result of the aged pumping equipment, oversized sludge feed components, dewatering facility locations, and piping configurations is a sludge feed system that is difficult to operate and maintain.

This project, WRRF Improvements to the Sludge Feed System for Solids Processing (the Project), involves making improvements to the dewatering sludge feed pumping systems, improving drainage of SSTs 1-4, and mitigating flooding of the Sludge Processing Complex A basement. The scope includes conducting discipline-specific condition assessments and evaluations in order to recommend cost-effective upgrades and improvements to achieve robust, sustainable, and long-term upgrades while reducing maintenance efforts, improving operational flexibility, and maintaining treatment operations at all times. This assessment and evaluation work will be documented in technical memoranda (TMs). This document is Technical Memorandum 5A (TM-5A) and covers the pumping technology evaluation performed for the Project.

The purpose of TM-5A is provide a description of each pump type considered, present the advantages and disadvantages of each pump type, and provide CDM Smith's recommendation for shortlisting. The short-listed pumping technologies will be further evaluated in subsequent TMs for implementation on the Project.

2.0 Pumping Technologies Considered

Numerous pumping technologies were considered for implementation. TM-4 Dewatering Systems Sludge Demands discusses the sludge flows and loads required of the pumping systems. In general, the Project requires pumping technologies capable of conveying blended thickened primary sludge (TPS) and thickened waste activated sludge (TWAS) between 2.0 and 8.3 percent solids. The ability to handle grit and rag loads is also needed. The pumping technologies considered in this evaluation include:

- Rotodynamic Type Pumps
  - Chopper

- Recessed Impeller
- Vortex/Screw Impeller

- Positive Displacement Type Pumps
  - Rotary Lobe
  - Progressing Cavity
  - Double Disc
  - Piston/Plunger

CDM Smith contacted manufacturers for each pump type to determine if they were capable of providing equipment that could meet the Project's requirements reliably. Advantages and disadvantages of each pump type were also discussed. A summary of the information received as well as CDM Smith's recommendation on whether to further consider each pump type for the Project is included in the subsequent sections.

3.0 Rotodynamic Pump Types

3.1 Chopper Pumps

Chopper pumps are rotodynamic pumps designed to combine the fluid movement action of a standard pump with the solids cutting function of a grinder. This combination eliminates the need for a separate inline grinder upstream of the pump. The pump is constructed with a cutter knife attached to a non-clog impeller. The design intent is to agitate and break up large solids that have the potential to block the pump's suction. As incoming solids and rags pass through the pump, they are effectively chopped by the rotating cutter knife as it moves across a cutter bar. **Figure 3-1** displays a cross-section of a Vaughan chopper pump.

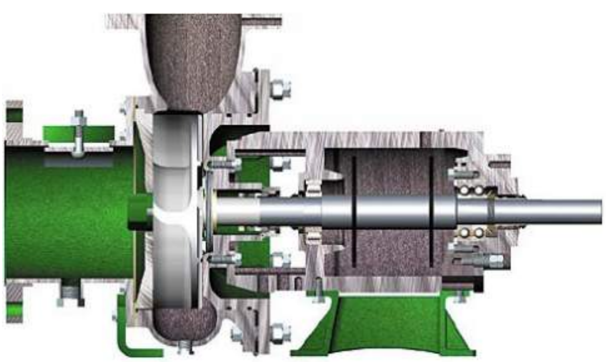

Figure 3-1: Vaughan Chopper Pump Cutaway

Chopper pumps are used in wide range of wastewater conveyance applications including raw sewage, clarifier scum, septage, as well as thickened, digested, and blended sludges. Chopper pump manufacturers for the wastewater industry include Vaughan, Xylem (Flygt), and Hayward Gordon. Vaughan is the current market leader for chopper pumps, and they are the only manufacturer who can provide large enough dry pit (horizontal or pedestal mount) chopper pumps for this application.

3.1.1 Advantages

Advantages of chopper pumps include the following:

- Relatively low capital cost: Chopper pumps offer cost-effective solutions for sludge pumping applications.
- Proven pumping technology: These pumps have a well-established track record and are widely used in the industry.
- Does not require upstream grinder: The integrated cutter knife eliminates the need for a separate grinder, saving space and costs.
- Relatively small footprint: Chopper pumps have a relatively compact design, making them suitable for installations with limited space.
- Demonstrated success in previous applications: Chopper pumps have been successfully utilized in CDM Smith sludge pumping applications.
- GLWA staff familiarity: GLWA is familiar with chopper pumps (no learning curve) as they are the existing pumping technology utilized for this application at the WRRF.

3.1.2 Disadvantages

Disadvantages of chopper pumps include the following:

- Cutter knife and impeller require careful handling during maintenance (sharp edges).
- Relatively low efficiency: Chopper pumps may have lower hydraulic efficiency when compared to positive displacement pumps.
- Limited pressure capability: These pumps have constraints on the maximum pressure they can generate.
- Regularly scheduled maintenance is expected: Like all pumps, chopper pumps require periodic maintenance to ensure reliable operation.
- Minimum speed constraint: To effectively chop rags, chopper pumps typically need to operate at a minimum speed of around 70%, limiting their allowable operating range.
- Typically not recommended for high percent solids sludges: Chopper pumps may not be suitable for handling high percent solids sludges with significant organic or oily content.

- Possibility of clogging in smaller pump suction applications if obstructed by the cutter nut or disintegrator tool.
- Higher NPSHr (Net Positive Suction Head required) compared to positive displacement pumps, necessitating flooded suction conditions.
- Limited operational flexibility: Limited ability to handle fluctuations in sludge percent solids (resulting in head fluctuations) while maintaining the same flow rate. The pump's relatively flat characteristic curve makes it more sensitive to variations in the system pressure impacting pump operation and limiting its operational flexibility.

3.1.3 Constraints and Specifications

General chopper pump constraints and specifications include the following:

- Pump Size: 3” to 16”
- Flow Range: up to 13,000 gpm
- Differential Head Range: up to 200 feet
- Hydraulic Efficiency: 50% to 70%
- Drive: Direct or belt
- Seal Type: Packing or mechanical (flushed cartridge)
- Materials: Heat treated hardened alloy steel impeller and cutter components

3.1.4 Considerations and Recommendation

Chopper pumps are currently used to convey sludge to the dewatering facilities and have proven capable of meeting the sludge flows and loads required (including grit and rags). GLWA O&M staff are familiar with this pump type and have indicated that they have performed satisfactorily. Small footprint and the ability to cut/chop rags are two major advantages of this pump type for this application.

Chopper pumps (as well as other rotodynamic type pumps) have a relatively narrow range of operation. Operating these pumps at a minimum speed of 70% is recommended to maintain the pump’s chopping capabilities. This limitation minimizes the pump’s turndown capabilities and reduces its effective operating range. Plant staff have indicated a desire for flexibility to be provided in the pumping system design (i.e., pumps can be used to convey sludge from a given storage tank to multiple dewatering facilities). Providing this flexibility while utilizing chopper pumps could prove challenging given the pump’s limitations.

Based on their proven track record in this application at the WRRF, CDM Smith recommends further considering chopper pumps for implementation on the Project.

3.2 Recessed Impeller Pumps

Recessed impeller pumps are a type of rotodynamic pump that have an impeller that is set back or recessed into the pump casing, effectively removing it from the main flow path. **Figure 3-2** displays a recessed impeller pump cutaway for visual representation.

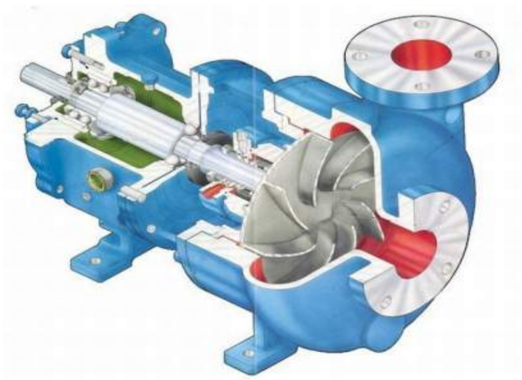

Figure 3-2: Recessed Impeller Pump Cutaway

The impeller is equipped with vanes attached to a single shroud. Its rotation imparts energy to the fluid within the pump without the fluid directly passing through the impeller. Due to this design, a portion of the fluid passing through the pump does not make direct contact with the impeller. As a result, the size of solids that the pump can handle is typically limited only by the diameter of the suction and discharge nozzles of the pump casing. Larger recessed impeller pumps are capable of passing noncompressible objects as large as 3” to 4” in diameter.

It's worth noting that in applications where flow control is critical, recessed impeller pumps may not be suitable. These pumps have characteristic curves with flat slopes, indicating a low change in head per change in flow. Therefore, they are best suited for pumping systems with steep system curves, where a modest change in head will not significantly affect the pump's flow rate.

Recessed impeller pumps find common usage in pumping municipal wastewater and sludges containing grit and other abrasive materials. Manufacturers including Trillium (Wemco®), Egger, and Hayward Gordon offer pumps of this type for various sludge pumping applications.

3.2.1 Advantages

Advantages of recessed impeller pumps include the following:

- Proven pumping technology: Recessed impeller pumps have a well-established track record and are widely used in the industry.
- Low shear of pumped fluid: Limited contact between the impeller and pumped fluid results in minimal shear which is advantageous for pumping flocculated materials.
- Relatively low maintenance requirements: These pumps are designed for longevity and require less frequent maintenance compared to some other pump types.
- Small footprint: Recessed impeller pumps have a compact design making them suitable for installations with limited space.
- Long tool life and high reliability: These pumps are built to withstand harsh conditions resulting in high reliability and long service life in appropriate applications.
- Non-clog design: The impeller's recessed location removes it from the main flow path, allowing the passage of larger solids and stringy materials that could potentially clog a traditional rotodynamic pump.
- GLWA staff familiarity: GLWA is familiar with recessed impeller pumps (no learning curve) as they were previously utilized for this application at the WRRF.

3.2.2 Disadvantages

Disadvantages of recessed impeller pumps include the following:

- Relatively low efficiency: Recessed impeller pumps may have lower hydraulic efficiency when compared to positive displacement pumps.
- No chopping/cutting of rags and fibrous materials: These pumps are capable of conveying fluids with some rags and fibrous materials but do not chop or cut the material. This could result in operational challenges for downstream equipment.
- Typically not recommended for high percent solids sludges: Recessed impeller pumps may not be suitable for handling high percent solids sludges (typically higher than 6%).
- Higher NPSHr compared to positive displacement pumps, necessitating flooded suction conditions.
- Limited operational flexibility: Limited ability to handle fluctuations in sludge percent solids (resulting in head fluctuations) while maintaining the same flow rate. The pump's relatively flat characteristic curve makes it more sensitive to variations in the system pressure impacting pump operation and limiting its operational flexibility.

3.2.3 *Constraints and Specifications*

General recessed impeller pump constraints and specifications include the following:

- Pump Size: 1” to 8”
- Flow Range: up to 4,500 gpm
- Differential Head Range: up to 230 feet
- Hydraulic Efficiency: 30% to 60%
- Drive: Direct or belt
- Seal Type: Packing or mechanical (flushed cartridge)
- Materials: High chrome impeller and liner

3.2.4 Considerations and Recommendation

Recessed impeller pumps were previously used to convey sludge to the dewatering facilities at the WRRF. GLWA O&M staff have indicated that these pumps did not perform well and had issues handling the rags and grit present in the sludge. Grinders would be required upstream of the pumps to minimize maintenance associated with rags and fibrous materials at the pumps and at the downstream process equipment. The addition of grinders would increase the amount of equipment requiring routine maintenance and could lead to potential pump issues including pump starvation and cavitation. Inability to reliably convey sludges above 6% total solids and limited operational flexibility are two other downsides of recessed impeller pumps for this application.

Based on previous WRRF experience and the limitations discussed above, CDM Smith does not recommend further consideration of recessed impeller pumps for implementation on the Project.

3.3 Vortex/Screw Impeller Pumps

Vortex or screw impeller pumps are rotodynamic pumps that utilize their unique impellers to create a tornado-like motion that draws fluid into the pump and then propels it into the discharge pipe with minimal or no contact with the impeller. This allows these pumps to better handle stringy and fibrous materials that may be present in the pumped fluid.

Unlike conventional rotodynamic pumps, the pumping action of a vortex pump is a two-stage process. The impeller is located outside the flow area of the volute and generates a primary vortex or swirling action in the fluid within and around its vanes. This primary vortex, in turn, induces a secondary vortex in the volute, which is responsible for generating the flow. **Figure 3-3** displays a vortex/screw impeller pump cutaway for visual representation.

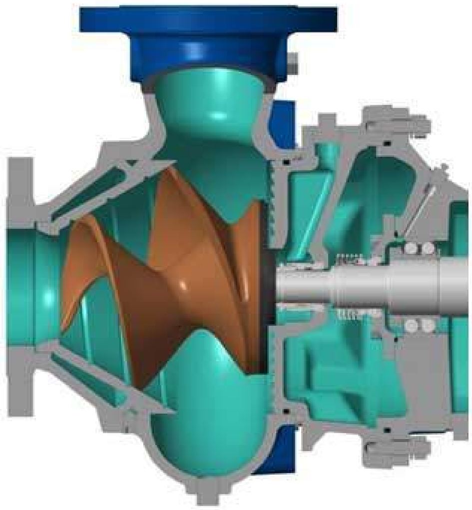

Figure 3-3: Vortex/Screw impeller Pump Cutaway

Vortex/screw impeller are used in pumping raw sewage as well as in industrial and municipal wastewater applications containing large amounts of fibrous materials. Manufacturers including Trillium (Wemco®), Egger, and Vaughan offer vortex/screw impeller pumps for these applications.

3.3.1 Advantages

Advantages of vortex/screw impeller pumps include the following:

- Low shear of pumped fluid: Limited contact between the impeller and pumped fluid results in minimal shear which is advantageous for pumping flocculated materials.
- Small footprint: vortex/screw impeller pumps have a relatively compact design making them suitable for installations with limited space.
- Long tool life and high reliability: These pumps are built to withstand harsh conditions resulting in high reliability and long service life in appropriate applications.
- Non-clog design: The impeller's pump design results in minimal contact with the pumped fluid and allows the passage of larger solids and stringy materials, preventing issues that may occur with traditional rotodynamic pumps.
- Operational flexibility: Reduction in radial forces allows vortex pumps to operate at low flows (for rotodynamic pumps) or shutoff conditions for extended periods without damage.

3.3.2 *Disadvantages*

Disadvantages of vortex/screw impeller pumps include the following:

- Higher NPSHr compared to positive displacement pumps, necessitating flooded suction conditions.
- No chopping/cutting of rags and fibrous materials: These pumps are capable of conveying fluids with some rags and fibrous materials but do not chop or cut the material. This could result in operational challenges for downstream equipment.
- Typically not recommended for high percent solids sludges: Vortex/screw impeller pumps may not be suitable for handling high percent solids sludges (typically higher than 6%).
- Limited operational flexibility: Operating at low flows (for rotodynamic pumps) is possible but requires the pumps to operate away from their Best Efficiency Point (BEP). Limited ability to handle fluctuations in sludge percent solids (resulting in head fluctuations) while maintaining the same flow rate..

3.3.3 *Constraints and Specifications*

General vortex/screw impeller pump constraints and specifications include the following:

- Pump Size: 3” to 16”
- Flow Range: up to 15,000 gpm
- Differential Head Range: up to 300 feet
- Hydraulic Efficiency: 50% to 70%
- Drive: Direct or belt
- Seal Type: Packing or mechanical (flushed cartridge)
- Materials: High chrome impeller and liner

3.3.4 *Considerations and Recommendation*

Vortex/screw impeller pumps have many of the same advantages and disadvantages when compared with recessed impeller pumps. These pumps can convey sludge with some rags and fibrous materials but typically require grinders upstream to operate reliably. The addition of grinders would increase the amount of equipment requiring routine maintenance and could lead to potential pump issues including pump starvation and cavitation. Inability to reliably convey sludges above 6% total solids and limited operational flexibility (although better than recessed impeller pumps) are two other downsides of vortex/screw impeller pumps for this application.

The design similarities between recessed impeller pumps and vortex/screw impeller pumps point to similar performance/reliability results for this application (although likely slightly better results for the vortex/screw impeller pumps). CDM Smith anticipates similar O&M challenges for vortex/screw impeller pumps to what the WRRF experienced when using recessed impeller pumps for this application in the past. As a result, CDM Smith does not recommend further consideration of vortex/screw impeller pumps for implementation on the Project.

4.0 Positive Displacement Pump Types

4.1 Progressing Cavity Pumps

Progressing cavity pumps are comprised of a rotating helically shaped rotor (usually chrome-plated steel), that rotates within and tightly meshes with a double helically shaped stator made of a rubber or rubber-like material. The motor shaft is connected to the rotor by a connecting rod with universal-type joints. A cutaway representation of this type of pump is shown in **Figure 4-1**. The pump operates by allowing flow to enter through the suction, where it gets trapped in a continuous series of sealed cavities formed by the meshing of the rotor and stator. As the rotor turns, these fluid-filled cavities progress through the casing towards the pump discharge.

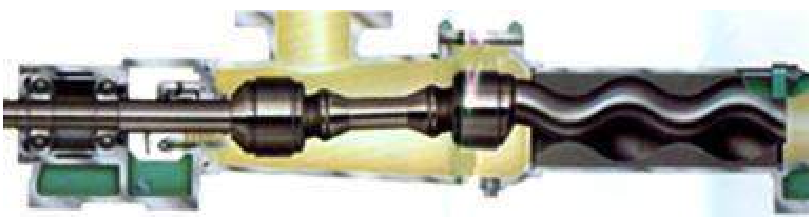

Figure 4-1: Progressive Cavity Pump Cutaway

Because of the tight clearances required between the rotor and stator, fluids containing grit can cause excessive wear of the stator. Such wear could result in frequent replacement of the rotor and stator. Therefore, a progressing cavity pump is not normally used for pumping fluids containing high loads of grit. Stringy materials in sludge may wrap around and bind the rotor; therefore, a grinder installed upstream of the pump is essential. Rags and stringy material can “jam up” the rotor.

Aside from the limitations noted above, progressing cavity pumps are well-suited for pumping raw sewage, sludge, and cake with high solids content and viscosities ranging from 1 submultiple centistokes (cSt) to 10 million cSt. Manufacturers including Netzsch, Seepex, and Moyno provide progressing cavity pumps for various applications at wastewater facilities.

4.1.1 Advantages

Advantages of progressing cavity pumps include the following:

- High pressure capabilities: Progressing cavity pumps can handle high-pressure applications efficiently.
- Wide flow range with limited effect on head: These pumps can cover a large range of flow rates by adjusting the pump speed with minimal impact on the pump's discharge pressure.
- Proven pumping technology: Progressing cavity pumps have a well-established track record and are widely used in wastewater applications.
- Capable of pumping high percent solids sludges (up to 30% solids).
- High suction capacity with low NPSHr: These pumps have a high suction capacity and low NPSHr, enabling them to operate without cavitation even without flooded suction conditions.

4.1.2 Disadvantages

Disadvantages of progressing cavity pumps include the following:

- Not suitable for high grit applications: The presence of grit in the fluid can lead to increased wear on the rotor and stator, necessitating more frequent replacements.
- High capital and O&M costs: Progressing cavity pumps have high equipment and spart parts costs.
- No chopping/cutting of rags and fibrous materials: These pumps require grinders upstream in applications with rags and stringy material. Stringy material passing the grinders can cause operational problems at the pumps.
- High discharge pressures could result in downstream equipment/piping failures if overpressure devices are not provided.
- Large footprint: Large footprint (long) compared to other pump types being evaluated.

4.1.3 Constraints and Specifications

General progressing cavity pump constraints and specifications include the following:

- Pump Size: up to 12”
- Flow Range: up to 2,200 gpm
- Differential Head Rage: up to 1,600 feet

- Hydraulic Efficiency: 50% to 75%
- Drive: Direct or belt
- Seal Type: Packing or mechanical (flushed cartridge)
- Materials: Hardened corrosion resistive rotor

4.1.4 Considerations and Recommendation

Progressing cavity pumps are well suited for pumping wastewater sludges with high percent solids concentrations and high discharge pressure requirements. These pumps have a large turndown range when VFD driven that can offer operational flexibility. However, these pumps are often not suitable for applications with high grit and rag loads. Excessive wear resulting in frequent replacement of the stator is expected in applications conveying sludge containing grit. Rags and stringy material can also "jam up" the rotor requiring upstream grinders as a minimum requirement. The addition of grinders would increase the amount of equipment requiring routine maintenance and add to the already large footprint required by this pump type and layout.

Based on the large grit and rag loads present in the sludge storage tanks and the limited space available for pump installations, CDM Smith does not recommend further consideration of progressing cavity pumps for implementation on the Project.

4.2 Rotary Lobe Pumps

Rotary lobe pumps, operate by trapping sludge between rotating lobes (rotors) and the pump casing **(Figure 4-2)**. Similar to progressing cavity pumps (although less severe), the close tolerances required between the rotors and the pump casing make them susceptible to excessive wear when conveying gritty sludges.

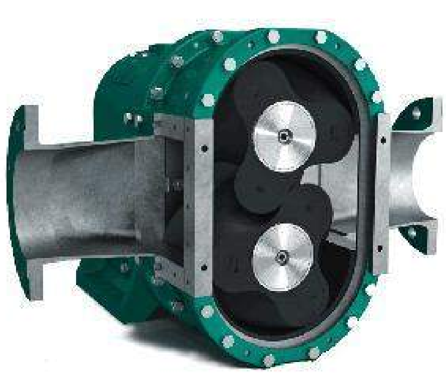

Figure 4-2: Rotary Lobe Pump Cutaway

A convenient feature of the rotary lobe pump is an automatic reversing action of the rotors that can be incorporated into the motor and drive. When a pump is jammed by a stick or other object lodged in the rotors, the rotation can be reversed to free the jam. Stringy materials in sludge may wrap around and bind the rotors; therefore, a grinder installed upstream of the pump is needed in applications with rags.

Rotary lobe pumps are used for pumping raw sewage, municipal and industrial wastewater, and various types of sludges. Manufacturers including Netzsch, Boerger, and SWABY are known for providing rotary lobe pumps for various sludge pumping applications.

4.2.1 Advantages

Advantages of rotary lobe pumps include the following:

- Relatively easy access and maintenance: Rotary lobe pumps are designed for easy access and maintenance.
- Wide flow range with minimal effect on head: These pumps can cover a large range of flow rates by adjusting the pump speed with minimal impact on the pump's pressure capabilities.
- Proven pumping technology: Rotary lobe pumps have a well-established track record and are widely used in wastewater applications.
- Good suction capacity with low NPSHr: Rotary lobe pumps demonstrate good suction capacity and require relatively low Net Positive Suction Head required for proper operation.
- High efficiencies: These pumps exhibit high efficiencies, particularly in lower-pressure applications.
- Wide variety of rotor types and materials: The availability of different rotor types and materials provides customization options, allowing users to select the most suitable rotor for specific fluid properties and application demands.

4.2.2 Disadvantages

Disadvantages of rotary lobe pumps include the following:

- Limited pressure capability: Rotary lobe pumps may have limitations in high-pressure applications.
- May not be suitable for high grit applications: The presence of grit in the fluid can lead to excessive wear on the rotors, necessitating more frequent replacements.

- No chopping/cutting of rags and fibrous materials: These pumps require grinders upstream in applications with rags and stringy material. Stringy material passing the grinders can cause operational problems at the pumps.
- Large footprint: Large footprint when compared to rotodynamic type pumps.
- High discharge pressure applications result in increased slippage which can exacerbate grit caused erosion and reduce efficiency.

4.2.3 Constraints and Specifications

General rotary lobe pump constraints and specifications include the following:

- Pump Size: up to 8"
- Flow Range: up to 6,300 gpm
- Differential Head Range: up to 270 feet
- Hydraulic Efficiency: 60% to 90%
- Drive: Direct or belt
- Seal Type: Packing or mechanical (flushed cartridge)
- Materials: Hardened steel or rubber corrosion resistive rotor

4.2.4 Considerations and Recommendation

Rotary lobe pumps have a large turndown range when VFD driven that can offer operational flexibility. However, similar to progressing cavity pumps, these pumps are often not suitable for applications with high grit and rag loads. Excessive wear resulting in frequent replacement of the rotors is expected in applications conveying sludge containing grit. Rags and stringy material can also "jam up" the rotors requiring upstream grinders as a minimum requirement. The addition of grinders would increase the amount of equipment requiring routine maintenance and add to the footprint required by this pump type and layout.

Rotary lobe pumps are currently used by the Biosolids Dryer Facility (BDF) to convey sludge from the sludge header to the centrifuges. NEFCO staff have indicated that these pumps have performed well in this application. The sludge at the BDF likely contains lower amounts of grit and rags than the sludges conveyed to C-I and C-II because of the lower percentage of TPS in the sludge blend to BDF.

Rotary lobe pumps offer some advantages that may offset their limitations and make them worth considering for this application. Operational flexibility, relatively small footprint, ease of maintenance, and successful installations in the BDF to name a few. CDM Smith recommends further considering rotary lobe pumps for implementation on the Project.

4.3 Double Disc Pumps

The double disc pump is a variant piston-style pump. It combines the functions of a diaphragm and check valve using a disc configuration which eliminates the need for separate internal ball check valves **(Figure 4-3)**. The pump operates through the reciprocating motion of connecting rods and a camshaft which move the discs in an up-and-down motion within the pump casing.

During operation, the reciprocating action forms a large cavity between the discs, where fluid is filled and exhausted in a continuous pulsation flow. The pump cycles between a suction phase and a discharge phase, with the disc movements creating a seal and controlling the flow path.

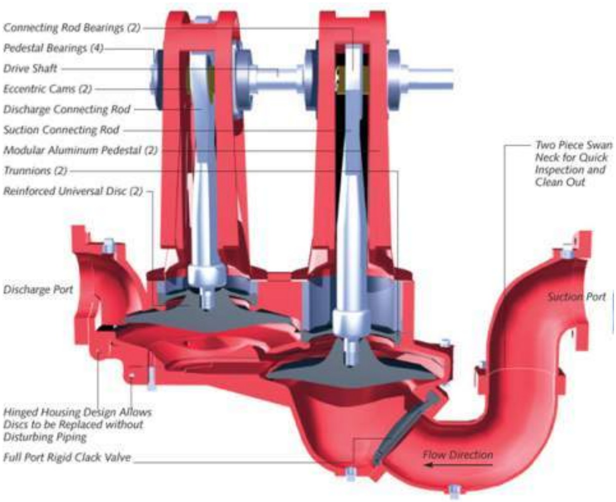

Figure 4-3: Double Disc Pump Cutaway

During the suction cycle **(Figure 4-4 left),** the suction disc (right) is lifted from its seat, creating a vacuum. The cavity between the discs is filled during the reciprocating motion of the suction disc, and a clack valve prevents return flow. Meanwhile, the discharge disc (left) is seated, creating a seal in the flow path during the suction cycle.

During the discharge cycle **(Figure 4-4 right),** the reciprocating action causes the suction disc (right) to seat and create a seal in the flow path. Simultaneously, a downward motion of the discharge disc (left) forces the fluid into the discharge pipe, completing the discharge cycle.

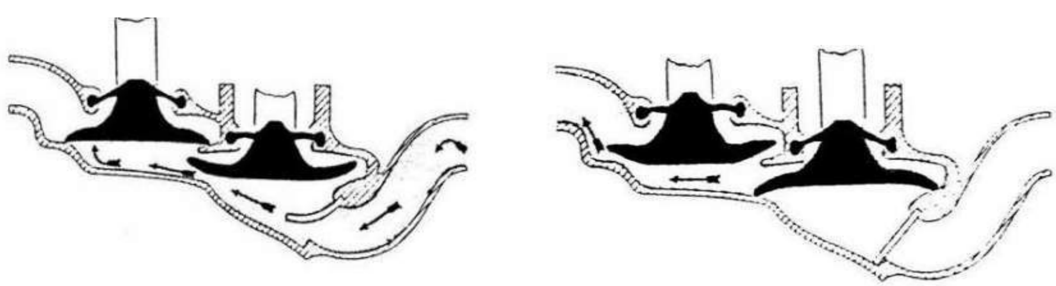

Figure 4-4: Double Disc Pump Suction (left) and Discharge (right) Cycles

Compared to other piston-style pumps, the double disc pump offers a simplified design with fewer moving parts. The flow path and internal components mainly consist of clack valves and discs, which are the only moving parts in the flow stream. Periodic maintenance is required for the rods and camshafts.

Double disc pumps are suitable for pumping various fluids and are capable of passing large rag and grit loads. Manufacturers including Penn Valley and Wastecorp offer double disc pumps for sludge pumping applications.

4.3.1 Advantages

Advantages of double disc pumps include the following:

- No grinders required: Double disc pumps can convey sludges with large rags. This however could result in issues for downstream processes and equipment.
- Passage of medium-size solids and stringy materials: The pump allows the passage of medium-sized solids (up to 2 inches) and stringy materials without clogging.
- Can operate dry without damage: The pump can operate dry without damage.
- Seal-less design: The pump features a seal-less design, minimizing the risk of leakage and reducing maintenance needs related to seals.
- Proven pumping technology: The double disc pump is a well-established and proven technology with a reliable performance track record.
- Low maintenance product: With only two maintenance elements in the flow stream, the pump requires minimal upkeep and servicing.
- Self-priming: The pump is capable of self-priming, in some operating conditions, which simplifies the startup process and improves operational efficiency.
- Less sensitivity to corrosive and abrasive fluids: The relatively slower moving parts and limited wetted moving components make the pump less sensitive to corrosive and abrasive fluids, increasing its durability.

4.3.2 Disadvantages

Disadvantages of double disc pumps include the following:

- Maintenance access: The pump's maintenance access is from the bottom can be difficult in tight installations.
- Relatively large footprint: The double disc pump occupies a larger footprint compared to some other pump types.

- Limited flow and head capacities: The pump has limitations in terms of flow and head capacities.
- Proprietary pump option with limited manufacturers: The availability of the double disc pump may be limited to specific manufacturers with proprietary designs.
- Pulsation of pump flow: The pulsation of the pump flow may have adverse effects on downstream demand points, although dampener columns can help reduce pulsation considerably.

4.3.3 Constraints and Specifications

General double disc pump constraints and specifications include the following:

- Pump Size: 2” to 8”
- Flow Range: up to 1,100 gpm
- Differential Head Range: up to 140 feet
- Hydraulic Efficiency: 50% to 70%
- Drive: Belt
- Seal Type: Seal-less

4.3.4 Considerations and Recommendation

Double disc pumps offer many advantages for certain pumping applications which include seal-less design, self-priming capability, and the ability to pass fluids with rags and grit. However, limited flow and pressure capacities (below what is required for the Project) and their large footprint are major disadvantages for this application. Grinders would also likely still be required upstream of the pumps to mitigate conveying large rag loads to the downstream processes and equipment.

CDM Smith does not recommend further consideration of double disc pumps for implementation on the Project.

4.4 Piston/Plunger Pumps

Piston/plunger pumps operate through the back-and-forth movement of a piston within a chamber, which creates both vacuum and pressure **(Figure 4-5)**. The pump's seal, which is disc-shaped, is driven by the piston, and fluid is forced through the hollow cylinder known as the cylinder bore.

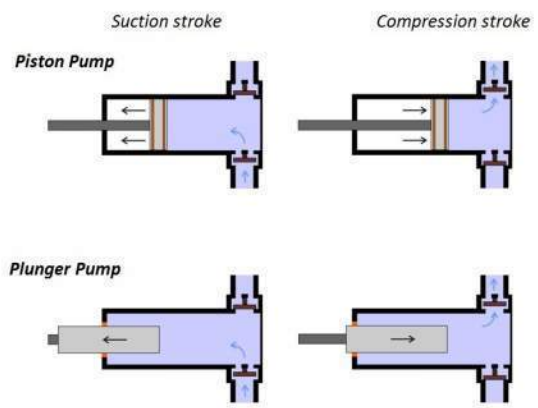

Figure 4-5: Piston/Plunger Pump Cycles

Piston pumps can come with a single or multiple pistons, which are timed to operate at different intervals to ensure a consistent flow. These pumps are commonly referred to as 3, 5, or 7 frame pumps, depending on the number of pistons within the pump head.

Piston/plunger pumps are used in various applications including high-pressure water, sewage, and sludge pumping. Manufacturers of piston/plunger pumps include Schwing, Ram, and Wastecorp.

4.4.1 Advantages

Advantages of piston/plunger pumps include the following:

- High pressure capabilities: Piston/plunger pumps can handle high-pressure applications efficiently.
- High efficiency: These pumps exhibit high efficiency in transferring fluids, contributing to energy savings and cost-effectiveness.
- No seal water required: Piston pumps do not require seal water, simplifying the system and reducing water consumption.
- Capable of pumping high percent solids sludges.
- High suction capacity with low NPSHr: The pump's design allows for high suction capacity with relatively low Net Positive Suction Head required, minimizing the risk of cavitation even without a flooded suction.

4.4.2 Disadvantages

Disadvantages of piston/plunger pumps include the following:

- Requires significant amounts of grease: Piston pumps require the use of grease, which can be messy and require proper handling and disposal.
- Pulsation dampener may be necessary: In some cases, a pulsation dampener is needed to mitigate pulsation in the flow.
- High Capital costs: Piston pumps can be costly, making them an expensive option for liquid transfer.
- Expensive parts and maintenance: Due to their high precision and compact design, piston pump parts can be costly, and maintenance may require experienced personnel.
- Additional accessories may be required: Additional components such as pressure regulating valves, relief valves, and pulsation dampeners may be necessary, adding complexity to pump setup.
- Large footprint: Installed piston pump units can occupy significant space, which can be a consideration in some applications.
- High discharge pressures could result in downstream equipment/piping failures if overpressure devices are not provided.
- No chopping/cutting of rags and fibrous materials: These pumps require grinders upstream in applications with rags and stringy material. Stringy material passing the grinders can cause operational problems at the pumps.

4.4.3 Constraints and Specifications

General piston/plunger pump constraints and specifications include the following:

- Pump Size: up to 6”
- Flow Range: up to 1,000 gpm
- Differential Head Range: up to 4,600 feet
- Hydraulic Efficiency: 80% to 90%

4.4.4 Considerations and Recommendation

Piston/plunger pumps are well suited for pumping wastewater sludges with high percent solids concentrations and high discharge pressure requirements. However, these pumps require a large footprint, provide relative low flows comparable to their required footprint, and have operational issues associated with sludges containing rags. These limitations are critical for the Project.

CDM Smith does not recommend further consideration of piston/plunger pumps for implementation on the Project.

5.0 Conclusion and Recommendation

Numerous pumping technologies were considered for implementation on the Project. Limited footprint, high percent solids sludge with a wide range of variability, and the presence of grit and rags make this a challenging pumping application. These challenges eliminate many of the pumping technologies discussed in the previous sections. CDM Smith recommends shortlisting chopper pumps and rotary lobe pumps for further consideration. Chopper pumps are currently utilized for this application at the WRRF and have proven successful. The chopping feature of these pumps eliminates the need for an upstream grinder and reduces the overall equipment footprint requirements (a major advantage for this Project). Rotary lobe pumps offer the most benefits of the positive displacement pumps considered for this application including operational flexibility, smallest footprint, ease of maintenance, and successful implementation at the BDF.

TM-5B Pumping Systems Evaluation will further analyze these two pumping technologies and provide a final recommendation for implementation on the Project. This additional analysis will consider pump sizing, layout, required building modifications, and operational flexibility.

cc: File

Technical Memorandum 5B

To: *Jared Buzo, METCO*
Sham Sihabdeen, AECOM
Chris Wilson, GLWA

From: *Steve Wyman, CDM Smith*
Mohsen Sadatiyan, CDM Smith

Date: *November 10, 2023*

Subject: *Great Lakes Water Authority (GLWA)*
Contract No. 2202790 – Water Resource Recovery Facility (WRRF) Improvements to the Sludge Feed System for Solids Processing
TM-5B Pumping Systems Evaluation

1.0 Purpose and Background

Great Lakes Water Authority (GLWA) owns and operates the Water Resource Recovery Facility (WRRF) located at 9300 W. Jefferson, Detroit, MI 48209. WRRF is a conventional activated sludge plant with a wet weather design capacity of 1,444 million gallons per day (MGD) and serves approximately one-third of the State of Michigan's population. This facility is one of the largest wastewater treatment plants in the world, with the capacity to treat up to 1,700 MGD through primary treatment and 930 MGD through secondary treatment.

Many of the components of the facility are 80 years old. In service for about 50 years, the majority of the process units were built and expanded in the 1970s. Influent pumping and a large portion of preliminary and primary treatment facilities went online in 1940, sludge incineration went online in the 1950s and 1970s, and secondary treatment was started in the 1970s with the advent of the Clean Water Act. The facility was expanded in the 1990s with the construction of Pump Station No. 2 and associated preliminary treatment and was then optimized for wet weather flow in the early 2000s. The Biosolids Drying Facility went online in 2016, allowing the decommissioning of the Complex I incinerators. Disinfection of primary effluent was implemented in 2019.

WRRF generates solids through primary and secondary clarification. Solids handling processes include gravity thickening, blending, storage, dewatering, incineration, and drying treatment processes. Thickened primary sludge (TPS) and thickened waste activated sludge (TWAS) are blended prior to being discharged into six sludge storage tanks (SSTs). The sludge feed system, comprised of sludge feed pumps (SFPs), sludge piping, and flow control equipment, supplies thickened blended sludges from the SSTs to sludge dewatering equipment at three different dewatering facilities. These dewatering facilities include belt filter presses (BFPs) located in Sludge

Dewatering Complex I (C-I); BFPs in Sludge Dewatering Complex II (C-II); and centrifuges (CFGs) in the Biosolids Drying Facility (BDF). Under normal operating conditions, BDF CFGs process 60 to 70 percent of WRRF's solids. BFPs in C-I and C-II are used to dewater the balance of sludge not processed by the BDF or when the BDF equipment is offline for maintenance. C-II is also equipped with CFGs which were discontinued by GLWA prior to 2018 in favor of utilizing the C-I and C-II BFPs to supplement dewatering at the BDF. Dewatered sludge from C-I and C-II is incinerated onsite and dried sludge from BDF is land-applied offsite.

The service life of many of the existing SFPs has been exceeded, and all SFP equipment and piping are oversized for the feed rates required at the dewatering facilities. Additionally, sludge feed piping "dead ends" at each of the dewatering facilities result in sludge feed header pressures that are difficult to maintain within the operating range required for the sludge flow control equipment at each piece of dewatering equipment. The end result of the aged pumping equipment, oversized sludge feed components, dewatering facility locations, and piping configurations is a sludge feed system that is difficult to operate and maintain.

The primary focus of this project, WRRF Improvements to the Sludge Feed System for Solids Processing (the Project), involves making improvements to the dewatering sludge feed pumping systems. This project also includes improving drainage of SSTs 1-4, and mitigating flooding of the Sludge Processing Complex A basement. The scope includes conducting discipline-specific condition assessments and evaluations in order to recommend cost-effective upgrades and improvements to achieve robust, sustainable, and long-term upgrades while reducing maintenance efforts, improving operational flexibility, and maintaining treatment operations at all times. This assessment and evaluation work will be documented in technical memoranda (TMs). This document is Technical Memorandum 5B (TM-5B and covers the pumping systems evaluation performed for the Project.

The purpose of TM-5B is to provide a description of the pumping system alternatives considered, present advantages and disadvantages of each, and provide CDM Smith's recommendation.

2.0 Existing Configuration

During normal operating conditions each SST has a dedicated SFP with the same number (i.e., SFP-1 serves SST-1). SFPs 3/4 and SFPs 5/6 are provided with piping and valves to allow either pump in the pair to pump from the other's dedicated SST. These interconnections are rarely utilized. SSTs 1/2 and their associated SFPs 1/2 feed sludge to the C-II BFPs. SSTs 3/4 and their associated SFPs 3/4 feed sludge to the CFGs at the BDF. SSTs 5/6 and their associated SFPs 5/6 feed sludge to the C-I BFPs. The current configuration of the sludge feed system is shown in **Figure 2-1**.

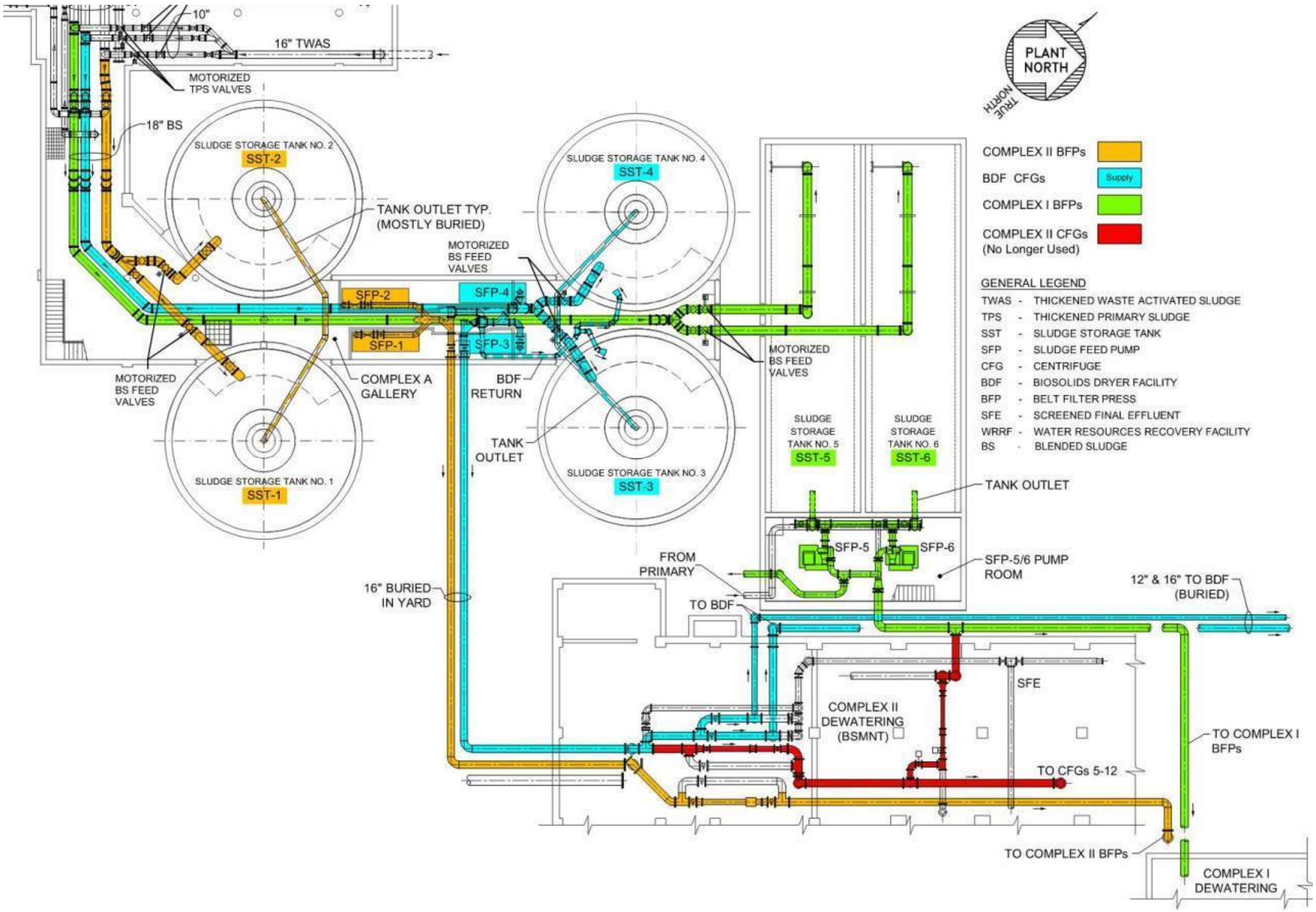

Figure 2-1: Sludge Feed System Existing Configuration

The existing pumping configuration relies on two large SFPs dedicated to each dewatering facility (1 duty, 1 standby). These SFPs are oversized so that they can cover the maximum flow operating scenarios required at each facility although these maximum flows are rarely needed at present. Additionally, the sludge feed piping "dead ends" at each of the dewatering facilities resulting in sludge feed header pressures that are difficult to maintain within the operating ranges required. The end result of the oversized sludge feed components and "dead end" sludge header piping configurations is a sludge feed system that is difficult to operate and maintain.

3.0 Alternative Development

GLWA developed and included two conceptual level alternatives in the request for proposal (RFP) for the Project. These alternatives are referred to as Alternative 1 (Alt-1) and Alternative 2 (Alt-2) in this TM-5B. Two additional conceptual level alternatives were included in the CDM Smith proposal which are referred to as Alternative 3 (Alt-3) and Alternative 4 (Alt-4). Each alternative was investigated and either eliminated or expanded on depending on the advantages and disadvantages found during the investigations.

3.1 Design Criteria

Technical Memorandum 4 (TM-4) Dewatering Systems Sludge Demands developed the sludge demands and design criteria for each of the dewatering facilities (BDF, C-I, and C-II). These criteria were selected to meet the operational needs of the WRRF and ensure compliance with National Pollutant Discharge Elimination System (NPDES) permit requirements. **Table 3-1** provides a summary of the design criteria for normal operation and BDF outage scenarios which were used in development of the sludge pumping system alternatives.

Table 3-1: Design Criteria for Normal Operation and BDF Outage Scenarios

Operation Scenarios	Parameter	BDF (Min/Avg/Max)	C-I (Min/Avg/Max)	C-II (Min/Avg/Max)
Normal	Feed Sludge Total Solids (%)	2.5/4.0/6.0	3.0/5.2/8.3	3.0/5.2/8.3
	Feed Sludge Flow (gpm)	350/1,200/2,400	200/450/750	200/450/750
	Feed Sludge Solids Loading (dtpd)	105/260/420	28/120/250	28/120/250
	Feed Sludge Header Pressure (psi)	5/10/25	25/30/40	15/20/30
BDF Outage	Feed Sludge Total Solids (%)	-	3.0/4.3/8.3	3.0/4.3/8.3
	Feed Sludge Flow (gpm)	-	200/450/1,500	200/450/1,800
	Feed Sludge Solids Loading (dtpd)	-	28/120/390	28/120/470
	Feed Sludge Header Pressure (psi)	-	25/32/40	15/22/30

3.2 Alternative Goals

Each alternative was developed considering the project goals outlined in the RFP and discussed during project meetings and workshops. High level project goals and constraints include:

- Retain all six sludge storage tanks.
- Right size and provide multiple pumps.
- Provide operational flexibility.
- Locate all pumps in the vicinity of the sludge storage tanks (i.e., at SSTs 1-4 Pipe Gallery and SST 5/6 Pump Building).
- Provide return lines for the pressurized sludge headers back to the sludge storage tanks.

3.3 Sludge Hydraulic Modeling and Preliminary Pump Sizing

CDM Smith developed an AFT Fathom hydraulic model of the sludge pumping systems at the WRRF. The model was developed to simulate the existing hydraulic systems between the SSTs and the sludge feed headers at each dewatering facility. Record drawings and site investigations were used to configure the model based on pipe sizes and routings. The model was calibrated using rheology data received from sludge sampling and testing. Additional calibration was performed based on data observed during onsite pumping system field testing conducted for each of the dewatering facilities.

The calibrated model was used to simulate the sludge pumping hydraulics for each alternative being evaluated. The model was updated to include alternative features such as new pump configurations, suction and discharge pipe arrangements, new interconnections, modified sludge headers, and the addition of sludge return loops. Return sludge flows of 250 gpm to 1,000 gpm were considered from the dewatering facilities back to the SSTs to minimize solids settling in the sludge return lines. The pressures required at the SFP discharges as determined by the sludge model were used in tandem with the required flows to each dewatering facility for preliminary pump sizing and selections.

4.0 Alternative Evaluation and Shortlisting

4.1 Alternative 1 – SSTs 1-4 Pipe Gallery Expansion

4.1.1 Concept Description

Alt-1 considers expanding the SSTs 1-4 Pipe Gallery to the east to accommodate six chopper pumps. Three pumps located on the south side of the gallery would convey sludge from SSTs 1/2 to the C-II BFPs. Three pumps located on the north side of the gallery would convey sludge from SSTs 3/4 to the BDF CFGs. Two or three rotary lobe pumps would be located in the basement of the SSTs 5/6 Pump Building and convey sludge from SSTs 5/6 to the C-I BFPs. The normal operation pumping configuration for this alternative is shown in **Figure 4-1**.

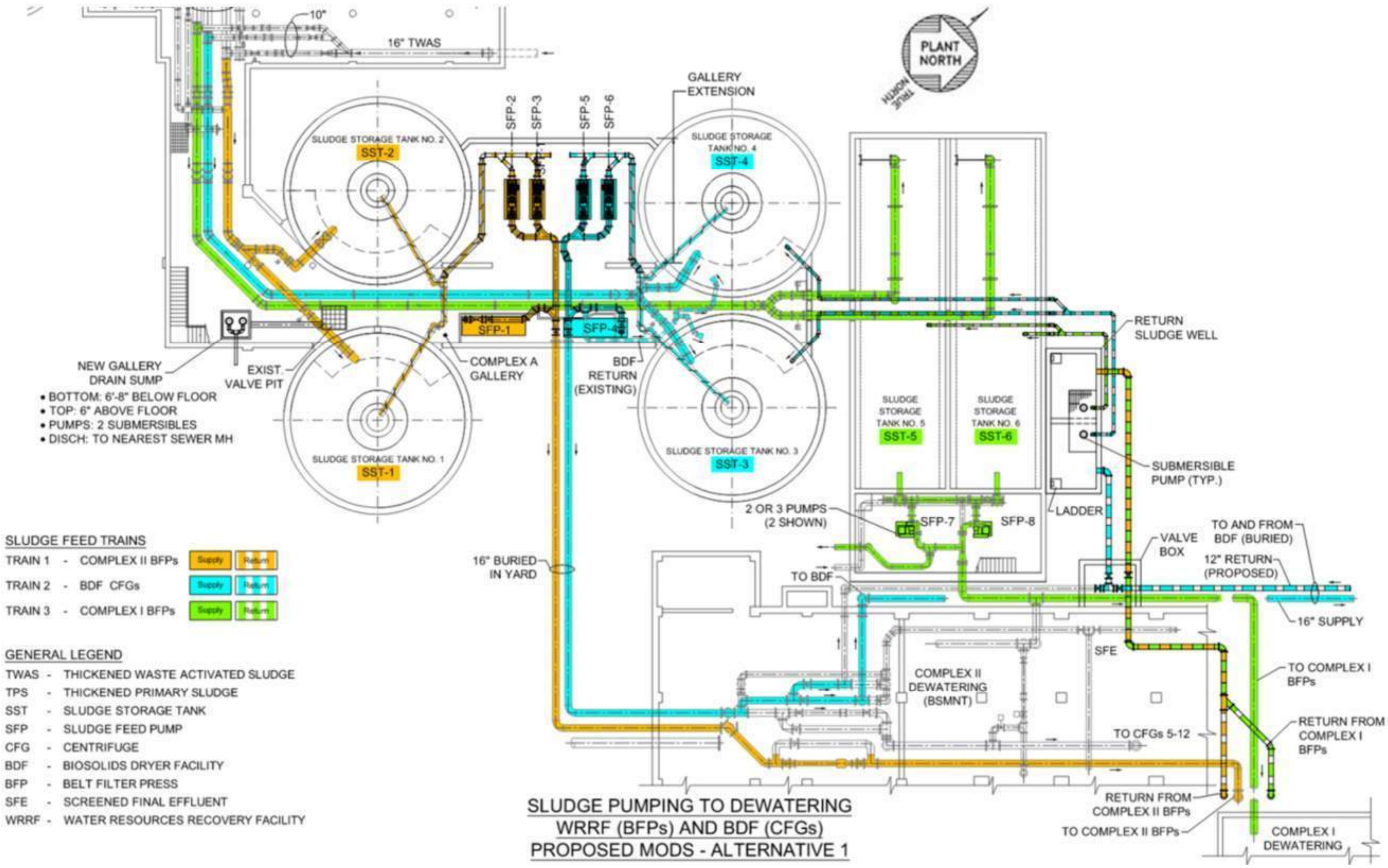

Figure 4-1: Alt-1 as Presented in Project RFP

Return sludge lines would be provided to eliminate the sludge header "dead ends" and provide a full sludge loop. Excess sludge from the end of each sludge feed header would be returned to its associated SST via the SFP line pressure or submersible pumps located in a return sludge well. The return sludge lines are discussed and evaluated in Section 5 of this TM-5B.

4.1.2 Process Mechanical - Preliminary Pump Sizing and Selections

Alt-1 includes three chopper type BDF sludge feed pumps (2 duty, 1 standby) located in the SSTs 1-4 Pipe Gallery. Pump sizing is based on the two duty pumps being capable of conveying the required 2,400 gpm feed sludge flow to the BDF during maximum operating conditions. To accomplish this, each feed pump (SFPs 1-3) would be sized for up to 1,500 gpm to meet the total flow requirement (with 2 pumps in service) with 600 gpm of return excess sludge. Based on this sizing, the operating flow range of each SFP to cover the BDF demands flow range would be 900 to 1,500 gpm. **Figure 4-2** shows this expected operating range overlayed on the preliminary pump selection pump curve (Vaughan HE4S6). This three-blade impeller pump has 6-inch suction and 4-inch discharge connections. Curve lines A to H in this graph show pump curves at 1,900 revolution per minutes (rpm) (100%) speed to 1,325 rpm (70%) speed.

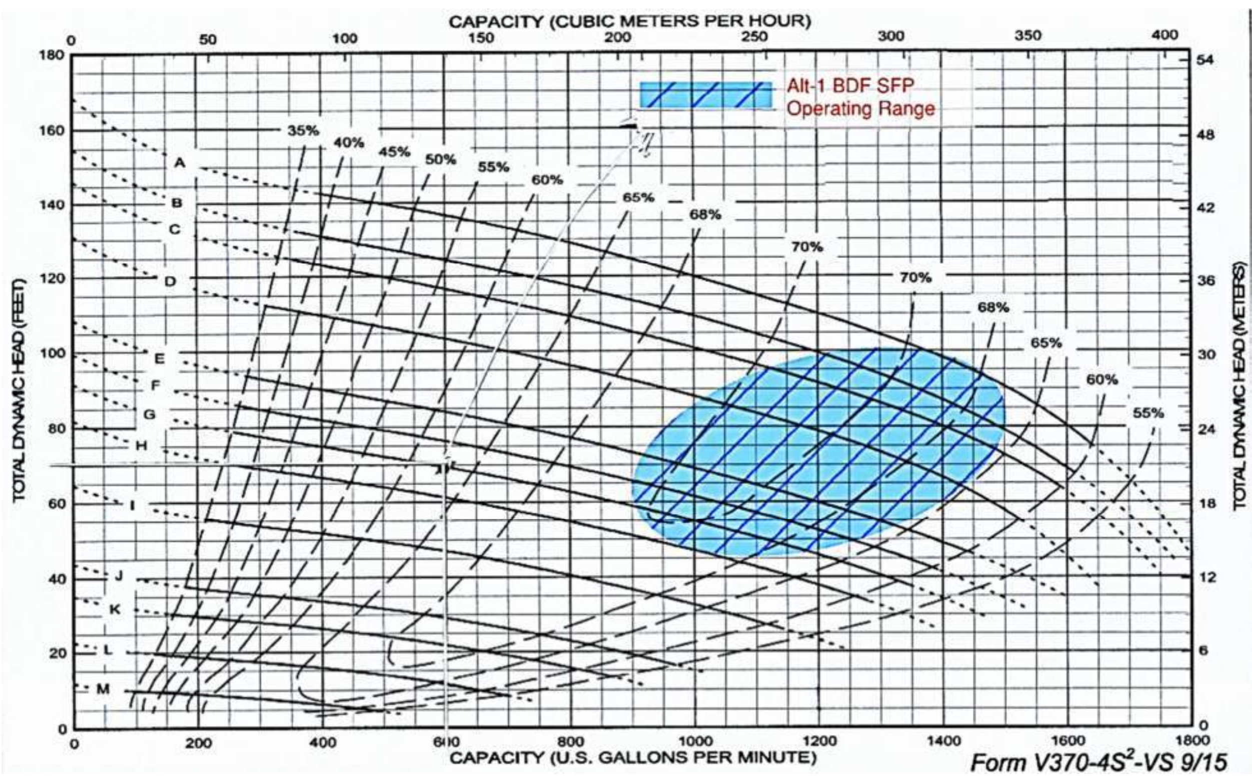

Figure 4-2: Alt-1 BDF SFPs Operating Range Overlayed on Vaughan Chopper HE4S6 Pump Curve

Alt-1 also includes three chopper type C-II sludge feed pumps (2 duty, 1 standby) located in the SSTs 1-4 Pipe Gallery. Pump sizing is based on the two duty pumps being capable of conveying the required 1,800 gpm feed sludge flow to C-II during maximum operating conditions. To accomplish this, each feed pump (SFPs 4-6) would be sized for up to 1,300 gpm to meet the total flow requirement (with 2 pumps in service) with 200 gpm of return excess sludge. Based on this sizing, the operating flow range of each SFP to cover the C-II demands would be from 800 to 1,300 gpm. **Figure 4-3** shows this expected operating range overlayed on the preliminary pump selection pump curve (Vaughan HE4V). This four-blade impeller pump has 8-inch suction and 4-inch discharge connections. Curve lines C to E in this graph show pump curves at 1,550 revolution per minutes (rpm) (87%) speed to 1,300 rpm (73%) speed.

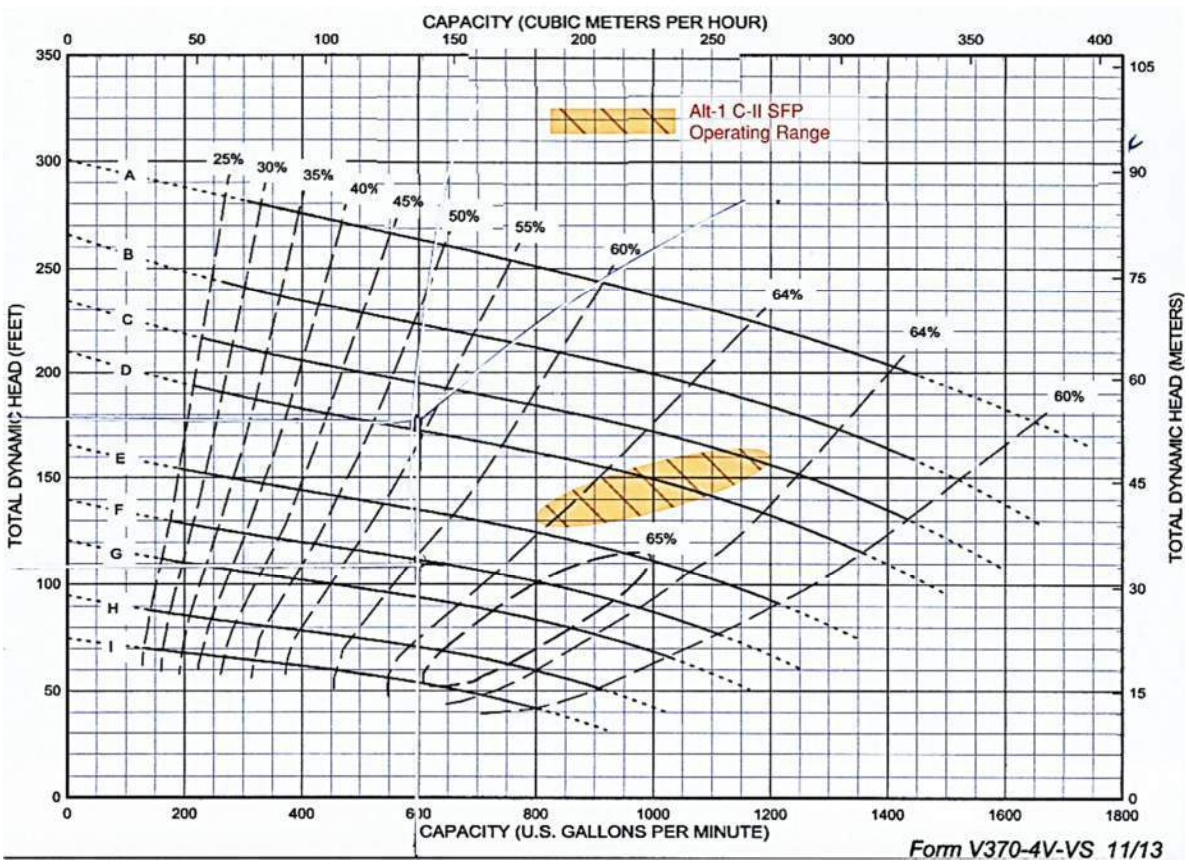

Figure 4-3: Alt-1 C-II SFPs Operating Range Overlayed on Vaughan Chopper HE4V Pump Curve

Lastly, Alt-1 includes three rotary lobe type C-I sludge feed pumps (2 duty, 1 standby) located in the SSTs 5/6 Pump Building. Pump sizing is based on the two duty pumps being capable of conveying the required 1,500 gpm feed sludge flow to C-I during maximum operating conditions. To accomplish this, each C-I SFP would be sized for 875 gpm to meet the total flow requirement (with 2 pumps in service) with 250 gpm of return excess sludge. Based on this sizing, the operating flow range of each SFP to cover the C-I demands would be from 700 to 900 gpm. **Figure 4-4** shows this expected operating range overlayed on the preliminary pump selection pump curve (Boerger XL1760). As shown, this flow range is achievable by operating the pumps at a speed range of 180 to 240 rpm.

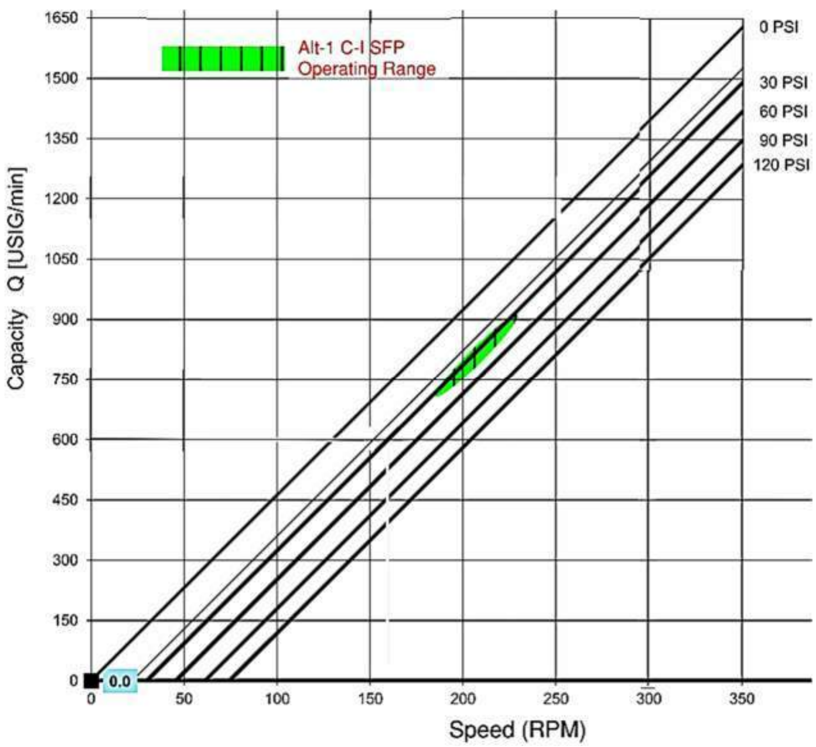

Figure 4-4: Alt-1 C-I SFPs Operating Range Overlayed on Boerger Rotary Lobe Pump XL1760 Pump Curve

4.1.3 Process Mechanical – SSTs 1-4 Pipe Gallery Equipment Layout

The Alt-1 conceptual equipment layout in **Figure 4-1** for the SSTs 1-4 Pipe Gallery was evaluated to determine its constructability and whether any enhancements are warranted. The conceptual layout shows interconnection suction piping between SSTs 1/2 and their associated SFPs and interconnection suction piping between SSTs 3/4 and their associated SFPs. These interconnections are needed to provide operational flexibility so that each set of pumps can draw suction from either of their associated SSTs. This piping would be routed below the floor slab in a pipe chase in locations that would otherwise impede plant staff access. Required structural modifications, potential interferences with drainage piping, and SFP suction conditions are considerations being factored into the evaluation of this alternative. Providing suction conditions per the requirements of the ANSI-HI 9.6.6 standard for rotodynamic pumps is desired for proper pump operation and longevity. However, due to the existing routing of the suction pipes and the limited building footprint available, complying with all piping requirements of ANSI-HI 9.6.6 may not be practical. Accordingly, some recommendations provided in Appendixes E and G of this standard would be considered to improve suction hydraulics in an effort to achieve the greatest extent of compliance possible given the existing condition constraints.

Expanding the SSTs 1-4 Pipe Gallery to the west to accommodate the proposed equipment layout poses considerable construction challenges and risks. **Figure 4-5** displays that there are major underground piping and utilities in the area where expansion would be required.

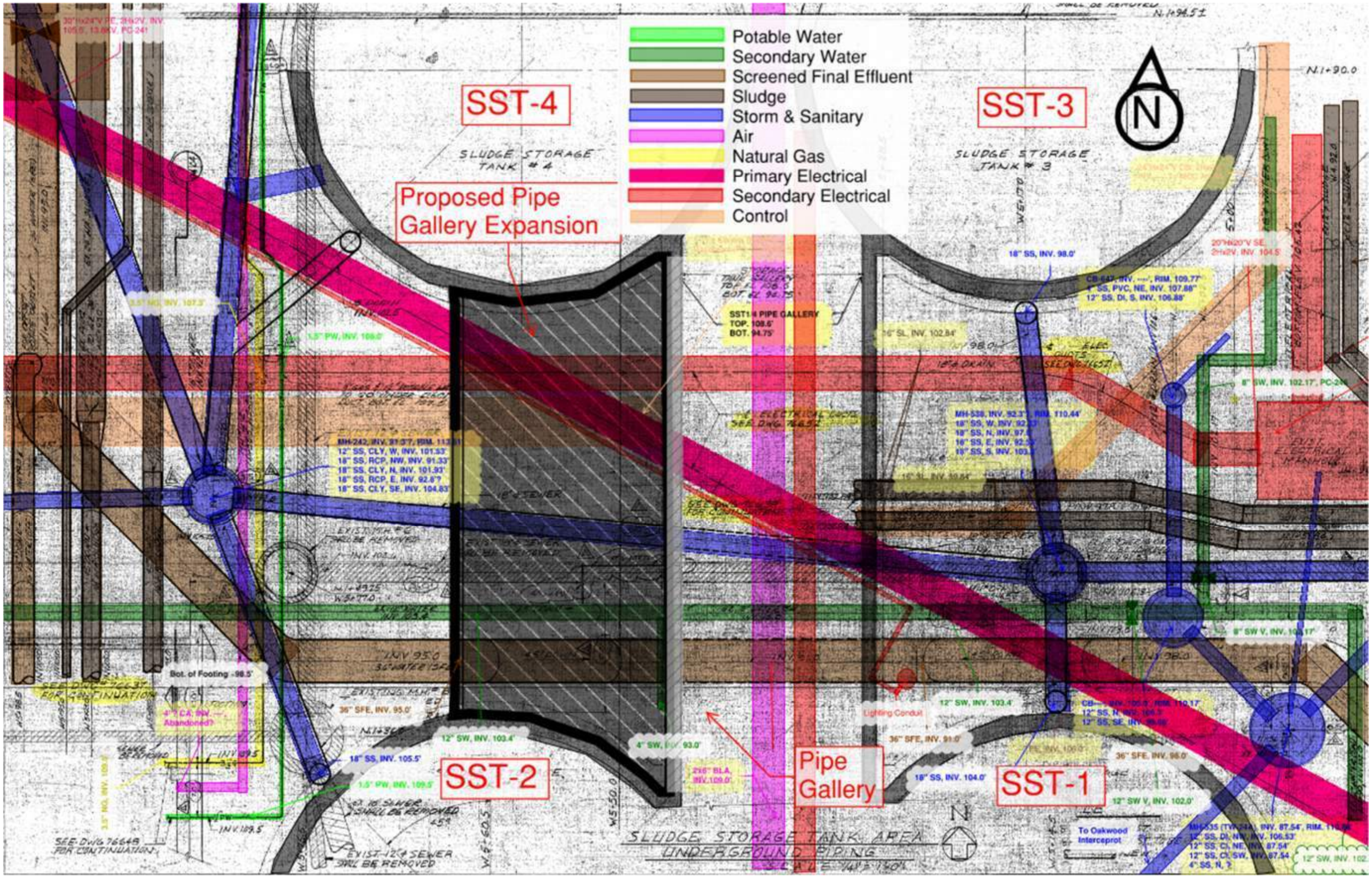

Figure 4-5: Major Underground Piping and Utilities Near SSTs 1-4 Pipe Gallery

Conflicts include the 36-inch screened final effluent (SFE) loop, 12-inch low-pressure secondary water (LPSW) pipe, primary electrical (up to 24 kV) duct bank, and secondary electrical (<600 V) duct bank. Rerouting the 36-inch SFE line and 12-inch LPSW would have a considerable impact on the maintenance of plant operations (MOPO). These lines feed critical demand points in Sludge Processing Complex A and Incineration Complex II. The 36-inch SFE line is 50 plus years old and is constructed of prestressed concrete cylinder pipe (PCCP). Excavating near and rerouting this pipe would add to the construction risk and cost associated with this expansion. The primary and secondary electrical duct banks are embedded in the SSTs 1-4 Pipe Gallery roof. Rerouting these conduits would require temporary shutdowns impacting numerous facilities within the project area. Other interferences such as deep sanitary and storm manholes used for adjacent process areas pose additional challenges.

4.1.4 Process Mechanical – SSTs 5/6 Pump Building Equipment Layout

The Alt-1 conceptual equipment layout in **Figure 4-1** for the SSTs 5/6 Pump Building was evaluated to determine its constructability and whether any enhancements are warranted.

Three rotary lobe pumps would be required (2 duty, 1 standby) to meet the C-I sludge feed maximum demands while operating the pumps at an acceptable speed. As discussed in TM-5A Pumping Technology Evaluation and Shortlisting, grinders would be provided upstream of each pump to minimize pump and downstream equipment maintenance associated with rags in the feed sludge. **Figure 4-6** displays the preliminary equipment layout for the SSTs 5/6 Pump Building. As shown in the layout, modifications to the existing concrete building column in the basement would be required. Providing access around the pumps for regular maintenance and disassembly was considered in the development of the layout. Maintenance access is critical for replacement of rotary lobe pump lobes, seals, and wear plates.

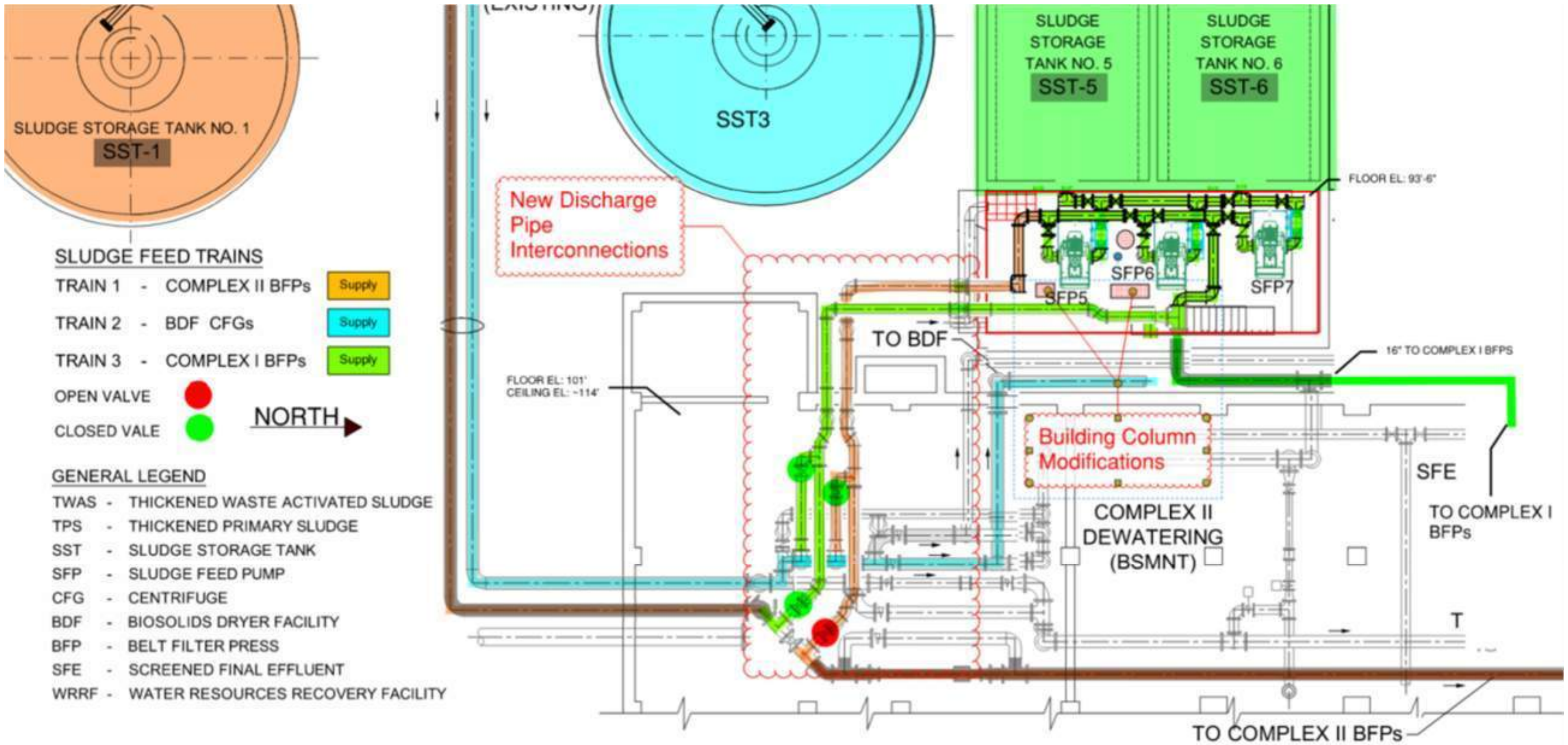

Figure 4-6: Alt-1 SSTs 5/6 Pump Building Layout

4.1.5 Structural Modifications and Considerations

There are multiple structural concerns and coordination items to consider regarding the excavation of the proposed SSTs 1-4 Pipe Gallery expansion in this alternative. It is unlikely sheet piles could be installed due to the congested arrangement of underground piping in the area. Excavation would likely need to be completed with an open-cut excavation, which may result in issues with exposure of the area around the sanitary piping, specifically MH-242 and the 12-inch sanitary lines to the west of the proposed expansion. Additional concerns with keeping electrical ducts operational during excavation would need to be addressed. This wwould require the contractor to locate the ducts prior to excavation and develop a plan to support the ducts during and after excavation.

It's noted that the top of the pipe gallery base slab is at same elevation as the sludge storage tank foundations, (EL. 96.00 ft). This raises concerns with the excavation required down below the base slab to complete the 36-inch SFE pipe rerouted connections, which has approximately 1.5 ft clear distance between the tank foundation and south face of the pipe. Earth retention systems may be required on tank foundations at a localized location during the pipe rerouting and construction.

If the west wall of the existing pipe gallery is to be demolished for the proposed expansion, a new support system would be required at the west end of the existing concrete top slab. It should be noted that the existing top slab was designed to span east-west, the slab has #8@6-inch bottom bars in the east-west direction and #5@12-inch bottom bars in the north-south direction. The slab would not be able to span the proposed new width of gallery (approximately 32 ft). The following are support options for demolishing either a portion or the entire existing west pipe gallery wall:

- Support Option 1: Demolish a center section of the west wall to allow for pumps to be moved into the expansion area and add a new beam to span over the length of the demoed west wall to support the top slab above the opening. Consideration must be made to the height of the pumps and the clear weight of the opening. A preliminary structural analysis sized the beam at a W16 (16-inch depth).

- Support Option 2: Demolish the entire west wall and add a new center beam spanning north-south at the center of the expanded pipe gallery with three columns spaced at approximately 20 ft.

The SSTs 5/6 Pump Building equipment layout results in an interference with the concrete column located in the basement. To accommodate the layout, approximately 2' of the column needs to be removed from the north side. Removing this section of column requires installation of two new 2' x 1' columns (one located just south of the existing column, one located close to the midspan between the existing column and the exterior wall). Installation of the new columns would need to be completed prior to removal of the existing column section. The midspan column is required due to the concrete confinement being lost as a result of the shear ties being cut.

4.1.6 Electrical and Instrumentation Modifications and Considerations

The six SFPs proposed for installation in the SSTs 1-4 Pipe Gallery would be provided with new power feeders and controllers to replace the existing. The existing SFP feeders are located in MCC-A3 and MCC-A4 in the Electrical Room and the existing VFDs are located in the basement of Sludge Processing Complex A below the Electrical Room. The existing sections for SFP-1 and SFP-3 in MCC-A3 would be demolished and replaced with circuit breaker feeders for three new pumps. The existing sections for SFP-2 and SFP-4 in MCC-A4 would be demolished as shown in **Figure 4-7** and would be replaced with circuit breakers for the three remaining new pumps as shown in **Figure 4-8**. New VFD control panels would be provided for each of the new pumps in the basement of Sludge Processing Complex A below the Electrical Room.

Figure 4-7: MCC-A4 Vertical Section Demolition

Figure 4-8: MCC-A4 Vertical Section Additions

For the SSTs 5/6 Pump Building, the four proposed new pumps' power feeders and controls would replace the existing feeders for SFP-5 and SFP-6 and use the existing spare Size NEMA 1 motor starters in MCC-A5 and MCC-A6 located in the upper level of the building. The existing MCC circuit breaker feeders for each SFP would be refurbished as needed to provide necessary improvements for proper operation of the new pumps and their upstream grinders. New VFD control panels would be provided for each of the new rotary lobe pumps in the upper level of the building.

4.1.7 MOPO and Construction Phasing Considerations

The sludge feed system (SSTs and SFPs) is a critical WRRF solids handling process. All solids received by the plant are eventually conveyed by the sludge feed system for processing at one of the three dewatering facilities (BDF, C-I, or C-II). The WRRF must continually process solids during construction to comply with its NPDES permit requirements (500 dtpd average, 850 dtpd peak). Therefore, a complete unit process outage during construction is not acceptable. Considerations for staging the proposed Alt-1 improvements were evaluated and include the following:

- Phase 1 - SSTs 5/6 and SSTs 5/6 Pump Building Outage
  - SSTs 5/6 and SSTs 5/6 Pump Building are taken out of service while all associated improvements to their associated pumping systems are completed. Existing C-I SFPs out of service during this time.

  - SSTs 1-4 and existing SFPs 1-4 remain in service during this phase conveying sludge to the BDF and C-II. The existing SFP pumping capacity could feed adequate sludge for the BDF to process up to 420 dtpd and for C-II to process up to 430 dtpd (11 BFPs) to meet the peak NPDES permit requirements.

- Phase 2 – C-II SFP Outage
  - Upon completion of the SSTs 5/6 Pump Building improvements, SSTs 1/2 and SFPs 1/2 will be taken out of service. The SSTs 1-4 Pipe Gallery expansion and new C-II SFP improvements can then be constructed.
  - SSTs 3/4 and existing SFPs 3/4 remain in service during this phase conveying sludge to the BDF (up to 420 dtpd). The new SSTs 5/6 Pump Building SFPs can be used to convey sludge to the C-I BFPs (10) to process up 390 dtpd. This results in 810 dtpd of peak capacity during Phase 2 which is below the NPDES permit peak requirement. This 40 dtpd deficiency can be overcome by obtaining a construction exemption from MI-EGLE or by renting standby portable dewatering units for added capacity if needed.

- Phase 3 – Final SFP Improvements
  - Upon completion of the SSTs 1-4 Pipe Gallery expansion and new C-II SFP improvements, the final three pumps on the north half of the gallery can be installed. The two pumps located in the gallery expansion can be installed and made ready for startup. Existing SFPs 3/4 can then be removed from service as the new pumps are tied in and put online. Existing SFP-3 will be the last pump to be removed from service and replaced.

4.1.8 Shortlist Recommendation

The Alt -1 concept accomplishes most of the project goals but has limitations on the flexibility provided to plant operations staff. This alternative requires the expansion of the SSTs 1-4 Pipe Gallery. Expanding this structure can be done, but critical piping and utilities located in close proximity would result in significant risks and costs being added to the Project. CDM Smith does not recommend further consideration of this alternative for implementation on the Project.

4.2 Alternative 2A – 4 Rotary Lobe Pumps in SSTs 5/6 Pump Building

4.2.1 Concept Description

Alt-2A considers providing four rotodynamic chopper pumps in the SSTs 1-4 Pipe Gallery dedicated to conveying sludge from SSTs 1-4 (typically SSTs 3/4) to the BDF CFGs under normal operating conditions. These pumps would also serve as backup to convey sludge from SSTs 1/2 to the C-II BFPs if needed during a BDF outage. Four rotary lobe pumps would be located in the basement of the SST 5/6 Pump Building and convey sludge from SSTs 5/6 to the C-I and C-II BFPs. The normal operation pumping configuration for this alternative is shown in **Figure 4-9**.

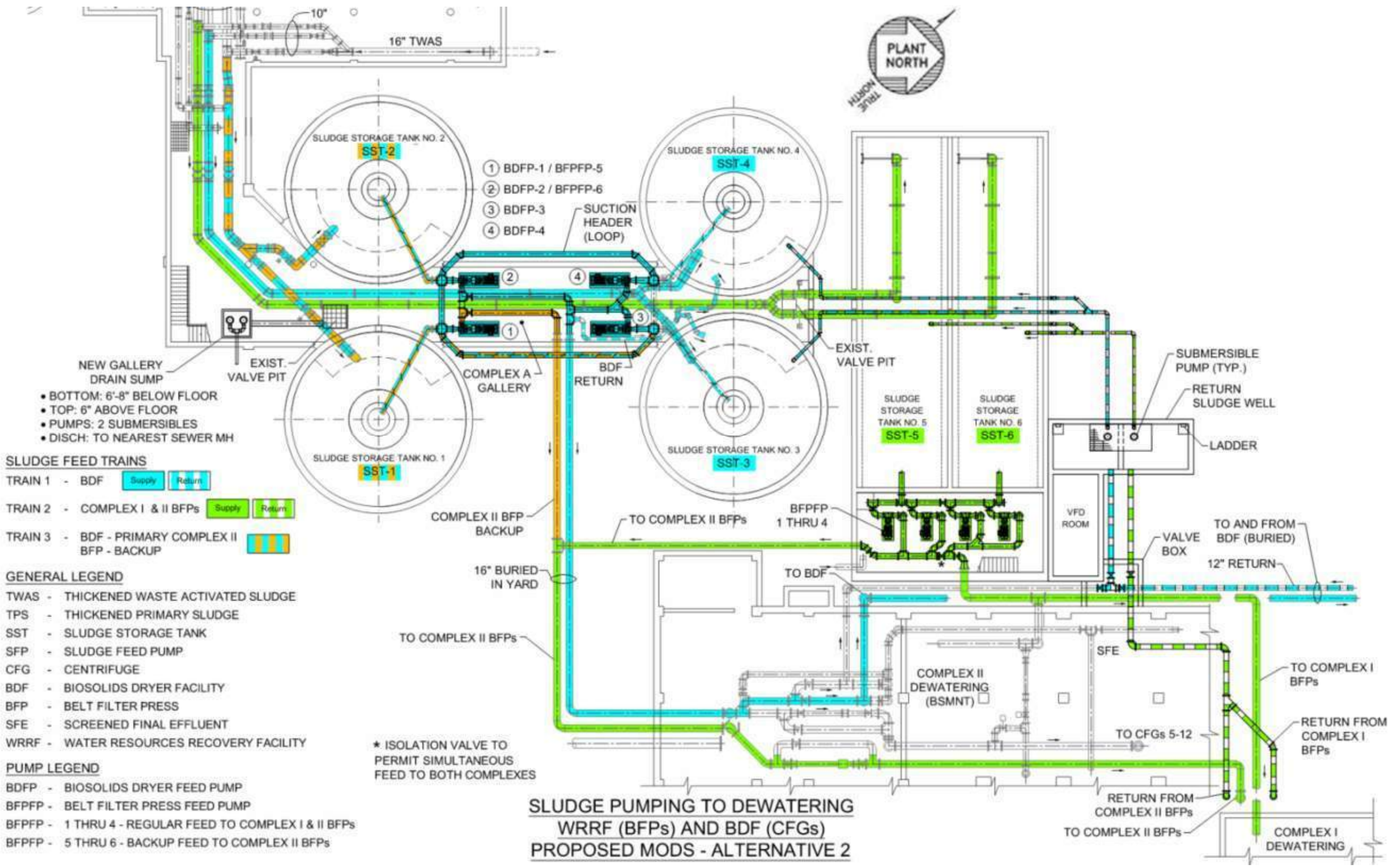

Figure 4-9: Alt-2 as Presented in Project RFP

Return sludge lines would be provided to eliminate the sludge header "dead ends" and provide a full sludge loop. Excess sludge from the end of each sludge feed header would be returned to its associated SST via the SFP line pressure or submersible pumps located in a return sludge well. The return sludge lines are discussed and evaluated in Section 5 of this TM-5B.

4.2.2 Concept Evaluation and Developments

TM-4 Dewatering Systems Sludge Demands determined that under normal operating conditions more than two-thirds of the solids loading to the WRRF is processed by the BDF CFGs. This alternative matches the BDF feed sludge storage ratio to the BDF's solids loading processing ratio by making four of the six SSTs (two-thirds) available for BDF feed sludge storage during normal operating conditions. It is noted that the WRRF may opt to continue to use two SSTs for this purpose.

The Project's AFT Fathom sludge hydraulic model was used to determine the feasibility of using the BDF sludge feed pumps as backup to feed the C-II BFPs during a BDF outage. It was determined that using these pumps as backup to feed the C-I BFPs is more applicable as these two hydraulic systems have relatively similar system curves when compared to the C-II system curve. This is discussed further as part of the preliminary pump selection in this TM-5B. The hydraulic model was also used to determine that the return sludge flows can be piped directly back to their associated SSTs without the need for an intermediate sludge return well with submersible pumps.

4.2.3 Process Mechanical - Preliminary Pump Sizing and Selections

Alt-2A includes four chopper type BDF sludge feed pumps (3 duty, 1 standby). Pump sizing is based on the three duty pumps being capable of conveying the required 2,400 gpm feed sludge flow to the BDF during maximum operating conditions. To accomplish this, each feed pump (SFPs 1-4) would be sized for 1,000 gpm to meet the total flow requirement with 600 gpm of return excess sludge. During a BDF outage scenario, two pumps operating at this size would convey 1,750 gpm to the C-I BFPs which is 250 gpm above the C-I maximum flow requirements with all 10 BFPs in service.

Based on this sizing, the operating flow range of each SFP to cover the BDF or C-I demands will be from 800 to 1,300 gpm. **Figure 4-10** shows these expected operating ranges overlayed on the preliminary pump selection pump curve (Vaughan HE4S6). This three-blade impeller pump has 6-inch suction and 4-inch discharge connections. Curve lines A to H in this graph show pump curves at 1,900 revolutions per minute (rpm) (100%) speed to 1,325 rpm (70%) speed.

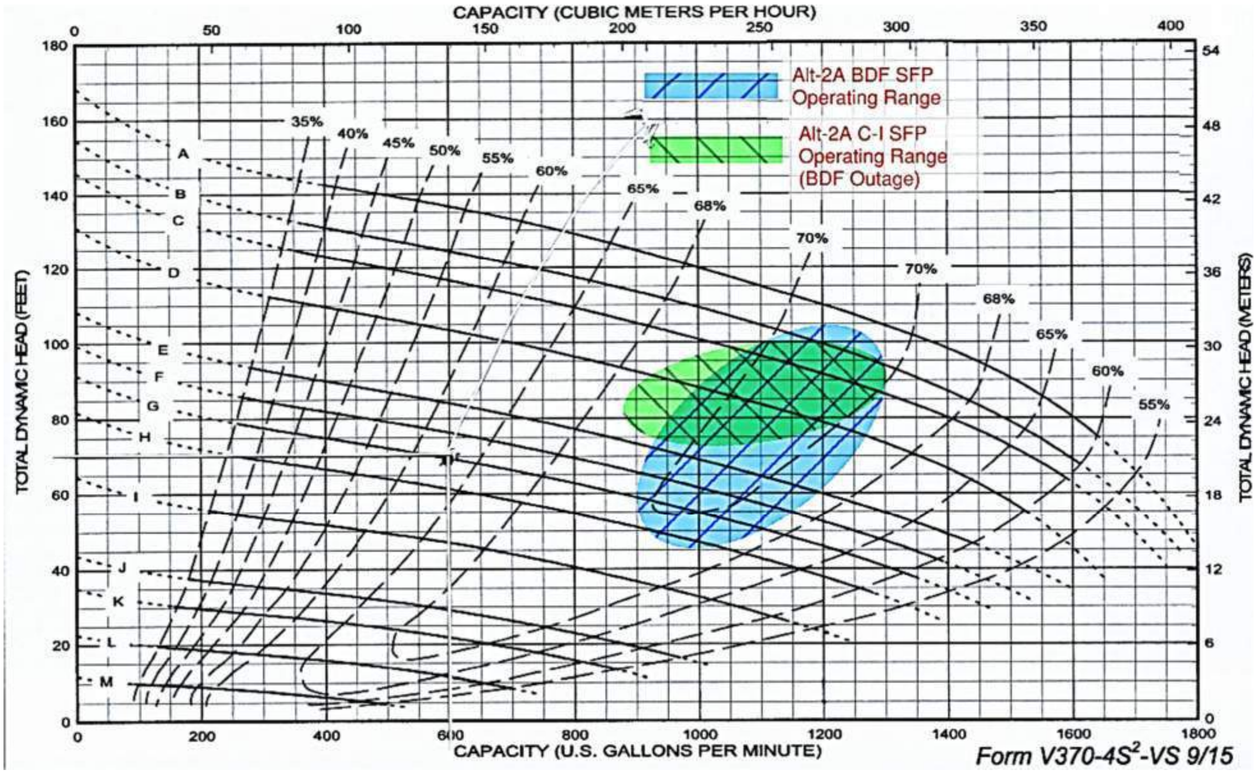

Figure 4-10: Alt-2A BFP SFP Operating Range Overlayed on Vaughan Chopper HE4S6 Pump Curve

Alt-2A also includes two rotary lobe type C-I sludge feed pumps (1 duty, 1 standby) and two rotary lobe type C-II sludge feed pumps (1 duty, 1 standby). All four pumps would be sized the same and valving would be provided to allow any of the four pumps to be used to feed C-I or C-II when needed. Pump sizing for SFPs 5-8 is based on each pump being capable of conveying the C-I or C-II normal maximum operating condition flow requirement of 750 gpm with 250 gpm of return excess sludge (1,000 gpm total). During a BDF outage scenario, two pumps operating at this size could convey 2,050 gpm to the C-II BFPs which is 250 gpm above the C-II maximum flow requirements with all 12 BFPs in service. Flow to the C-I BFPs would be provided by the BDF feed pumps during this BDF outage scenario.

Based on this sizing, the required operating flow range of these SFPs to cover the operational scenarios will be from 725 to 1025 gpm. **Figure 4-11** shows this expected operating range overlayed on the preliminary pump selection pump curve (Boerger XL1760). As shown, this flow range is achievable by operating the pumps at a speed range of 200 to 270 rpm.

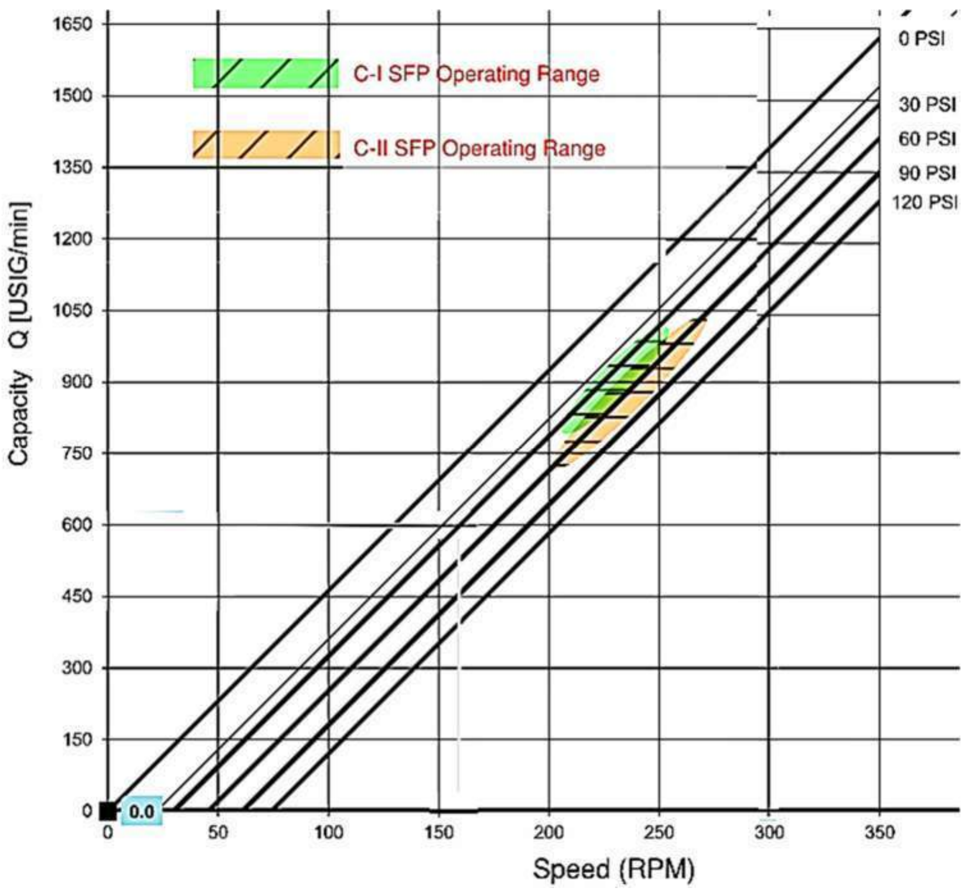

Figure 4-11: Alt-2A C-I and C-II SFP Operating Ranges Overlayed on Boerger Rotary Lobe Pump XL1760 Pump Curve

4.2.4 Process Mechanical – SSTs 1-4 Pipe Gallery Equipment Layout

The Alt-2A conceptual equipment layout in **Figure 4-9** for the SSTs 1-4 Pipe Gallery was evaluated to determine its constructability and whether any enhancements are warranted.

The conceptual layout includes interconnection suction piping between all four SFPs. These interconnections are needed to provide operational flexibility so that each of the pumps can draw suction from any of the four SSTs. Installing this piping in the yard outside the gallery would require relatively deep excavations near critical underground piping and utilities. To avoid the risks associated with this challenging excavation, layouts which include the interconnection suction piping within the building footprint were considered. **Figures 4-12** and **4-13** display how the existing suction pipes can be tied-into above the floor level and then routed below the floor slab to make the suction interconnections. Valve vaults with floor drains would be required in select locations as shown. Required structural modifications, potential interferences with drainage piping, and SFP suction conditions are considerations being factored into the evaluation of this alternative. Providing suction conditions per the requirements of the ANSI-HI 9.66 standard for rotodynamic pumps is desired for proper pump operation and longevity. Due to space limitations and existing structure constraints complying with all piping requirements of ANSI-HI 9.6.6 is unlikely. Accordingly, some recommendations provided in Appendixes E and G of this standard will be considered to improve suction hydraulics in an effort to achieve the greatest extent of compliance possible given the existing condition constraints.

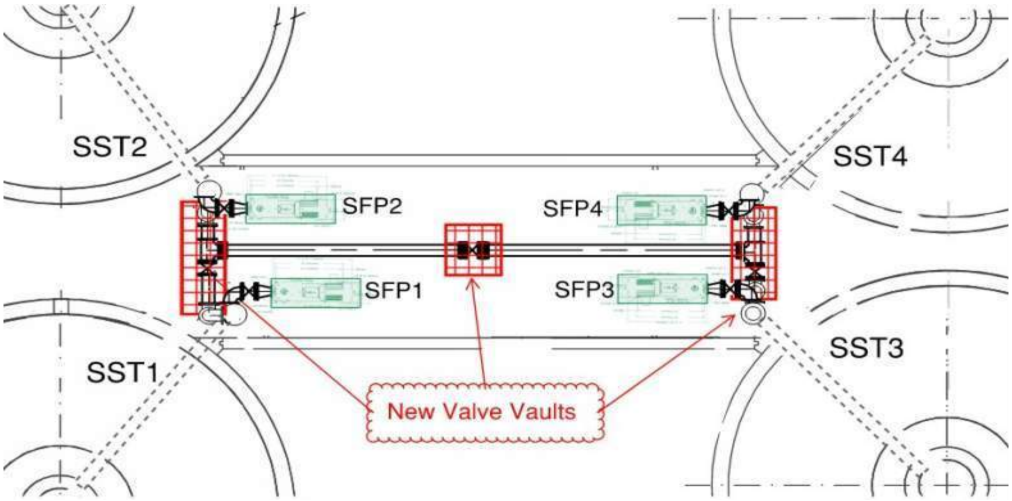

Figure 4-12: Alt-2A SSTs 1-4 Pipe Gallery Proposed Layout – Plan View

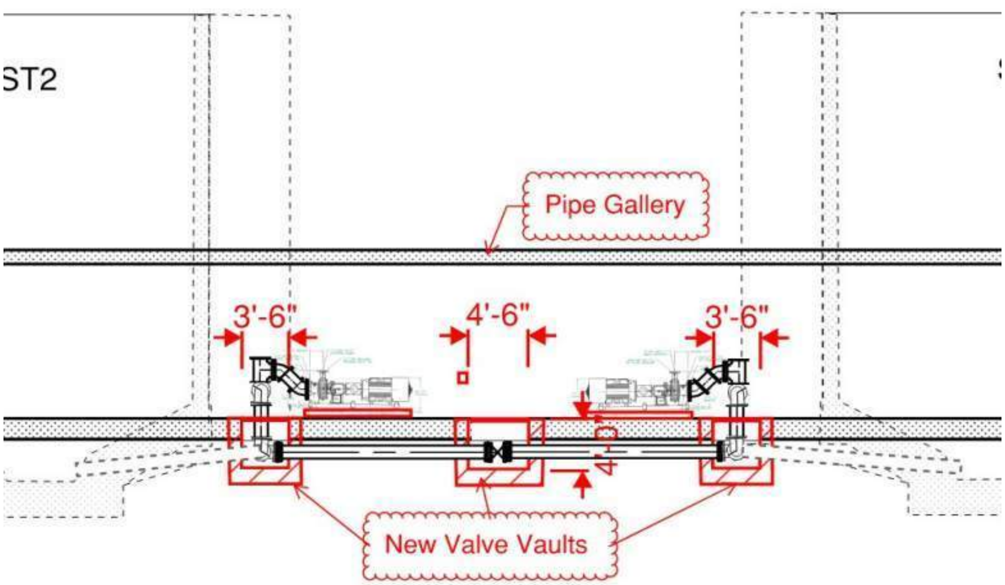

Figure 4-13: Alt-2A SSTs 1-4 Pipe Gallery Proposed Layout – Section View

Raising the SST tank floors is being considered to improve tank drainage as part of TM-6 SSTs Drainage and Complex A Basement Flooding Evaluations. Raising the tank floors would allow for replacement of the existing SFP suction piping with improved suction piping designed for the proposed pump layout. Improved NPSH would be an additional SFP benefit of raising the tanks.

Figures 4-14 and **4-15** display the proposed suction piping layout if the SSTs are raised. Reduction of storage tank volume could be avoided by raising the SST tank walls and tank internal components (air mixing piping, sludge inlet piping, etc.).

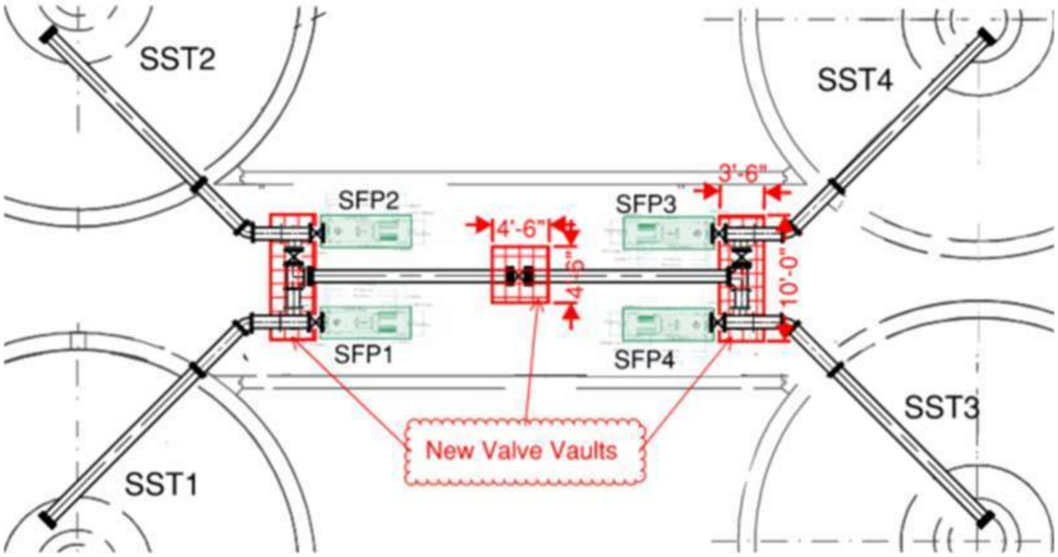

Figure 4-14: Alt-2A SSTs 1-4 Pipe Gallery Proposed Layout with Raised SSTs – Plan View

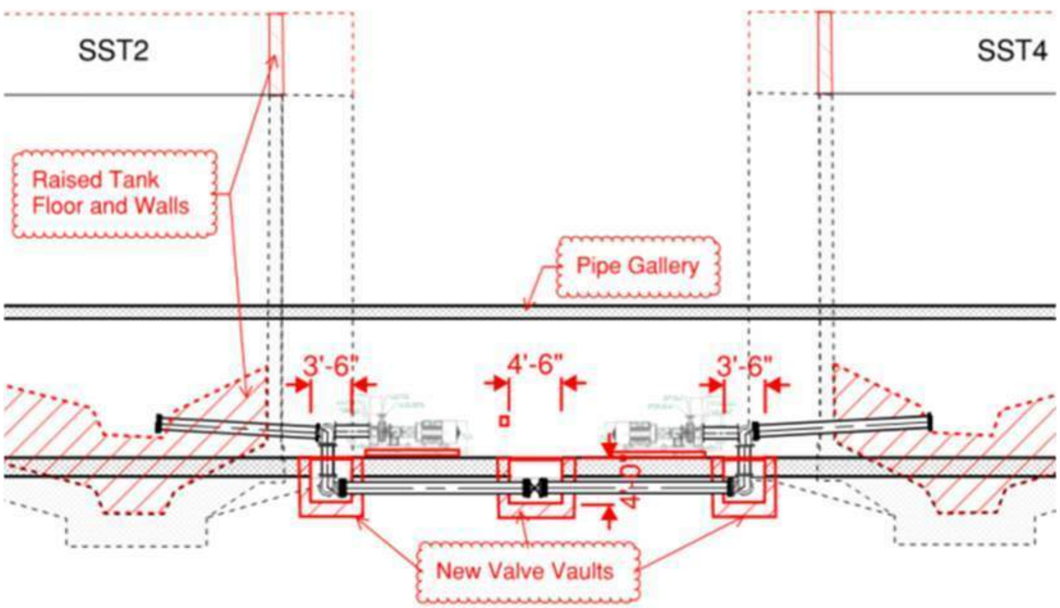

Figure 4-15: Alt-2A SSTs 1-4 Pipe Gallery Proposed Layout with Raised SSTs – Section View

4.2.5 Process Mechanical – SSTs 5/6 Pump Building Equipment Layout

The Alt-2 conceptual equipment layout in **Figure 4-9** for the SSTs 5/6 Pump Building was evaluated to determine its constructability and whether any enhancements are warranted.

As discussed in TM-5A Pumping Technology Evaluation and Shortlisting, grinders would be provided upstream of each pump to minimize pump and downstream equipment maintenance associated with rags in the feed sludge. As shown in **Figure 4-16**, a building expansion of approximately 15 feet would be required to accommodate the proposed equipment layout while incorporating the grinders and providing ample clearance for pump maintenance activities. Expanding the building to the north (as shown) would require relocation of some underground piping and utilities including 12-inch and 16-inch diameter sludge pipes, secondary electrical conduits, and small diameter water piping.

Valving would be provided to allow each pair of SFPs to be dedicated to C-I and C-II respectively during normal operations. During a BDF outage, valving would allow for all four pumps to be available for feeding C-II while C-I is being fed from the BDF SFPs. New interconnections would be provided between the three dewatering facilities' sludge feed pipes in the basement of C-II to maximize operational flexibility.

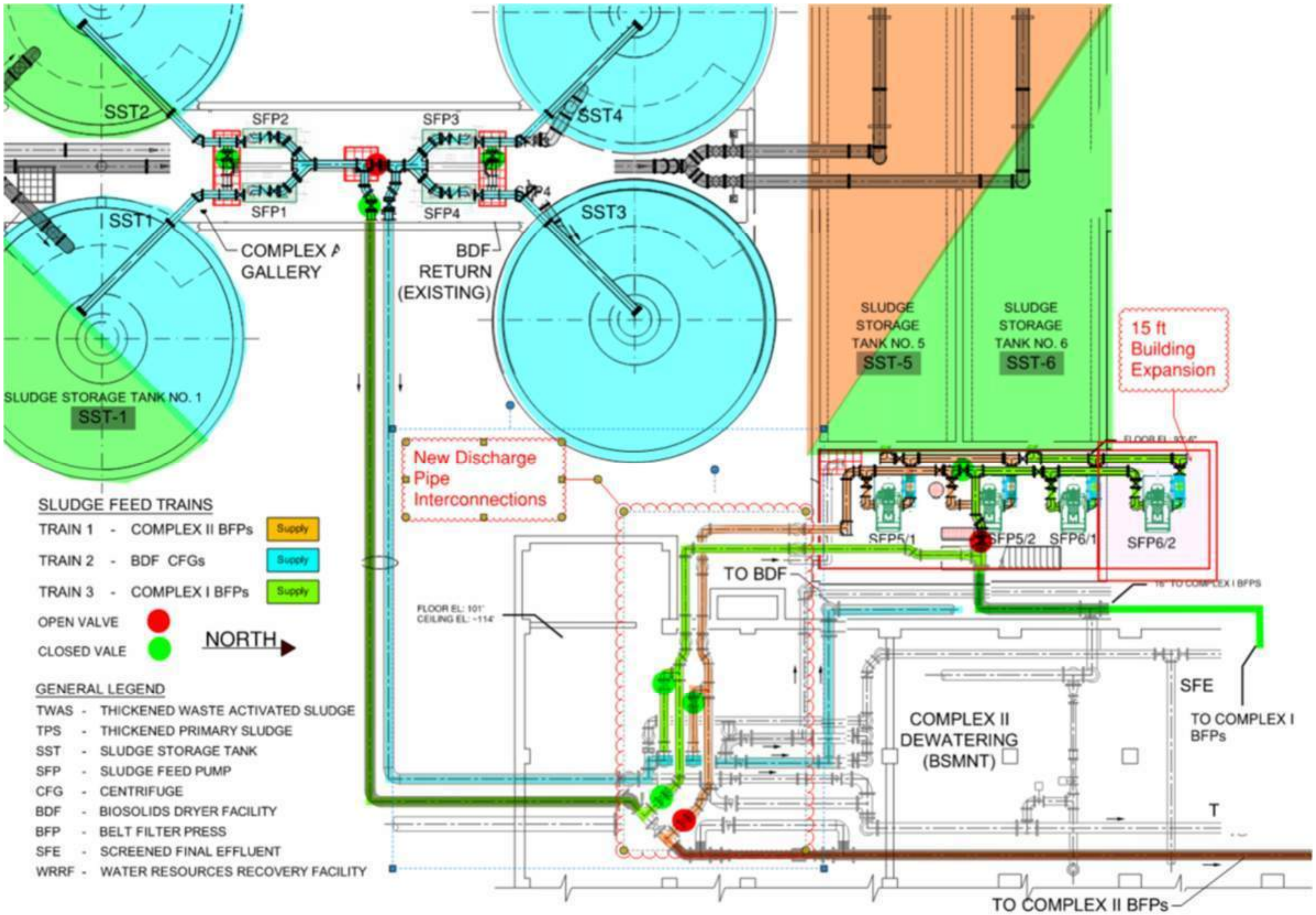

Figure 4-16: Alt-2A SSTs 5/6 Pump Building Proposed Layout

4.2.6 Structural Modifications and Considerations

The proposed modifications to the existing SSTs 1-4 Pipe Gallery floor slab of adding three new accessible valve vaults is structurally feasible. Considerations are needed to ensure the structural integrity of the concrete gallery walls and base slab are not undermined. As shown in **Figure 4-14**, the two proposed end vaults are to be 3.5 ft L x 10 ft W x 4 ft D and the new center vault is to be 4.5 ft L x 4.5 ft W x 4 ft D. Based on the location of the required excavations they will likely be required to be hand dug following the localized cutting and demolition of the existing concrete slab. The new vaults would have removable grating over the top at the base slab elevation to allow for accessibility to the valves. Intermediate steel structural supports for the grating may be required depending upon the final weights of the removable grating sections.

The clear span of pipe gallery is 15 ft, which would leave 2.5 ft on either side of the proposed end vaults to the existing gallery concrete walls. Cutting of slab will likely result in the cutting of the wall dowels, which are No. 8 bars at 7-inch spacing, at the two end sections resulting in a localized reduction in the wall capacity (See **Figure 4-17**).

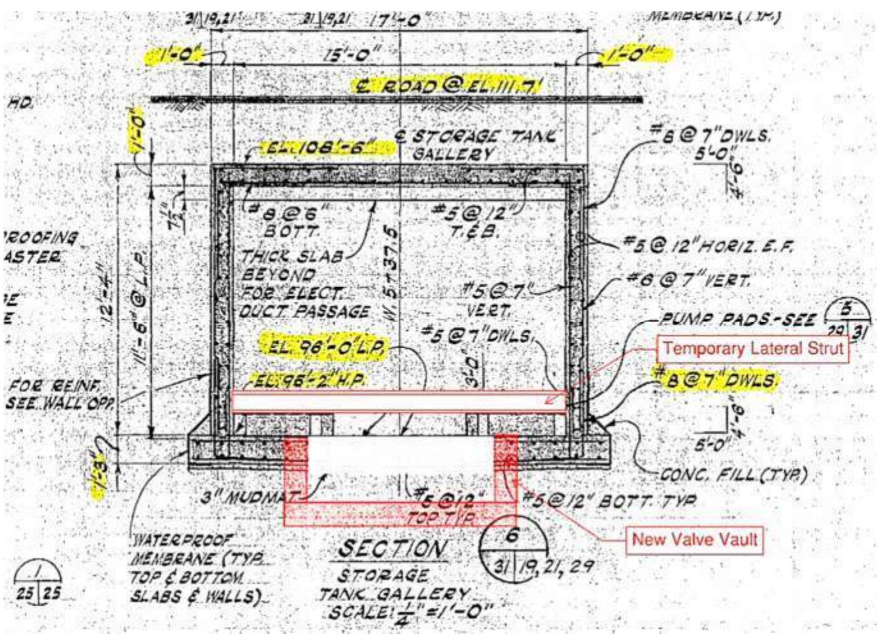

Figure 4-17: Section of Pipe Gallery and New Valve Vault with Temporary Lateral Strut

The existing walls will need to be analyzed to ensure they are adequate to distribute loading on either side of the excavation during construction. Installation of temporary steel lateral struts between gallery walls to support the base of the walls laterally over the excavation area during construction may be required if the walls are determined to not be adequate following the in-depth analysis. Additionally, an option to over-excavate the gallery base slab and place new reinforcement and concrete base slab to transfer the lateral loading around the new sump pits will be considered.

In this option, temporary steel lateral struts will be required to support the walls during construction.

The proposed expansion of the SSTs 5/6 Pump Building is to be approximately 15 ft to the north of the existing building. The expansion includes the basement floor at elevation 93.5 ft up to the top slab at elevation 114 ft. The concrete base slab and wall thicknesses of the building expansion to match that of the existing building. The C-II building is located approximately 6.5 ft to the east of the SSTs 5/6 Pump Building. The C-II building foundation is supported on driven piles down to bedrock at an approximate elevation of 22 ft.

Expansion of the SSTs 5/6 Pump Building is structurally feasible. Considerations needed to be made to ensure the construction does not undermine the foundation of SST 6 and adjacent C-II. The new expansion of SSTs 5/6 Pump Building would be supported on deep foundations similar to that of existing building. The preliminary layout would require 12 x 12-inch diameter piles spaced at 6.25 ft in the north-south and 4.5 ft in the east and west as shown in **Figure 4-18**. The piles would be driven down to bedrock. Boring records from project PC-256 were taken close to the proposed expansion location. A topsoil of compact fine ground sand was noted to elevation 100 ft. Soft gray silty clay was noted below the topsoil to the bedrock at approximately elevation 30 ft.

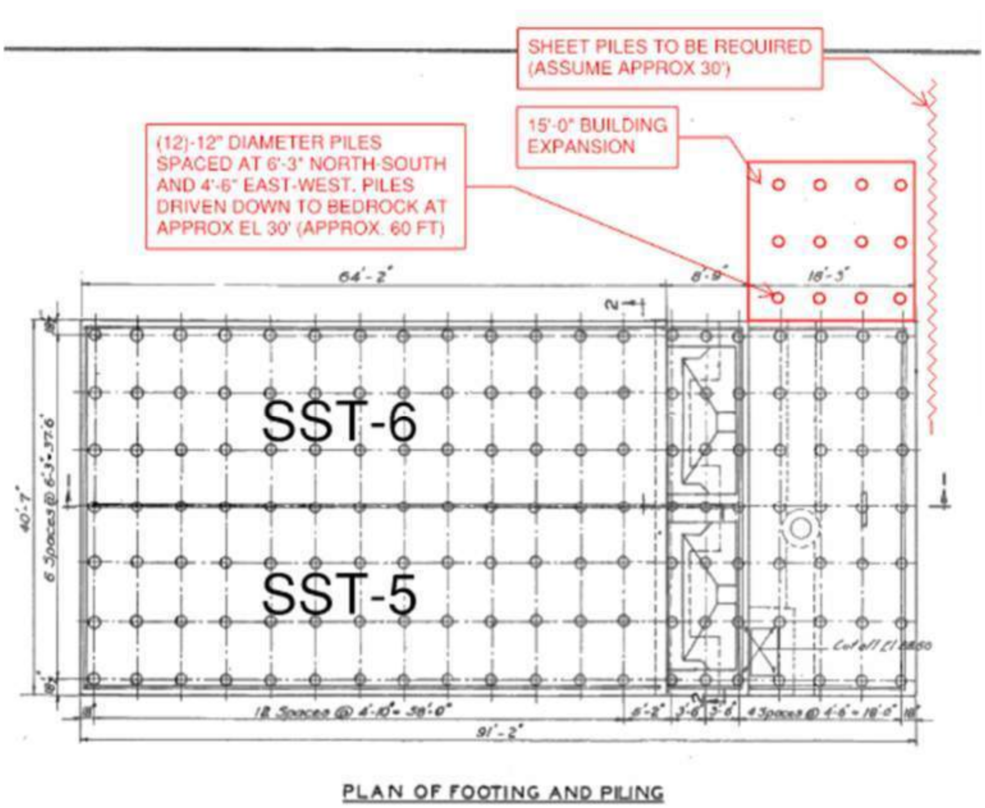

Figure 4-18: SSTs 5/6 Pump Building Expansion - Preliminary Foundation and Pile Layout

Sheet piling between the SSTs 5/6 Pump Building and C-II will be required for soil retention during excavation for the new expansion basement to ensure the foundation of C-II is not undermined. These sheet piles would need to be coordinated with the new and existing piping located between the existing buildings.

4.2.7 Electrical and Instrumentation Modifications and Considerations

The four SFPs proposed for installation in the SSTs 1-4 Pipe Gallery would be provided with new power feeders and controllers to replace the existing. The existing SFP feeders are located in MCC-A3 and MCC-A4 in the Electrical Room and the existing VFDs are located in the basement of Sludge Processing Complex A below the Electrical Room. The existing sections for SFP-1 and SFP-3 in MCC-A3 will be demolished and replaced with circuit breaker feeders for two new pumps. The existing sections for SFP-2 and SFP-4 in MCC-A4 will be demolished as shown in **Figure 4-7** and will be replaced with circuit breakers for the two remaining new pumps (similar as shown in **Figure 4-8)**. New VFD control panels will be provided for each of the new pumps in the basement of Sludge Processing Complex A below the Electrical Room.

For the SSTs 5/6 Pump Building, options for providing power feeder and controls for the four new rotary lobe pumps and their upstream grinders include the following:

- Option 1: Refurbish MCC-A5 and MCC-A6 to provide two new 250-amp circuit breaker feeders in each MCC. Each of the MCCs would require buckets and vertical sections rearranged to have the allowable ampacity of each vertical bus accommodate the required power loads of the new pumps. Replace SFP-5 VFD with a similar VFD control cabinet to SFP-6 VFD, refurbish SFP-6 VFD control cabinet, and provide two new VFD control cabinets similar to the others.

- Option 2: Replace MCC-A5, MCC-A6, SFP-5 VFD and SFP-6 VFD. Both MCCs were installed in 2004 and are reaching their useful life span. The amount of refurbishment required would result in one or two new vertical sections out of the three existing vertical sections. New VFD control panels will be provided for each of the new pumps.

4.2.8 MOPO and Construction Phasing Considerations

The sludge feed system (SSTs and SFPs) is a critical WRRF solids handling process. All solids received by the plant are eventually conveyed by the sludge feed system for processing at one of the three dewatering facilities (BDF, C-I, or C-II). The WRRF must continually process solids during construction to comply with its NPDES permit requirements (500 dtpd average, 850 dtpd peak). Therefore, a complete unit process outage during construction is not acceptable. Proposed phasing of the Alt-2A improvements is similar to that of Alt-1 discussed in Section 4.1.7 with some benefits. Phase 2 of Alt-2A would not require an NPDES construction exemption or portable dewatering units as this alternative will have the ability to feed sludge to C-I and C-II from the SSTs 5/6 Pump Building after Phase 1 is complete.

4.2.9 Shortlist Recommendation

The Alt-2A concept accomplishes the project goals and results in operational flexibility for plant operations staff. This alternative requires the expansion of the SSTs 5/6 Pump Building. Expanding this structure has some challenges but is not considered to add significant risk to the Project. CDM Smith recommends further consideration of this alternative for implementation on the Project.

4.3 Alternative 2B – 3 Rotary Lobe Pumps in SSTs 5/6 Pump Building

4.3.1 Concept Description

Alt-2B is a similar concept to Alt-2A but with a different pump configuration in the SSTs 5/6 Pump Building. This alternative considers three rotary lobe pumps located in the basement of the SST 5/6 Pump Building to convey sludge from SSTs 5/6 to the C-I and C-II BFPs. The same improvements as Alt-2A would be provided in the SSTs 1-4 Pipe Gallery, see Section 4.2.1.

Return sludge lines would be provided to eliminate the sludge header "dead ends" and provide a full sludge loop. Excess sludge from the end of each sludge feed header would be returned to its associated SST via the SFP line pressure or submersible pumps located in a return sludge well. The return sludge lines are discussed and evaluated in Section 5 of this TM-5B.

4.3.2 Concept Evaluation and Developments

Developments are the same as Alt-2A. See Section 4.2.2.

4.3.3 Process Mechanical - Preliminary Pump Sizing and Selections

The Alt-2B preliminary pump sizing and selections are the same as Alt-2A. see Section 4.2.3.

4.3.4 Process Mechanical – SSTs 1-4 Pipe Gallery Equipment Layout

The Alt-2B layout for the SSTs 1-4 Pipe Gallery is the same as the Alt-2A, see Section 4.2.4.

4.3.5 Process Mechanical – SSTs 5/6 Pump Building Equipment Layout

The Alt-2B conceptual equipment layout for the SSTs 5/6 Pump Building is shown in **Figure 4-19**. Three rotary lobe pumps with upstream grinders would be provided in the existing building footprint. As shown in the layout, modifications to the existing concrete building column in the basement is required. Providing access around the pumps for regular maintenance and disassembly was considered in the development of the layout. Maintenance access is critical for replacement of rotary lobe pump lobes, seals, and wear plates.

Valving would be provided to allow one SFP to be dedicated to C-I and C-II respectively during normal operations. During a BDF outage, valving would allow for all three pumps to be available for feeding C-II while C-I is being fed from the BDF SFPs. New interconnections would be provided between the three dewatering facilities' sludge feed pipes in the basement of C-II to maximize operational flexibility.

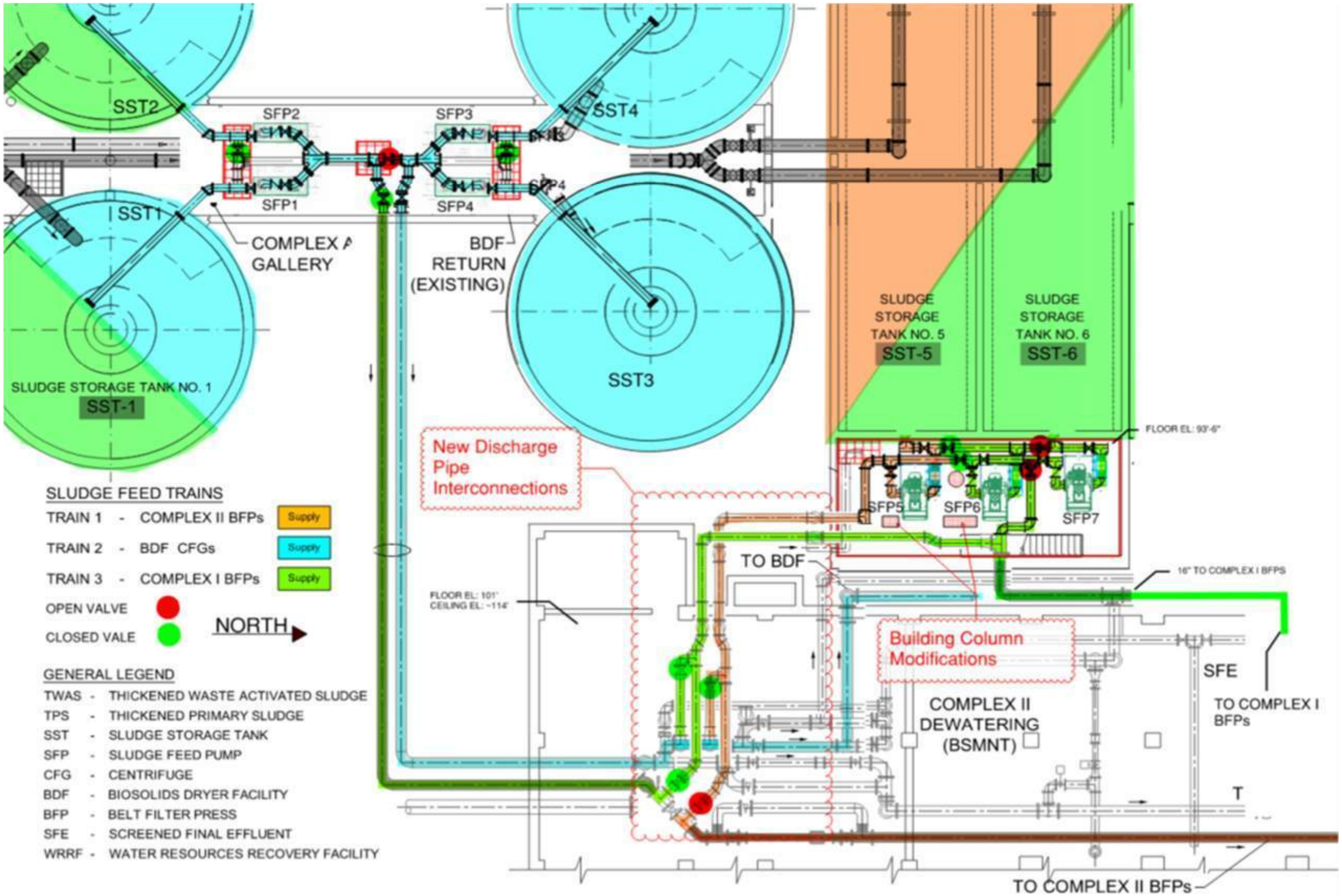

Figure 4-19: Alt-2B SSTs 5/6 Pump Building Proposed Layout

4.3.6 Structural Modifications and Considerations

The Alt-2B structural modifications are the same as Alt-2A for the SSTs 1-4 Pipe Gallery layout, see Section 4.2.6. See Section 4.1.5 for discussion on SSTs 5/6 Pump Building concrete column modifications.

4.3.7 Electrical and Instrumentation Modifications and Considerations

The Alt-2B electrical modifications are the same as Alt-2A for the SSTs 1-4 Pipe Gallery improvements and similar for the SSTs 5/6 Pump Building improvements, see Section 4.2.7.

4.3.8 MOPO and Construction Phasing Considerations

The Alt-2B MOPO and Construction Phasing Considerations are the same as Alt-2A, see Section 4.2.8.

4.3.9 Shortlist Recommendation

The Alt-2B concept accomplishes the project goals and results in operational flexibility for plant operations staff. This alternative does not require any building expansions. CDM Smith recommends further consideration of this alternative for implementation on the Project.

4.4 Alternative 2C – 5 Chopper Pumps in SSTs 5/6 Pump Building

4.4.1 Concept Description

Alt-2C is a similar concept to Alt-2A but with a different pump configuration in the SSTs 5/6 Pump Building. This alternative considers five rotodynamic chopper pumps located in the basement of the SST 5/6 Pump Building to convey sludge from SSTs 5/6 to the C-I and C-II BFPs. The same improvements as Alt-2A would be provided in the SSTs 1-4 Pipe Gallery, see Section 4.2.1.

Return sludge lines would be provided to eliminate the sludge header "dead ends" and provide a full sludge loop. Excess sludge from the end of each sludge feed header would be returned to its associated SST via the SFP line pressure or submersible pumps located in a return sludge well. The return sludge lines are discussed and evaluated in Section 5 of this TM-5B.

4.4.2 Concept Evaluation and Developments

Developments are the same as Alt-2A. See Section 4.2.2.

4.4.3 Process Mechanical - Preliminary Pump Sizing and Selections

Alt-2C includes the same improvements as Alt-2A in the SSTs 1-4 Pipe Gallery, see Section 4.2.3. Alt-2C also includes five rotodynamic chopper type SFPs located in the SSTs 5/6 Pump Building basement to serve the C-I and C-II sludge demands.

Two C-I SFPs (1 duty, 1 standby) would be provided. The C-I SFP sizing is based on the one duty pump being capable of conveying the required 750 gpm feed sludge flow to C-I during maximum normal operating conditions with 250 gpm of return excess sludge (1,000 gpm total). Based on this sizing, the operating flow range of each SFP to cover the C-I demands will be from 800 to 1000 gpm.

Figure 4-20 shows this expected operating range overlayed on the preliminary pump selection pump curve (Vaughan HE4S6). This three-impeller pump has 6-inch suction and 4-inch discharge connections. Curve lines C to E in this graph show pump curves at 1,770 revolutions per minute (rpm) (93%) speed to 1,525 rpm (80%) speed.

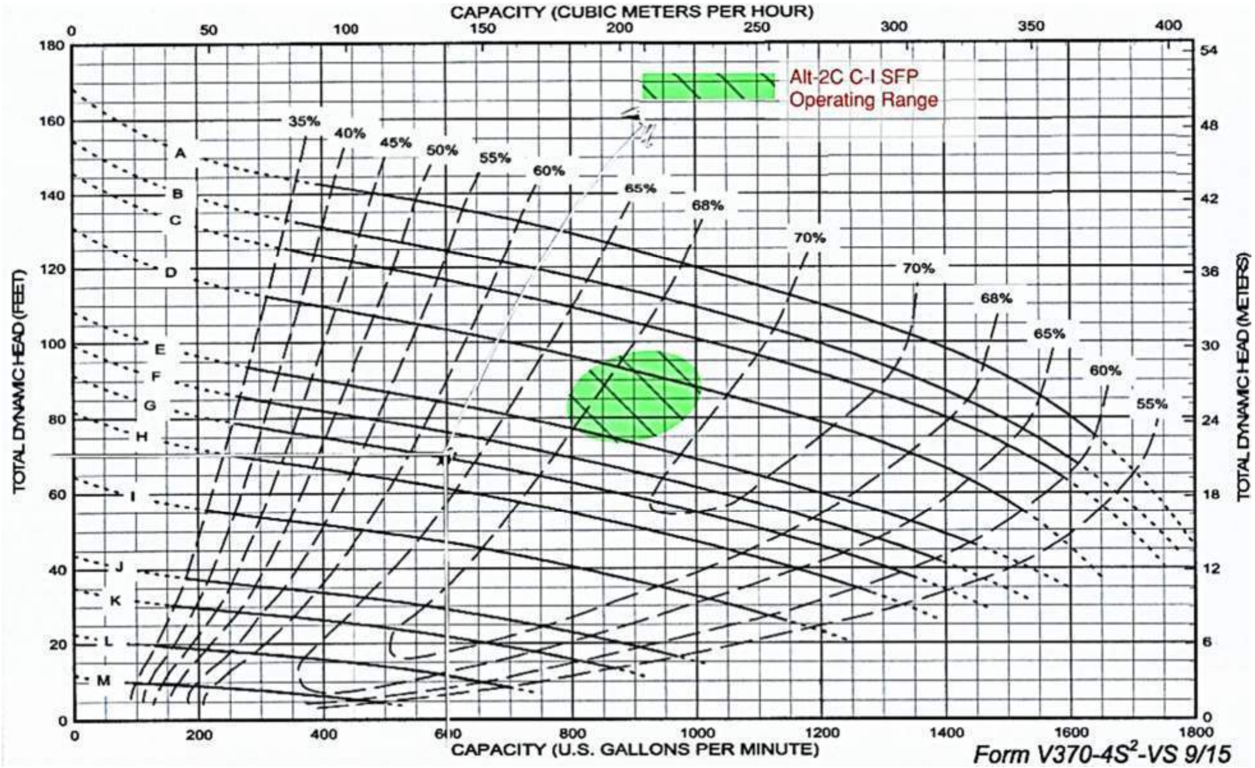

Figure 4-20: Alt-2C C-I SFP Operating Range Overlayed on Vaughan Chopper HE4S6 Pump Curve

Three C-II SFPs (2 duty, 1 standby) would be provided. The C-II SFP sizing is based on the two duty pumps being capable of conveying the required 750 gpm feed sludge flow to C-II during maximum normal operating conditions with 250 gpm of return excess sludge (1,000 gpm total). During a BDF outage scenario, two pumps operating at this size could convey 2,050 gpm to the C-II BFPs which is 250 gpm above the C-II maximum flow requirement with all 12 C-II BFPs in service.

Based on this sizing, the operating flow range of each SFP to cover the C-II demands will be from 725 to 1,025 gpm. **Figure 4-21** shows this expected operating range overlayed on the preliminary pump selection pump curve (Vaughan HE4V). This four-impeller pump has 8-inch suction and 4-inch discharge connections. Curve lines C to F in this graph show pump curves at 1,550 revolutions per minute (rpm) (85%) speed to 1,200 rpm (65%) speed.

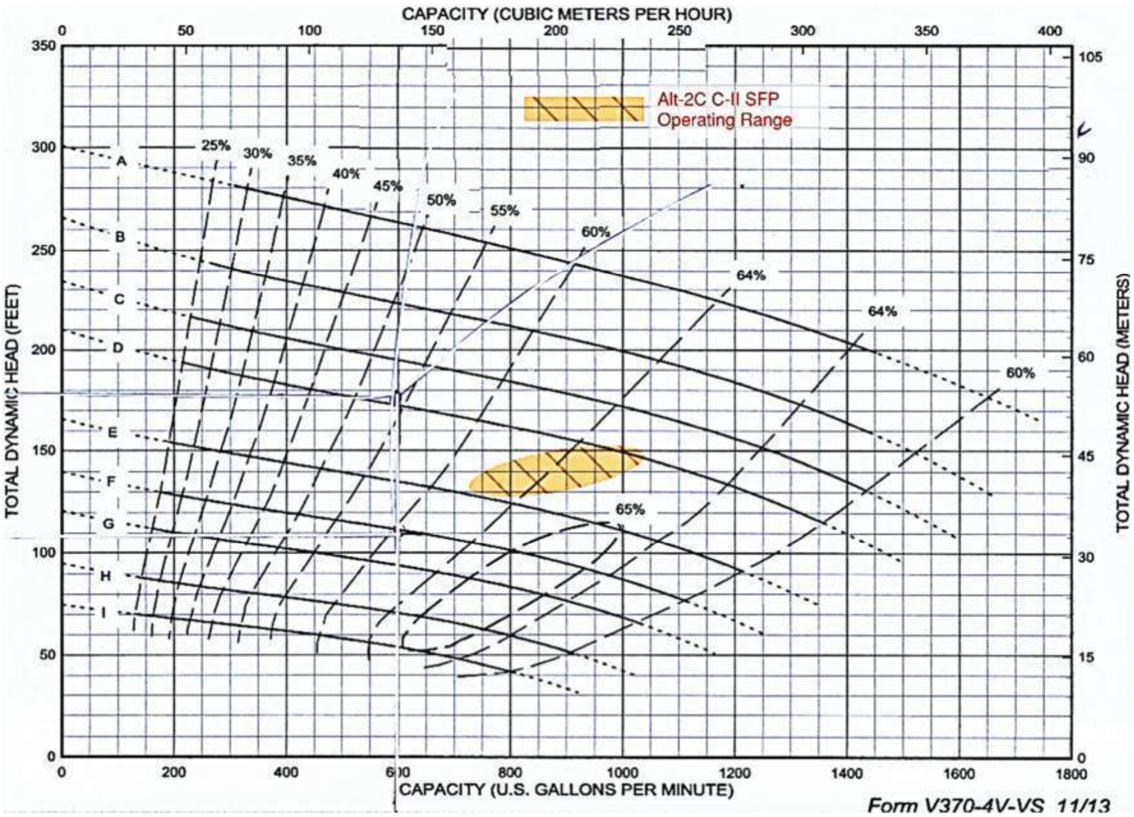

Figure 4-21: Alt-2C C-II SFPs Operating Range Overlayed on Vaughan Chopper HE4V Pump Curve

4.4.4 Process Mechanical – SSTs 1-4 Pipe Gallery Equipment Layout

The Alt-2C layout for the SSTs 1-4 Pipe Gallery is the same as the Alt-2A, see Section 4.2.4.

4.4.5 Process Mechanical – SSTs 5/6 Pump Building Equipment Layout

The Alt-2C conceptual equipment layout for the SSTs 5/6 Pump Building is shown in **Figure 4-22**. Five rotodynamic vertical chopper pumps (pedestal mount) would be provided in the existing building footprint. No modifications to the existing building structure are anticipated. Providing access around the pumps for regular maintenance and disassembly was considered in the development of the layout. The layout shown provides approximately 2’-9” between SFPs 5-7 and 3’-0” between SFPs 8 /9. While this layout is slightly more congested than optimal, it was determined that expanding the building to provide some additional clearance around the pumps was not warranted.

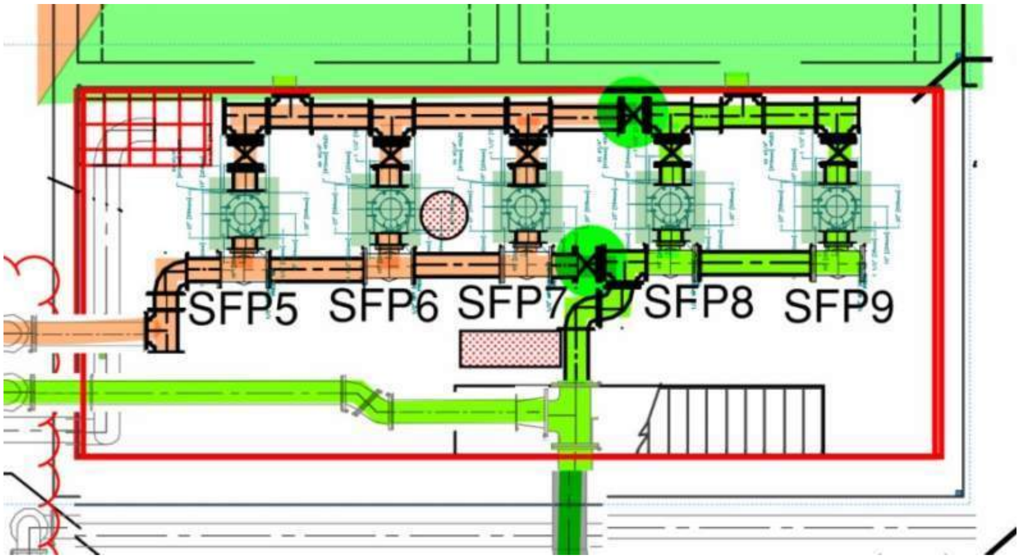

Figure 4-22; Alt-2C SSTs 5/6 Pump Building Proposed Layout

Valving would be provided to dedicate SFPs 5-7 to C-II and SFPs 8/9 to C-I. In this alternative these two sets of pumps would remain isolated in all expected operational scenarios. It is noted that the dedicated pumps could be used to feed the other facilities in an emergency scenario, but the pumps would need to be operated outside of their preferred operating range.

4.4.6 Structural Modifications and Considerations

The Alt-2B structural modifications are the same as Alt-2A for the SSTs 1-4 Pipe Gallery layout, see Section 4.2.6. No structural modifications are anticipated for the SSTs 5/6 Pump Building.

4.4.7 Electrical and Instrumentation Modifications and Considerations

The Alt-2B electrical modifications are the same as Alt-2A for the SSTs 1-4 Pipe Gallery improvements and similar for the SSTs 5/6 Pump Building improvements, see Section 4.2.7.

4.4.8 MOPO and Construction Phasing Considerations

The Alt-2B MOPO and Construction Phasing Considerations are the same as Alt-2A, see Section 4.2.8.

4.4.9 Shortlist Recommendation

The Alt-2C concept accomplishes the project goals and results in operational flexibility for plant operations staff. This alternative does not require any building expansions. CDM Smith recommends further consideration of this alternative for implementation on the Project.

4.5 Alternative 3 – Combined C-I and C-II Sludge Loop

4.5.1 Concept Description

Alt-3 considers providing three rotodynamic chopper pumps in the SSTs 1-4 Pipe Gallery dedicated to conveying sludge from SSTs 1-4 (typically SSTs 3/4) to the BDF CFGs under normal operating conditions. These pumps would also serve as backup to convey sludge from SSTs 1/2 to the C-II BFPs if needed during a BDF outage. Two rotary lobe pumps with grinders would be located in the basement of the SST 5/6 Pump Building and convey sludge from SSTs 5/6 to the C-I and C-II BFPs through a single combined sludge loop. The normal operation pumping configuration for this alternative is shown in **Figure 4-23**.

Return sludge lines would be provided to eliminate the sludge header "dead ends" and provide a full sludge loop. Excess sludge from the end of each sludge feed header would be returned to its associated SST via the SFP line pressure.

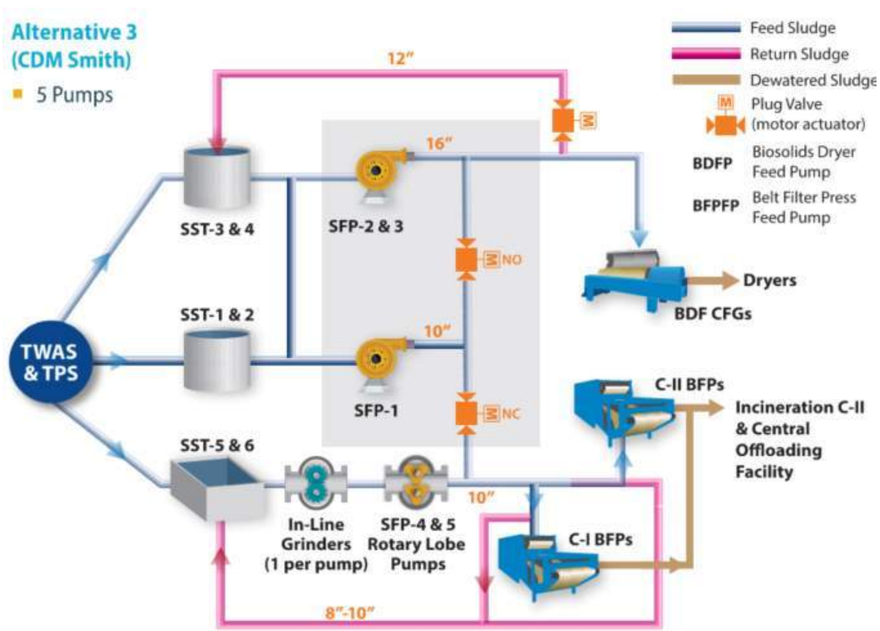

Figure 4-23: Alt-3 as Presented in CDM Smith Project Proposal

4.5.2 Concept Evaluation and Developments

The intent of Alt-3 was to reduce the total number of pumps required by combining the C-I and C-II sludge loops into one large loop that fed both facilities. The concept was to convey sludge to the C-II BFPs first (higher elevation) and then rely on the static head pressure of the sludge loop to feed the C-I BFPs prior to returning excess sludge to the SSTs.

The Project's AFT Fathom sludge hydraulic model was used to determine the feasibility of this approach. It was determined that the elevation difference between C-I and C-II BFPs would result in excessive pressure conditions at the C-I sludge header. Provisions to reduce the line pressure between the two facilities were investigated but did not result in a practical and reliable solution worth being considered further.

4.5.3 Shortlist Recommendation

Further investigation of the Alt-3 concept determined that combining the C-I and C-II sludge loops would result in operational and maintenance difficulties associated with sludge loop hydraulics. GLWA has stressed the importance of pumping redundancy. Minimizing the total number of pumps is not a project objective. CDM Smith does not recommend further consideration of this alternative for implementation on the Project.

4.6 Alternative 4 – BDF Sludge EQ Basin

4.6.1 Concept Description

Alt-4 is a similar concept to Alt-3 but with an added equalization basin as part of the BDF sludge loop. Three rotodynamic chopper pumps would be located in the SSTs 1-4 Pipe Gallery dedicated to conveying sludge from SSTs 1-4 (typically SSTs 3/4) to the BDF CFGs under normal operating conditions. These pumps would also serve as backup to convey sludge from SSTs 1/2 to the C-II BFPs if needed during a BDF outage. Two rotary lobe pumps with grinders would be located in the basement of the SST 5/6 Pump Building and convey sludge from SSTs 5/6 to the C-I and C-II BFPs through a single combined sludge loop. The normal operation pumping configuration for this alternative is shown in **Figure 4-24**.

Return sludge lines would be provided to eliminate the sludge header "dead ends" and provide a full sludge loop. Excess sludge from the end of the C-I and C-II sludge feed header would be returned to its associated SST via the SFP line pressure. Excess sludge from the BDF sludge feed header would be returned to an equalization basin (EQ basin) located near the BDF facility. The EQ basin would be provided with submersible pumps to convey the excess sludge back through the sludge feed header to the BDF.

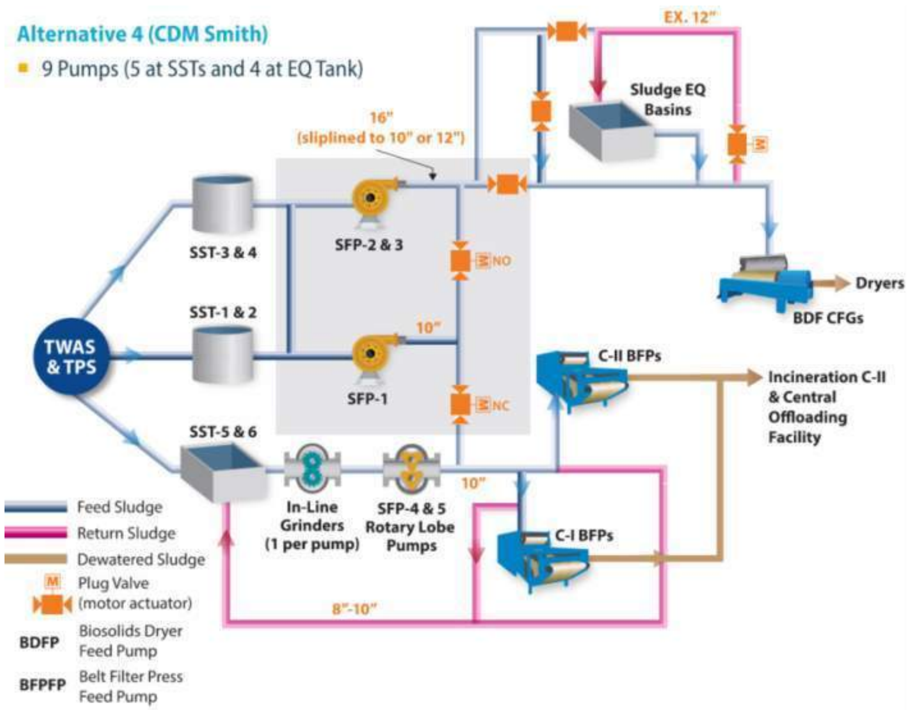

Figure 4-24: Alt-4 as Presented in CDM Smith Project Proposal

4.6.2 Concept Evaluation and Developments

The Alt-4 concept expands on Alt-3 by providing an EQ basin as part of the BDF sludge loop. Excess sludge from the BDF sludge loop would return back to an EQ basin located near the BDF facility. Pumps located within the EQ basin would then feed the excess sludge to the BDF without the return sludge needing to be conveyed the long distance back to the SSTs. Providing this "wide spot" in the BDF sludge loop would provide operational flexibility to increase flows through the 16-inch and 12-inch BDF sludge lines to reduce settlement and periodically flush the lines. The concept also intended to reduce the pressure requirement of the BDF SFPs to make the pumping requirements more similar to that of the C-I and C-II SFPs.

As noted in Alt-3, the sludge hydraulic model was used to determine that combining the C-I and C-II sludge headers into one loop would result in hydraulic control challenges. Addition of the proposed EQ basin to the sludge model determined that the hydraulic benefits of adding the EQ basin were minimal.

4.6.3 Shortlist Recommendation

Similar to Alt-3, the Alt -4 concept would result in hydraulic control challenges associated with combining the C-I and C-II sludge loops. It was also determined that the benefits associated with the proposed EQ basin would be minimal. CDM Smith does not recommend further consideration of this alternative for implementation on the Project.

5.0 Sludge Loop Evaluation

The existing sludge feed pipe headers "dead end" at each of the dewatering facilities which results in sludge feed header pressures that are difficult to maintain within the required operating ranges. Providing return sludge lines from the end of each existing sludge header back to the SSTs (resulting in a full sludge loop) is one of the goals of the Project. Sludge modeling and hydraulic analysis was performed to determine that the return excess sludge can be conveyed back to the SSTs by the SFP line pressures with no intermediate pumping or return sludge wells required. Evaluation of the sludge loops considered:

- Return sludge line sizing to ensure minimum required velocities are met to minimize solids settling.
- Minimizing low points or pipe traps where solids can accumulate.
- Providing flushing and drainage locations.
- Provisions must be provided on each sludge loop to maintain the required pressures at the dewatering equipment branch locations. Sludge loop routing and pressure control alternatives were evaluated for implementation.
- Piping restraints to accommodate forces resulting from vertical pipe drops.
- Freeze protection in exposed piping locations.

5.1 Sludge Header Pressure Control at Dewatering Facilities

Hydraulic sludge modeling determined that routing the return lines of each sludge loop directly from the end of the sludge feed headers back to the SSTs would result in sludge header pressures at the dewatering facilities below the requirements determined in TM-4. Provisions were evaluated to determine how best to provide the required backpressure at each complex.

5.1.1 Backpressure Valve

CDM Smith contacted multiple valve manufacturers to determine if they offered backpressure valves capable of continual and reliable operation on sludges similar to those being conveyed in this application. The manufacturers that were contacted did not recommend any valves suitable for this application.

5.1.2 Flow Control Valve

Providing a flow control valve on the sludge headers downstream of the dewatering equipment feed branches is being considered. A modulating pinch valve would be provided to open and close as additional backpressure is needed. This would operate similar to MOV-123 which is currently used for controlling the return flow from the short return line on the BDF SFP discharge piping. Plant staff have indicated maintenance issues with this valve, reporting it typically requires replacement every 6 months. The MOV-123 manufacturer (Red Valve) has indicated that there are likely opportunities to extend this valve sleeve's expected life. Changes could be made to use erosion resistance sleeve materials (natural rubber or neoprene), or the valve could be resized to better handle the application. Using a flow control valve as the sole means of providing the required backpressures for these applications could prove challenging and result in additional maintenance activities. However, flow control valves have been used successfully to provide backpressure in suitable applications and will be considered further herein.

5.1.3 Standpipe

Providing a standpipe downstream of the dewatering equipment feed branches is also being considered. Routing the sludge header piping to a higher elevation downstream of the dewatering feed branch locations will result in backpressure being provided by the static head of sludge in the pipe. This alternative adds piping to each loop but does not require any flow control equipment or valves which are typically maintenance intensive items. Standpipe is the preferred backpressure alternative for sludge piping if building elevations are able to accommodate the piping elevations needed to provide the required backpressure. Standpipe configurations would likely result in some variations in the upstream sludge header pressures depending on the flows and percent solids of sludge being conveyed at any given time.

5.2 Sludge Loop Recommendations

Providing a full sludge loop for each dewatering facility is feasible but presents multiple challenges. Loop pipe routing and constructability, means to provide required backpressure to dewatering feed equipment, and provisions to accommodate vertical pipe drops (air vacuum/release valves and piping restraints) must be considered. Providing short sludge loops (return loops in close proximity to the SFPs) or no sludge loops (maintain existing "dead end" sludge feed header configurations) are alternatives to providing a full sludge loop. These alternatives have challenges of their own and were not investigated in detail as they do not align with the objectives of the Project.

5.2.1 Proposed BDF Sludge Loop

Two existing parallel sludge feed pipes (12-inch and 16-inch) are currently available to convey sludge from the SFPs to the BDF. The current sludge feed design is based on one of these lines being in service with the line size selected based on the flow being conveyed. Plant staff have indicated that the 12-inch pipe is primarily used with the 16-inch header only used for high flow scenarios. Analysis of operational data for the past three years indicates that the sludge velocity through this 12-inch pipe ranges from 1.8 to 4.7 ft/s more than 90% of the time. CDM Smith proposes utilizing the existing 16-inch sludge feed line as the primary feed line and converting the 12-inch pipe to the sludge loop return to the SSTs. This can be accomplished by providing some modifications at both ends of the existing sludge feed piping. By utilizing the existing piping, excavation can be minimized which will reduce the project costs and risks associated with excavating around congested underground utilities.

Total flow to the BDF (dewatering equipment demands plus excess return sludge) is expected to range from 1,300 gpm to 3,000 gpm. Conveying sludge to the BDF through the 16-inch sludge feed pipe would result in velocities ranging from 2.1 to 4.8 ft/s. Excess return sludge from the BDF to the SSTs is expected to range from 600 gpm to 1,000 gpm. Returning this flow range through the 8-inch and 12-inch sludge return line would result in velocities ranging from 1.7 to 6.4 ft/s. **Figure 5-1** and **Figure 5-2** display the proposed modifications to implement the proposed BDF sludge loop. Sludge would be fed to the BDF through the existing 16-inch sludge feed line, through the existing sludge feed header, and then return downstream of the sludge header through the existing 8-inch drain line to the 12-inch return line back to the SSTs.

The proposed BDF sludge loop features and required piping modifications include:

- The existing 16-inch sludge feed line will become the primary feed line.
- The existing 12-inch sludge feed line will be converted to the excess sludge return line. Note – this line can still be used to feed sludge to the BDF if needed during emergency conditions.
- A new valve vault north of SST-6 will be provided to allow sludge to be fed or returned from either the 12-inch or 16-inch parallel lines.
- The existing blowoff standpipe downstream of the centrifuge feed branches will be raised to provide a relatively constant and consistent backpressure on the BDF sludge feeder header.

The proposed standpipe modification is limited to a maximum elevation of +/-157 ft due to the ceiling height in the BDF centrifuge mezzanine area. At this proposed elevation, the standpipe would provide a total backpressure of 9 to 14 psi on the existing BDF sludge feed pressure monitoring instrument (PIT-110) which is located on the sludge blowoff standpipe at an elevation +/-142.5 ft (above the mezzanine floor). The 5-psi range of the backpressure provided by the standpipe is the result of varying excess sludge return flows through the 8-inch excess sludge return piping.

The new standpipe elevation would result in a constant 17.5 ft of sludge column above the suction side of centrifuge feed equipment (flooded suction to grinders and centrifuge feed pumps) as long as sludge is circulating through the BDF sludge loop. Monitoring and adjusting the SFP operations based on the return sludge flow in lieu of the sludge feed header pressure will result in operational flexibility and minimize "false alarm" equipment shutdowns. The proposed standpipe elevation would result in vertical pipe drops of 23 ft, 15.5 ft and 12.5 ft on the excess sludge return line. Piping restraints would be provided to account for forces exerted on the pipe as a result of the pipe drop. Drainage and flushing locations would be provided at locations as determined during detailed design.

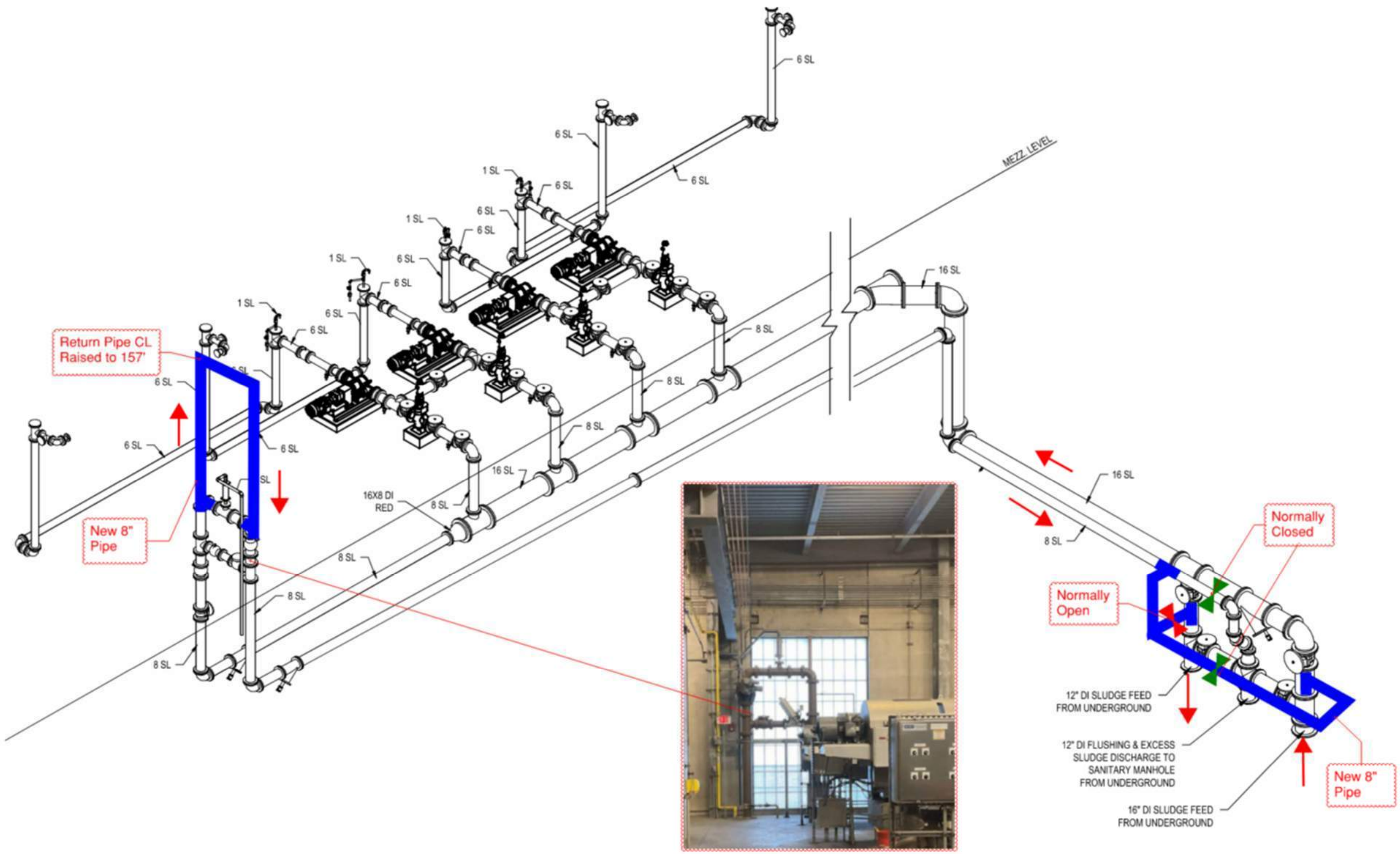

Figure 5-1: Proposed BDF Sludge Feed Line Modifications at BDF

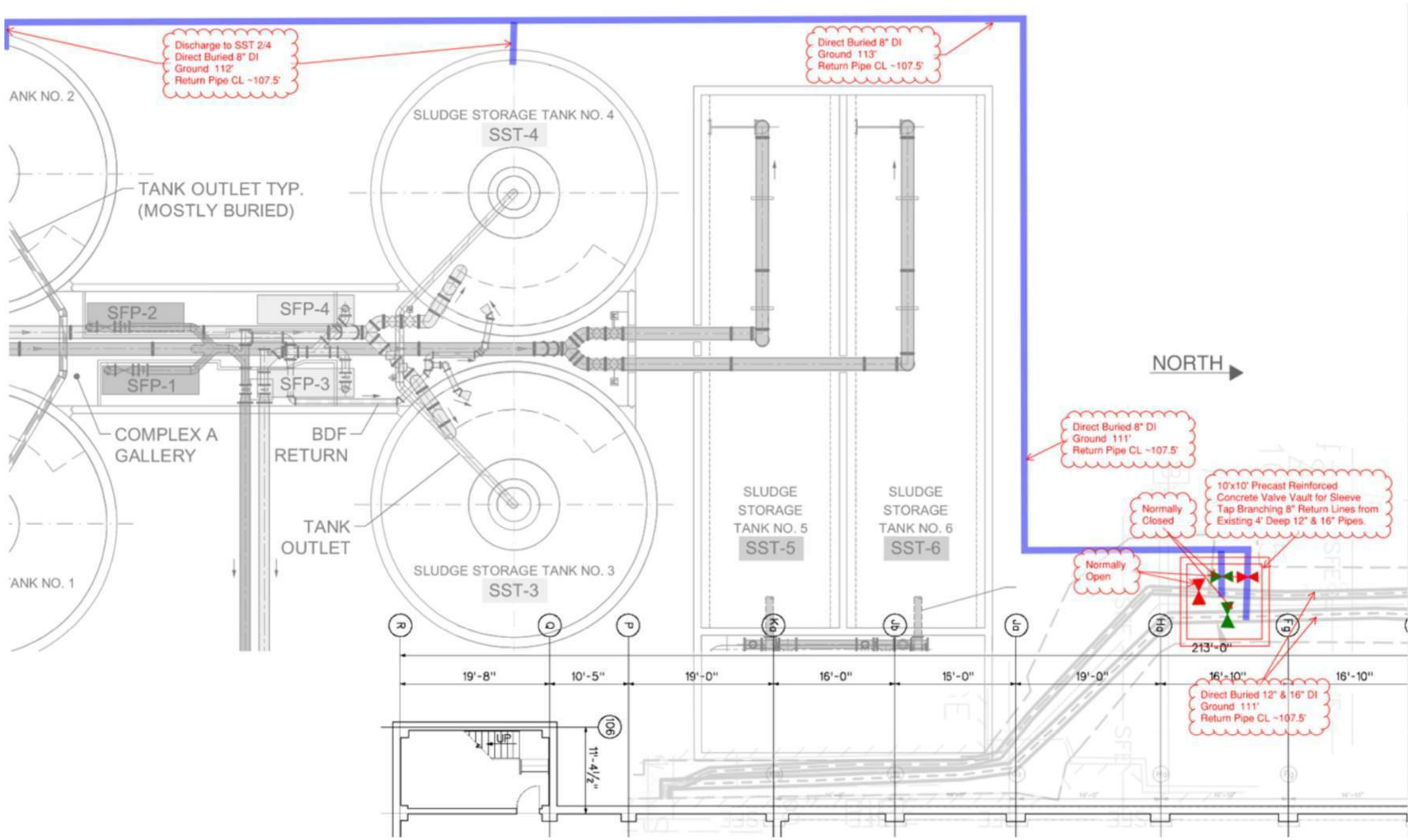

Figure 5-2: Proposed BDF Sludge Feed Line Modifications at SSTs

5.2.2 Proposed C-I Sludge Loop

The proposed C-I sludge loop includes utilizing the existing C-I sludge feed header and adding a return line from the downstream end of the feed header back to the SSTs. A standpipe will be provided on the excess sludge return line to provide backpressure on the C-I sludge feed header. **Figure 5-3** displays the proposed routing to implement the proposed C-I sludge loop.

A 6-inch ductile iron excess sludge return line will be branched from the sludge feed header in the basement of C-I between the BFP 3 and BFP 5 feed branches. The return line will be routed toward the west end of the C-I basement along the pipe corridor on the south wall. The pipe will then penetrate the C-I basement ceiling and enter the west end of the Polymer Room on the C-I upper level. Routing will then continue through paneling on the west end of the Polymer Room and enter the C-II centrifuge dewatering level. The return line will then be routed vertically on the south wall of C-II to the 5th floor passing through a utility chase on the 4th floor. The C-I sludge loop standpipe will be located on the 5th floor of C-II at an elevation of 172 ft as shown in **Figure 5-4**. This elevation will result in 68 ft of static head pressure and +/-30 psi of total head above the existing C-I sludge header pressure transmitter which is within the required operating pressure range of 25 to 40 psi as noted in TM-4.

Excess sludge passing through the standpipe will vertically drop to the C-II 3rd floor where it will be routed westward above the bridge crane in the centrifuge dewatering area prior to being routed south and then dropping again vertically to the C-II first floor level. The piping will then be routed from C-II to the SSTs 5/6 Pump Building and lastly to its discharge locations through the SSTs 5/6 east walls. Return piping in the SSTs 5/6 Pump Building will be routed to avoid the existing monorail crane. The full length of the C-I sludge loop will be located within climate-controlled spaces except for the 6 feet of pipe section spanning C-II and the SSTs 5/6 Pump Building. This section of piping will be provided with heat tracing or a pipe chase can be constructed to connect this pipe section to the C-II air space.

Excess C-I sludge return flows are expected to range from 250 to 600 gpm which will result in expected line velocities of 2.8 to 6.8 ft/s through the 6-inch return sludge pipe. These velocities in combination with the piping elevation drops throughout the pipe routing are expected to minimize solids accumulation within the sludge loop. Drainage and flushing locations would be provided at locations as determined during detailed design. Vertical pipe drops of 19 ft and 27 ft are being proposed. Piping restraints would be provided to account for forces exerted on the pipe as a result of the pipe drops in these locations.

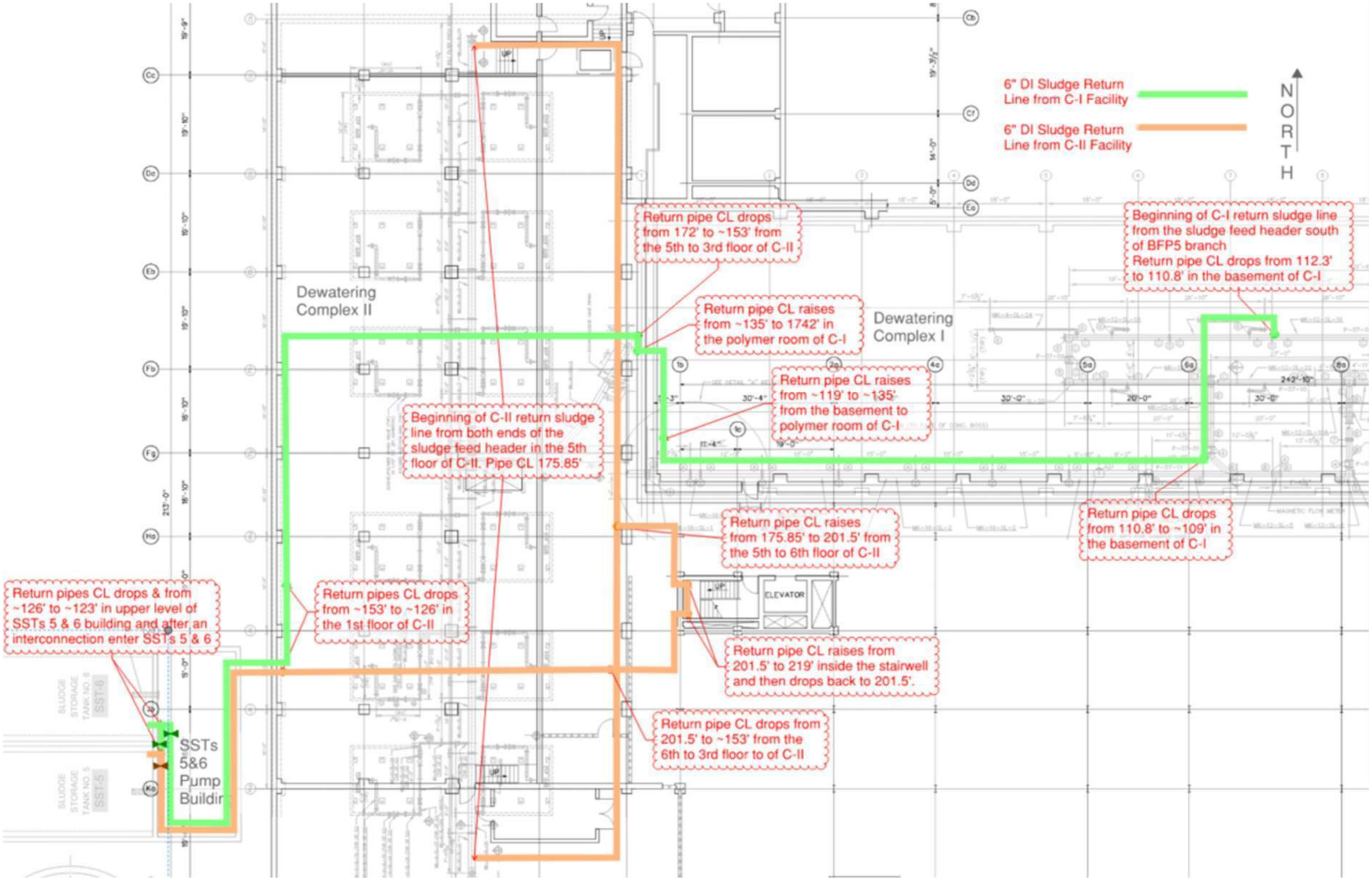

Figure 5-3: Proposed C-I and C-II Excess Sludge Return Pipe Routing

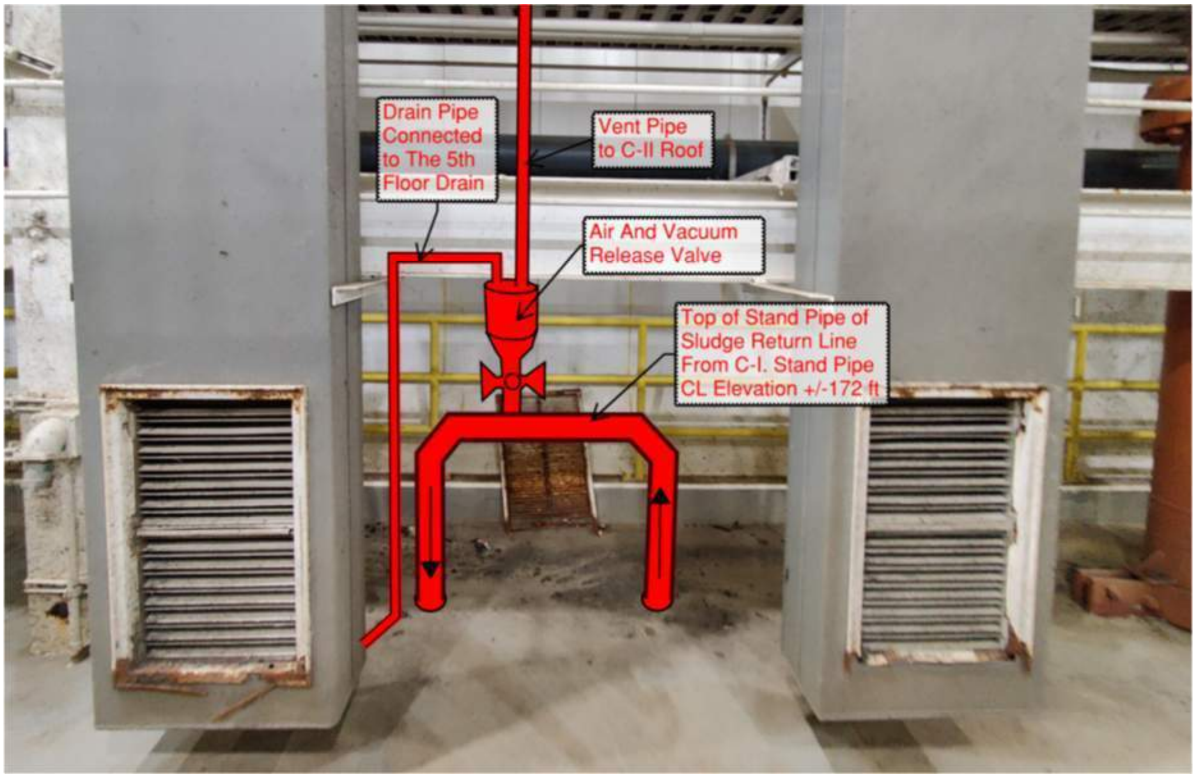

Figure 5-4: Proposed C-I Standpipe on C-II 5th Floor

5.2.3 Proposed C-II Sludge Loop

The proposed C-II sludge loop includes utilizing the existing C-II sludge feed header and adding a return line from the downstream end of the feed header back to the SSTs. A standpipe will be provided on the excess sludge return line to provide backpressure on the C-II sludge feed header. **Figure 5-3** displays the proposed routing to implement the proposed C-II sludge loop.

A 6-inch ductile iron excess sludge return line will be branched from each end of the sludge feed header on the C-II 5th floor. The two lines will be routed to the east wall of the BFP area and combine into 6-inch return line. The pipe will then be routed above the Electrical Room prior to penetrating the C-II stairwell. In the stairwell, the pipe will be routed vertically to the standpipe location at elevation 219 ft as shown in **Figure 5-5**. This elevation will result in 43 feet of static head pressure and +/-22 psi total head above the existing C-II sludge header pressure transmitters which is within the required operating pressure range of 15 to 30 psi as determined in TM-4.

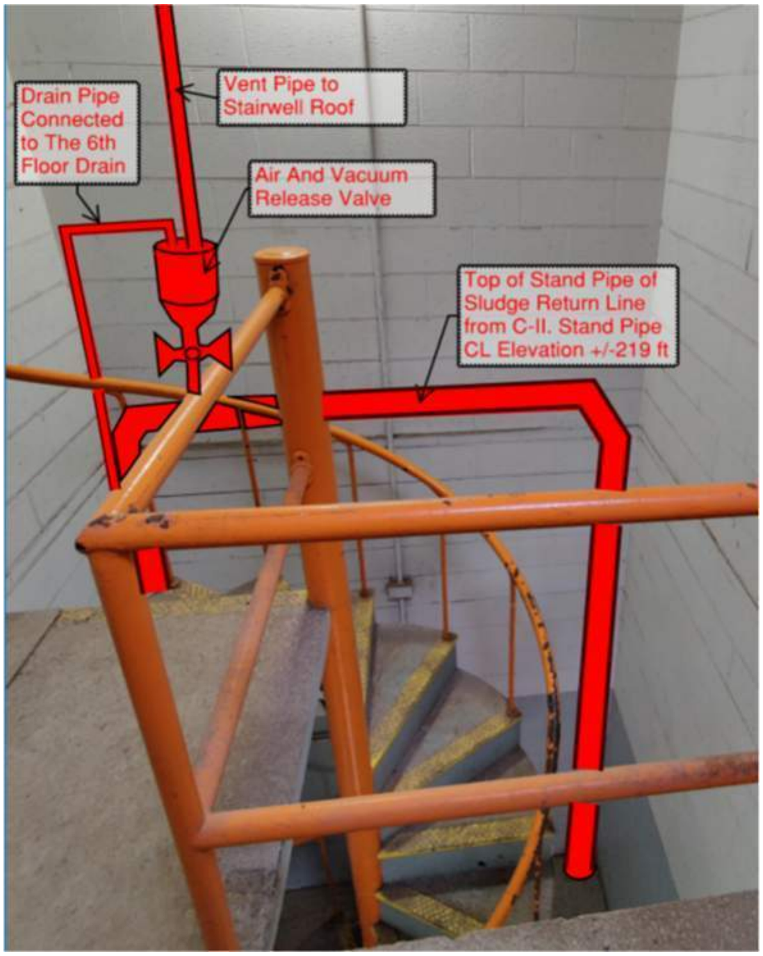

Figure 5-5: Proposed C-II Standpipe in C-II Stairwell

Excess sludge passing through the standpipe will vertically drop in the stairwell prior to entering the C-II 6th floor where it will then be routed vertically down to the C-II 3rd floor level. Routing will continue westward above the bridge crane in the centrifuge dewatering area prior to being routed south and then dropping again vertically to the C-II first floor level. The piping will then be routed from C-II to the SSTs 5/6 Pump Building and lastly to its discharge locations through the SSTs 5 and 6 east walls. Return piping in the SSTs 5/6 Pump Building will be routed to avoid the existing monorail crane. The full length of the C-II sludge loop will be located within climate-controlled spaces except for the 6 feet of pipe section spanning C-II and the SSTs 5/6 Pump Building. This section of piping will be provided with heat tracing or a pipe chase can be constructed to connect this pipe section to the C-II air space.

Excess C-II sludge return flows are expected to range from 250 to 600 gpm which will result in expected line velocities of 2.8 to 6.8 ft/s through the 6-inch return sludge pipe. These velocities in combination with the piping elevation drops throughout the pipe routing are expected to minimize solids accumulation within the sludge loop. Vertical pipe drops of 17.5 ft, 48.5 ft, and 27 ft are being proposed. Piping restraints would be provided to account for forces exerted on the pipe as a result of the pipe drops in these locations. Modifying the pipe routing to change the 48.5 ft vertical pipe drop into two lesser elevation drops may be desired to lower the forces exerted on the piping systems. This as well as providing drainage and flushing locations would be s determined during detailed design.

6.0 Final Alternative Comparison and Recommendation

Three alternatives have been shortlisted for further consideration (Atl-2A, Alt-2B, and Alt-2C). Operating scenarios, advantages and disadvantages, and associated lifecycle costs for each alternative were analyzed. Lifecycle cost assumptions include:

- 2023 baseline year
- 20-year lifecycle period
- 4.0% escalation rate
- $0.14 electricity costs ($/kWh)
- 20% Contractor's overhead and profit, including permit costs, insurances, bonds and sales tax
- 30% Contingency

6.1 Alternative 2A – 4 Rotary Lobe Pumps in SSTs 5/6 Pump Building

6.1.1 Proposed Improvements

Four rotodynamic chopper pumps (SFPs 1-4) each sized for 900 to 1,300 gpm at 48' to 79' TDH would be provided in the SSTs 1-4 Pipe Gallery. SFPs 1-4 would be dedicated to conveying sludge from SSTs 1-4 (typically SSTs 3/4) to the BDF CFGs under normal operating conditions. These pumps would also serve as backup to convey sludge from SSTs 1/2 to the C-II BFPs if needed during a BDF outage. Four rotary lobe pumps (SFPs 5-8) each sized for 800 to 1,000 gpm at 73' to 140' TDH would be provided in the basement of the SST 5/6 Pump Building to convey sludge from SSTs 5/6 to the C-I and C-II BFPs.

Improvements required to implement Alt-2A include:

- Four chopper pumps including power, controls, and associated suction and discharge piping in the SSTs 1-4 Pipe Gallery. NOTE – Raising the SST floors and tank walls is not recommended unless it is warranted per the outcome of TM-6.
- Four rotary lobe pumps including power, controls, and associated suction and discharge piping in the SSTs 5/6 Pump Building.

- Four grinders including power and controls upstream of the rotary lobe pumps in the SSTs 5/6 Pump Building.
- Expand SSTs 5/6 Pump Building to accommodate pump layout including all necessary structural, architectural, HVAC, plumbing, electrical, and automation improvements.
- Proposed full sludge loop improvements as outlined in Section 5.0.

6.1.2 Operational Scenarios

Minimum, average, maximum, and BDF outage scenarios were considered to determine how Alt-2A would accommodate various dewatering demand requirements. The scenarios are based on:

- Minimum - minimum sludge flow requirements at the minimum percent solids.
- Average - average sludge flow requirements at the average percent solids.
- Maximum - maximum sludge flow requirements at the average percent solids.
- BDF Outage - maximum solids loading to meet NPDES requirements.

Table 6-1 displays the pumping requirements and excess sludge return flows expected for each scenario in the Alt-2A configuration. Based on operational data for the past 3 years, the average operating scenario is the expected condition more than 50% of the time.

Table 6-1: Alt-2A Operating Scenarios

Scenario	Facility	Required Flow (gpm)	Pumps in Service	Pumps in Standby	Pumped Flow (gpm)	Return Flow (gpm)	Approx. Pump Head (ft)	Approx. Pump Speed (% or rpm)	Feed Header Velocity (ft/s)	Return Line Velocity (ft/s)
Minimum	BDF	350	1	3	1,300	950	48	77%	2.1-3.7[4]	2.7-6.1[5]
	C-I[1]	200	1	1	800	600	73	210	1.3-2.3[4]	6.8[6]
	C-II[1]	200	1	1	800	600	129	220	1.3-2.3[4]	6.8[6]
Average	BDF	1,200	2	2	1,800	600	63	77%	2.9-5.1[4]	1.7-3.8[5]
	C-I[1]	450	1	1	800	350	85	215	1.3-2.3[4]	4.0[6]
	C-II[1]	450	1	1	800	350	135	225	1.3-2.3[4]	4.0[6]
Maximum	BDF	2400	3	1	3,000	600	79	85%	4.8-8.5[4]	1.7-3.8[5]
	C-I[1]	750	1	1	1,000	250	96	250	1.6-2.8[4]	2.8[6]
	C-II[1]	750	1	1	1,000	250	140	260	1.6-2.8[4]	2.8[6]
BDF Outage	BDF	-	-	-	-	-	-	-	-	-
	C-I[2]	1,500	2	2	1,750	250	95	89%	2.8-5.0[4]	2.8[6]
	C-II[3]	1,800	2	2	2,050	250	150	270	3.3-5.8[4]	2.8[6]

[1] Based on historic operating data, typically only C-I or C-II (not both) are in operation during the minimum, average, and maximum scenarios. Values for C-I and C-II are shown to display that either facility can accommodate the scenario.

[2] During a BDF outage, 2 of the BDF feed pumps can be used to feed all 10 BFPs in C-I.

[3] During a BDF outage, all 4 of the pumps in the SSTs 5/6 Pump Building are available to feed all 12 BPFs in C-II (only 2 pumps are needed).

[4] 12-inch and 16-inch sludge feed headers.

[5] 8-inch and 12-inch sludge return lines.

[6] 6-inch sludge return line.

6.1.3 Lifecycle Costs

A lifecycle cost analysis was performed to determine the present-day costs of implementing the Alt-2A improvements. A breakdown of the cost items is presented below.

- SSTs 1-4 Pipe Gallery - Equipment and Piping Improvements $2,375,000
- SSTs 5/6 Pump Building – Equipment and Piping Improvements $3,460,000
- Sludge Loop Improvements $1,950,000
- SSTs 5/6 Pump Building Expansion $1,760,000
- Electrical and Automation $2,945,000

- **Total Capital Cost** **$12,490,000**
- Lifecycle Energy Cost $2,420,000
- Lifecycle Preventative Maintenance Cost $500,000
- Lifecycle Rehab Maintenance Cost $135,000
- **Total Lifecycle Cost** **$15,545,000**

6.1.4 Advantages

Advantages of Alt-2A when compared to the other alternatives include the following:

- C-I SFPs and C-II SFPs can be used interchangeably to feed either C-I, C-II, or both facilities.
- C-I and C-II SFPs each have a standby pump for redundancy.
- SSTs 5/6 Building expansion allows for adequate clearances around equipment for maintenance activities.

6.1.5 Disadvantages

Disadvantages of Alt-2A when compared to other alternatives include the following:

- Most added equipment (8 pumps, 4 grinders).
- Highest maintenance requirements.
- Highest capital and lifecycle costs.
- Equipment learning curve – plant staff are not familiar with rotary lobe pumps.
- Rotary lobe replacement parts are expensive (lobes).
- Includes three different types of equipment (chopper pumps, rotary lobe pumps, grinders).

6.2 Alternative 2B – 3 Rotary Lobe Pumps in SSTs 5/6 Pump Building

6.2.1 Proposed Improvements

Four rotodynamic chopper pumps (SFPs 1-4) each sized for 900 to 1300 gpm at 48’ to 79’ TDH would be provided in the SSTs 1-4 Pipe Gallery. SFPs 1-4 would be dedicated to conveying sludge from SSTs 1-4 (typically SSTs3/4) to the BDF CFGs under normal operating conditions. These pumps would also serve as backup to convey sludge from SSTs 1/2 to the C-II BFPs if needed during a BDF outage. Three rotary lobe pumps (SFPs 5-7) each sized for 800 to 1,000 gpm at 73’ to 140’

TDH would be provided in the basement of the SST 5/6 Pump Building to convey sludge from SSTs 5/6 to the C-I and C-II BFPs.

Improvements required to implement Alt-2B include:

- Four chopper pumps including power, controls, and associated suction and discharge piping in the SSTs 1-4 Pipe Gallery. NOTE – Raising the SST floors and tank walls is not recommended unless it is warranted per the outcome of TM-6.
- Three rotary lobe pumps including power, controls, and associated suction and discharge piping in the SSTs 5/6 Pump Building.
- Three grinders including power and controls upstream of the rotary lobe pumps in the SSTs 5/6 Pump Building.
- Modify concrete column in the basement of SSTs 5/6 Pump Building to accommodate the pump layout.
- Proposed full sludge loop improvements as outlined in Section 5.0.

6.2.2 Operational Scenarios

Minimum, average, maximum, and BDF outage scenarios were considered to determine how Alt-2B would accommodate various dewatering demand requirements. The scenarios are based on:

- Minimum – minimum sludge flow requirements at the minimum percent solids.
- Average – average sludge flow requirements at the average percent solids.
- Maximum – maximum sludge flow requirements at the average percent solids.
- BDF Outage – maximum solids loading to meet NPDES requirements.

Table 6-2 displays the pumping requirements and excess sludge return flows expected for each scenario in the Alt-2B configuration. Based on operational data for the past 3 years, the average operating scenario is the expected condition more than 50% of the time.

Table 6-2: Alt-2B Operating Scenarios

Scenario	Facility	Required Flow (gpm)	Pumps in Service	Pumps in Standby	Pumped Flow (gpm)	Return Flow (gpm)	Approx. Pump Head (ft)	Approx. Pump Speed (% or rpm)	Feed Header Velocity (ft/s)	Return Line Velocity (ft/s)
Minimum	BDF	350	1	3	1,300	950	48	77%	2.1-3.7[5]	2.7-6.1[6]
	C-I[1]	200	1	1[2]	800	600	73	210	1.3-2.3[5]	6.8[7]
	C-II[1]	200	1	1[2]	800	600	129	220	1.3-2.3[5]	6.8[7]
Average	BDF	1,200	2	2	1,800	600	63	77%	2.9-5.1[5]	1.7-3.8[6]
	C-I[1]	450	1	1[2]	800	350	85	215	1.3-2.3[5]	4.0[7]
	C-II[1]	450	1	1[2]	800	350	135	225	1.3-2.3[5]	4.0[7]
Maximum	BDF	2,400	3	1	3,000	600	79	85%	4.8-8.5[5]	1.7-3.8[6]
	C-I[1]	750	1	1[2]	1,000	250	96	250	1.6-2.8[5]	2.8[7]
	C-II[1]	750	1	1[2]	1,000	250	140	260	1.6-2.8[5]	2.8[7]
BDF Outage	BDF	-	-	-	-	-	-	-	-	-
	C-I[3]	1,500	2	2	1,750	250	95	89%	2.8-5.0[5]	2.8[7]
	C-II[4]	1,800	2	1	2,050	250	150	270	3.3-5.8[5]	2.8[7]

[1] Based on historic operating data, typically only C-I or C-II (not both) are in operation during the minimum, average, and maximum scenarios. Values for C-I and C-II are shown to display that either facility can accommodate the scenario.

[2] C-I and C-II SFPs share a common standby pump in this Alt-2B.

[3] During a BDF outage, 2 of the BDF feed pumps can be used to feed all 10 BFPs in C-I.

[4] During a BDF outage, all 3 of the pumps in the SSTs 5/6 Pump Building are available to feed all 12 BPFs in C-II (only 2 pumps are needed).

[5] 12-inch and 16-inch sludge feed headers.

[6] 8-inch and 12-inch sludge return lines.

[7] 6-inch sludge return line.

6.2.3 Lifecycle Costs

A lifecycle cost analysis was performed to determine the present-day costs of implementing the Alt-2B improvements. A breakdown of the cost items is presented below.

SSTs 1-4 Pipe Gallery – Equipment and Piping Improvements	$2,375,000
SSTs 5/6 Pump Building – Equipment and Piping Improvements	$3,035,000
Sludge Loop Improvements	$1,950,000
Electrical and Automation	$2,650,000
Total Capital Cost	**$10,010,000**
Lifecycle Energy Cost	$2,420,000
Lifecycle Preventative Maintenance Cost	$500,000
Lifecycle Rehab Maintenance Cost	$175,000
Total Lifecycle Cost	**$13,105,000**

6.2.4 Advantages

Advantages of Alt-2B when compared to the other alternatives include the following:

- C-I SFPs and C-II SFPs can be used interchangeably to feed either C-I, C-II, or both facilities.
- No building expansions required.

6.2.5 Disadvantages

Disadvantages of Alt-2B when compared to other alternatives include the following:

- Second most added equipment (7 pumps, 3 grinders).
- C-I and C-II SFPs share a standby pump (limited redundancy).
- Second highest maintenance requirements.
- Second highest capital and lifecycle costs.
- Clearance around equipment is adequate but less than ideal.
- Equipment learning curve – plant staff are not familiar with rotary lobe pumps.
- Rotary lobe replacement parts are expensive (lobes).

- Includes three different types of equipment (chopper pumps, rotary lobe pumps, grinders).

6.3 Alternative 2C – 5 Chopper Pumps in SSTs 5/6 Pump Building

6.3.1 Proposed Improvements

Four rotodynamic chopper pumps (SFPs 1-4) each sized for 900 to 1,300 gpm at 48' to 79' TDH would be provided in the SSTs 1-4 Pipe Gallery. SFPs 1-4 would be dedicated to conveying sludge from SSTs 1-4 (typically SSTs 3/4) to the BDF CFGs under normal operating conditions. These pumps would also serve as backup to convey sludge from SSTs 1/2 to the C-I BFPs if needed during a BDF outage. Three rotodynamic chopper pumps (SFPs 5-7) each sized for 725 to 1,025 gpm at 129' to 150' TDH would be provided in the basement of the SST 5/6 Pump Building to convey sludge from SSTs 5/6 to the C-II BFPs. Two rotodynamic chopper pumps (SFPs 8-9) each sized for 800 to 1,300 gpm at 73' to 96' TDH would be provided in the basement of the SST 5/6 Pump Building to convey sludge from SSTs 5/6 to the C-I BFPs.

Improvements required to implement Alt-2C include:

- Four chopper pumps including power, controls, and associated suction and discharge piping in the SSTs 1-4 Pipe Gallery. NOTE – Raising the SSTs' floors and tank walls is not recommended unless it is warranted per the outcome of TM-6.
- Five chopper pumps including power, controls, and associated suction and discharge piping in the SSTs 5/6 Pump Building.
- Modify concrete column in the basement of SSTs 5/6 Pump Building to accommodate the pump layout.
- Proposed full sludge loop improvements as outlined in Section 5.0.

6.3.2 Operational Scenarios

Minimum, average, maximum, and BDF outage scenarios were considered to determine how Alt-2C would accommodate various dewatering demand requirements. The scenarios are based on:

- Minimum – minimum sludge flow requirements at the minimum percent solids.
- Average – average sludge flow requirements at the average percent solids.
- Maximum – maximum sludge flow requirements at the average percent solids.
- BDF Outage – maximum solids loading to meet NPDES requirements.

Table 6-3 displays the pumping requirements and excess sludge return flows expected for each scenario in the Alt-2C configuration. Based on operational data for the past 3 years, the average operating scenario is the expected condition more than 50% of the time.

Table 6-3: Alt-2C Operating Scenarios

Scenario	Facility	Required Flow (gpm)	Pumps in Service	Pumps in Standby	Pumped Flow (gpm)	Return Flow (gpm)	Approx. Pump Head (ft)	Approx. Pump Speed (% or rpm)	Feed Header Velocity (ft/s)	Return Line Velocity (ft/s)
Minimum	BDF	350	1	3	1,300	950	48	77%	2.1-3.7[3]	2.7-6.1[4]
	C-I[1]	200	1	1	800	600	73	78%	1.3-2.3[3]	6.8[5]
	C-II[1]	200	1	1	800	600	129	73%	1.3-2.3[3]	6.8[5]
Average	BDF	1,200	2	2	1,800	600	63	77%	2.9-5.1[3]	1.7-3.8[4]
	C-I[1]	450	1	1	800	350	85	82%	1.3-2.3[3]	4.0[5]
	C-II[1]	450	1	1	800	350	135	75%	1.3-2.3[3]	4.0[5]
Maximum	BDF	2,400	3	1	3,000	600	79	85%	4.8-8.5[3]	1.7-3.8[4]
	C-I[1]	750	1	1	1,000	250	96	90%	1.6-2.8[3]	2.8[5]
	C-II[1]	750	1	1	1,000	250	140	80%	1.6-2.8[3]	2.8[5]
BDF Outage	BDF	-	-	-	-	-	-	-	-	-
	C-I[2]	1,500	2	2	1,750	250	95	89%	2.8-5.0[3]	2.8[5]
	C-II	1,800	2	2	2,050	250	150	82%	3.3-5.8[3]	2.8[5]

[1] Based on historic operating data, typically only C-I or C-II (not both) are in operation during the minimum, average, and maximum scenarios. Values for C-I and C-II are shown to display that either facility can accommodate the scenario.

[2] During a BDF outage, 2 of the BDF feed pumps can be used to feed all 10 BFPs in C-I. Note – the 4 BDF SFPs and the 2 C-I SFPs are the same pump model in different configurations. These pumps can be used interchangeably.

[3] 12-inch and 16-inch sludge feed headers.

[4] 8-inch and 12-inch sludge return lines.

[5] 6-inch sludge return line.

6.3.3 Lifecycle Costs

A lifecycle cost analysis was performed to determine the present-day costs of implementing the Alt-2C improvements. A breakdown of the cost items is presented below.

- SSTs 1-4 Pipe Gallery – Equipment and Piping Improvements $2,375,000
- SSTs 5/6 Pump Building – Equipment and Piping Improvements $2,965,000
- Sludge Loop Improvements $1,950,000
- Electrical and Automation $2,650,000
- **Total Capital Cost** **$9,940,000**

- Lifecycle Energy Cost $2,260,000
- Lifecycle Preventative Maintenance Cost $320,000
- Lifecycle Rehab Maintenance Cost $45,000
- **Total Lifecycle Cost** **$12,565,000**

6.4 Recommendation

Based on the pumping systems evaluation performed in this TM-5B, CDM Smith has determined that Alt-2A, Alt-2B, and Alt-2C can all be successfully implemented to meet this project's objectives. Alt-2C offers some distinct advantages over the other two shortlisted alternatives. Alt-2C includes chopper pumps for all SFPs. Chopper pumps have proven successful in this application and plant staff are familiar with their operation and maintenance requirements. These pumps and their replacement parts are much less expensive and require less maintenance when compared to rotary lobe pumps and grinders. Providing chopper pumps in the SSTs 5/6 Pump Building in a vertical configuration allows the pumps to fit within the existing building footprint. The Alt-2C C-II flexibility disadvantage discussed above is overcome by the addition of a third C-II SFP. The two C-II duty SFPs are capable of feeding all 12 C-II BFPs with an additional SFP provided as standby. The C-I and BDF SFPs are the same pump model (different configurations) and can be used interchangeably or to supplement each other. Alt-2C provides operational flexibility across numerous WRRF operating scenarios. This alternative also results in the lowest capital and lifecycle costs of the three alternatives shortlisted. CDM Smith recommends implementing Alt-2C along with incorporating full sludge loops with standpipes provided for sludge header backpressure as proposed in this TM-5B.

7.0 Final Design Decisions

The Great Lakes Water Authority (GLWA), NEFCO, and the CDM Smith team held Workshop 2 for the GLWA WRRF Improvements to the Sludge Feed System for Solids Processing project on November 6, 2023, in person and via Teams. The team vetted the alternatives presented in this TM and made selections. Selected alternatives and final design decisions are the following:

- Pumping Systems: Alt-2B 3 Rotary Lobe Pumps in SSTs 5/6 Pump Building.
- No building expansions.
- Sludge Loops: Full sludge loops with standpipes for backpressure as proposed in this TM-5B.
- Sludge Loops: BDF yard piping (12" and 16") to be CCTV inspected and cleaned (if needed) during construction.
- Sludge Loops: Existing BDF short loop to be maintained or modified (manual throttling valve) for emergency backup to full sludge loop.

cc: File

Technical Memorandum 5C

To: *Scott Worth, PMA*
Sham Sihabdeen, AECOM
Chris Wilson, GLWA

From: *Steve Wyman, CDM Smith*
Mohsen Sadatiyan, CDM Smith

Date: *August 2, 2024*

Subject: *Great Lakes Water Authority (GLWA)*
Contract No. 2202790 – Water Resource Recovery Facility (WRRF) Improvements to the Sludge Feed System for Solids Processing
TM-5C SFPs 1-4 Additional Pumping System Evaluation

1.0 Purpose

The Great Lakes Water Authority (GLWA), NEFCO, and CDM Smith team held Workshop 5 for the GLWA WRRF Improvements to the Sludge Feed System for Solids Processing project on July 15, 2024, in person and via Teams. Workshop discussions regarding the proposed BDF feed system (SFPs 1-4) configuration and standard operating procedures warranted additional evaluation. Workshop discussions included the following:

- SFP-2 was recently replaced with a smaller chopper pump and has had challenges handling rag loads. Consider increasing the proposed pump size to minimize future issues with processing rags.
- Eliminating the proposed north/south suction piping that interconnects SFPs 1-4 is preferred to increase clearances around the pumps. Evaluate if operational flexibility can be provided by other means or demonstrate how the reduced operational flexibility may not be an issue.
- Variability in the sludge blend and percent solids to BDF presents a challenge for BDF operations. Preference is for sludge to be fed to BDF from one tank or one common feed source and for the upstream sludge feeds to be as consistent/constant as possible. Evaluate SFP/SST configuration and standard operating procedures to reduce or dampen sludge variability.
- Preference is to eliminate the “Input Mode” from the SFP automatic control strategy.

CDM Smith has performed additional evaluations regarding these discussions. Summarized findings and updated recommendations are provided in this TM-5C.

2.0 SFPs 1-4 Sizing and Selection

SFPs 1-4 were originally selected to be "right sized" to best match the operating condition range required to meet the BDF sludge demands. Vaughan chopper pump model HE4S6 was selected to meet these requirements, as shown in **Figure 2-1**, and is the current basis of design.

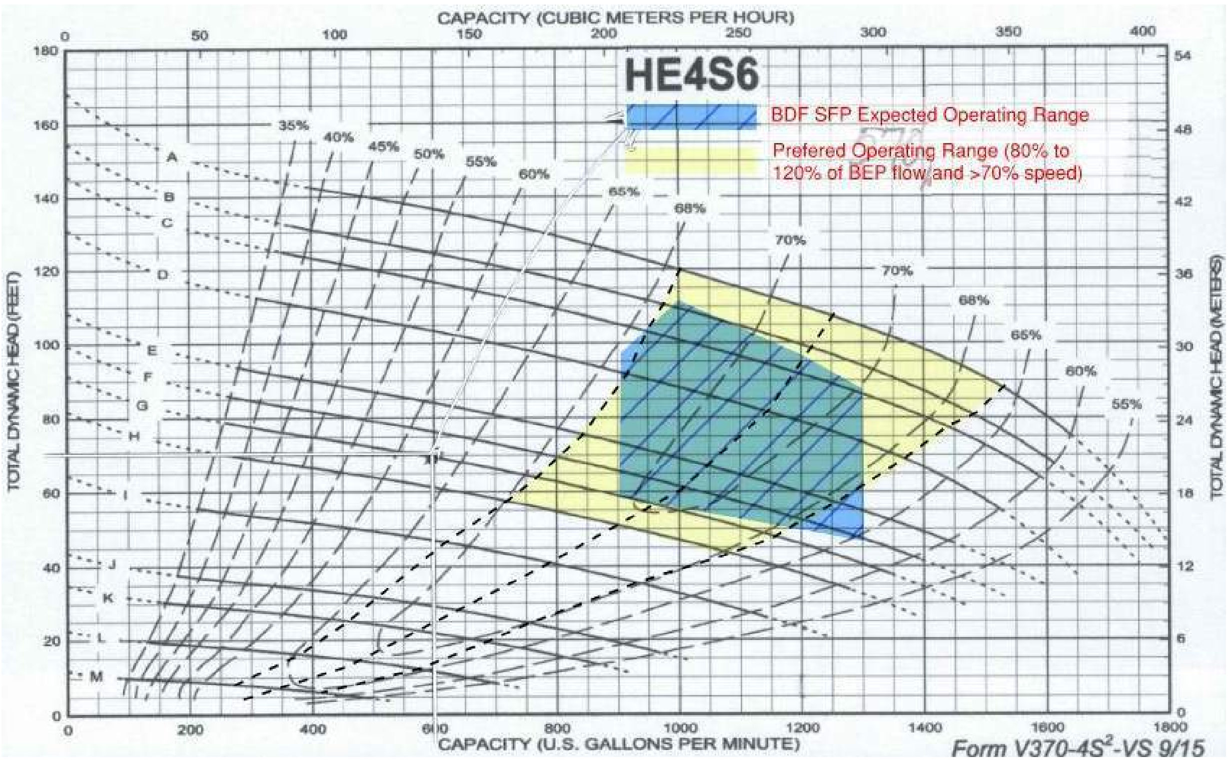

Figure 2-1: BDF SFP Expected Operating Range Overlayed on Vaughan Chopper HE4S6 Pump Curve

The Vaughn Chopper HE4S6 pump model is a 4" pump similar to the SFP-2 replacement pump that is experiencing issues processing rags. CDM Smith evaluated the next size larger 6" pump model (HE6U8) to determine if increasing the basis of design pump size is warranted. **Figure 2-2** shows the BDF expected operating range overlayed on the HE6U8 pump curve.

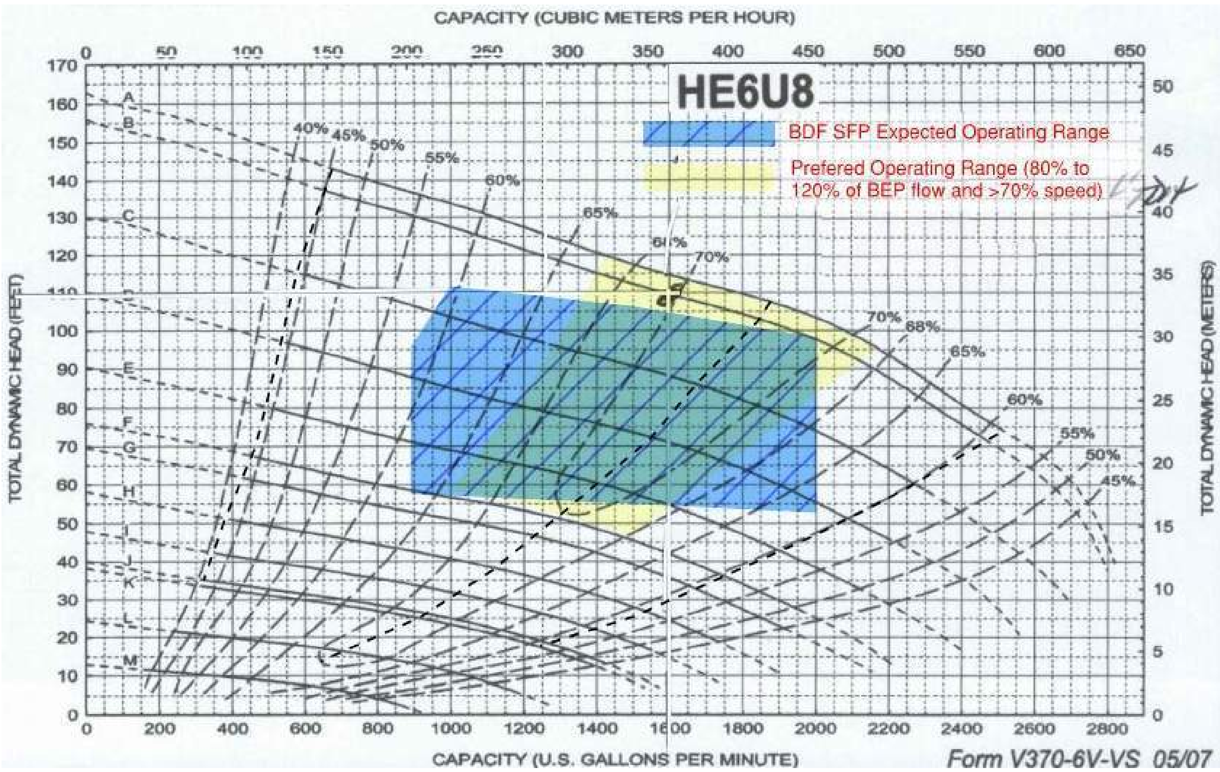

Figure 2-2: BDF SFP Expected Operating Range Overlayed on Vaughan Chopper HE6U8 Pump Curve

CDM Smith recommends increasing the basis of design pump size to the 6” HE6U8 model for the following reasons:

- Majority of the expected system operating range is still within the pump’s preferred operating range (POR).
- All of the expected system operating range is within the pump’s acceptable operating range (AOR).
- Increased operational flexibility and redundancy (2 pumps can handle all flow scenarios, vs 3 pumps required for max conditions previously).
- Reduces risk of excessive rag clogging/issues.

3.0 SFPs 1-4/SSTs 1-4 Layout, Configuration, and Standard Operating Procedures (SOPs)

Additional evaluation of the SSTs 1-4 Pipe Gallery equipment layouts, configuration, and SOPs was performed. Objectives of this evaluation were to:

- Maximize clearances around SFPs 1-4 for operation and maintenance activities.

- Provide as much operational flexibility as practical.
- Minimize sludge feed variability (blend and % solids) to BDF.

To accomplish these goals, CDM Smith recommends providing yard piping and valves to interconnect SSTs 1/3 and SSTs 2/4 as shown in **Figure 3-1** and **Figure 3-2**, and to operate each pair of tanks as one large tank during normal operating conditions. Operating a pair of tanks as one will eliminate the need for the SSTs 1-4 Pipe Gallery north/south interconnection piping, allow for maximum SFP operational flexibility, and provide a larger tank volume to dampen upstream sludge variability. The resultant SFP 1-4 layout is shown in **Figure 3-3.** This layout results in all four SFPs to be available for operation with one tank pair in service. CDM Smith also recommends evaluating the upstream processes as part of a separate task/project to determine if the consistency of the waste activated sludge (WAS) and thickened primary sludge (TPS) blend that is discharged to the SSTs can be improved.

Standard operating procedures for this SFP/SST configuration include:

- Each SST pair will be operated as one tank. One pair will be duty, one pair standby.
- A minimum level of 12' (108' elevation) will be maintained in the SSTs to sustain the tank interconnection. NOTE - This is 5' higher than the current minimum level.
- With one pair of SSTs in service, all four SFPs are available for operation.
- Sludge influent and excess sludge return will be discharged to one tank in the pair.
- One SFP will be in service during most operating flow scenarios (further discussed in later sections of this TM-5C). The tank pair will be operated such that sludge is withdrawn from one tank (SFP suction), while the other tank receives influent and excess return sludge. This is to promote circulation between tanks as displayed in **Figure 3-4**.
- Preferred operation for flow scenarios requiring two SFPs is for one south pump (SFP 1 or 2) and one north pump (SFP 3 or 4) to be in operation such that suction is pulled from both tanks. However, this is only a preference, and any two of the four pumps can be operated during these scenarios.

Figures 3-1 and 3-2 display the anticipated limits of excavation to install the yard piping and valve vaults. Required excavations will be relatively shallow and can be largely completed using hydro excavation to minimize risk associated with damaging existing utilities. Providing sluice gates within each SST could also be considered to eliminate the valve vaults and further ease construction of the yard piping.

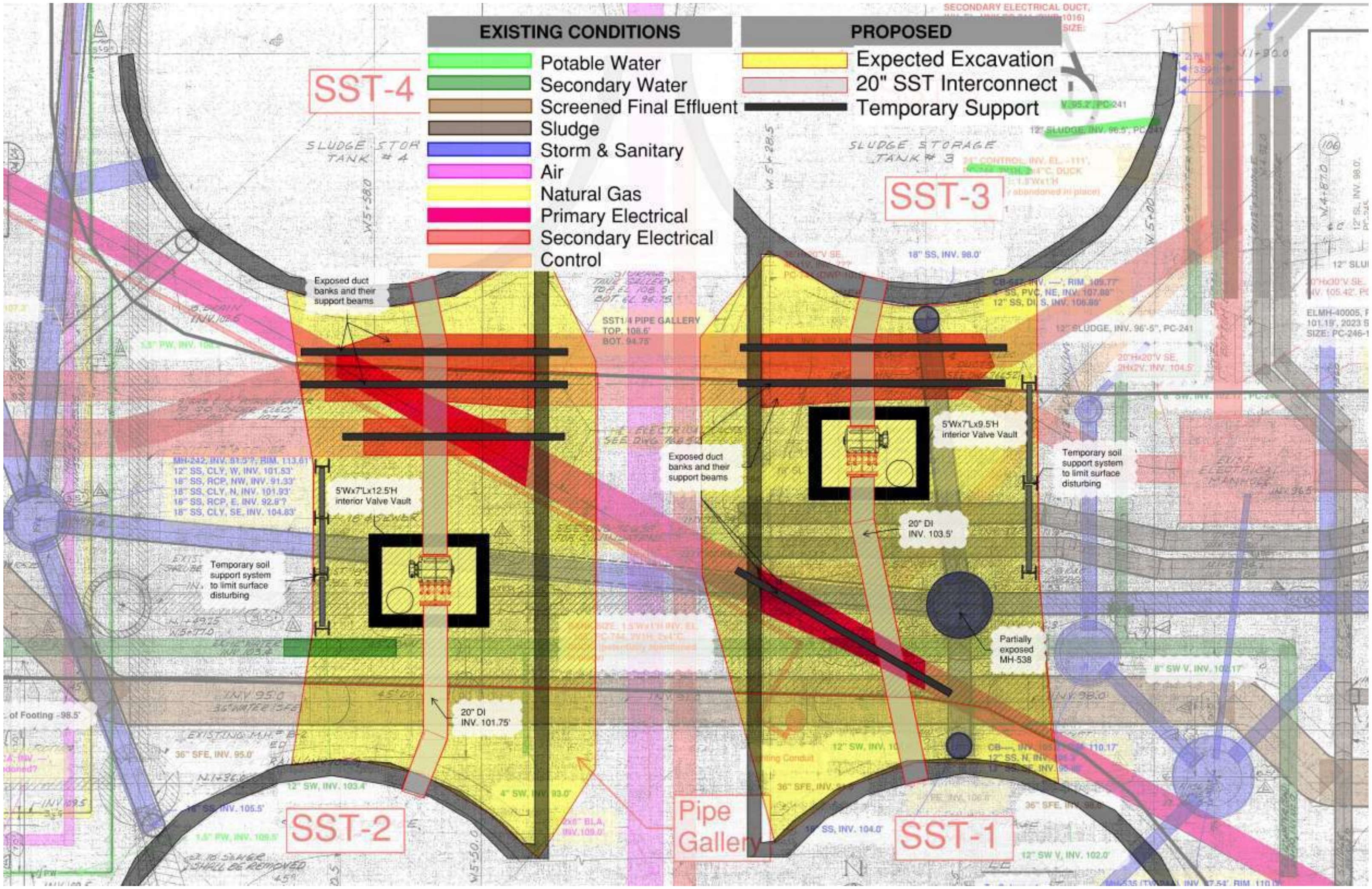

Figure 3-1: Proposed Tank Interconnections Considering Constructability (Plan View)

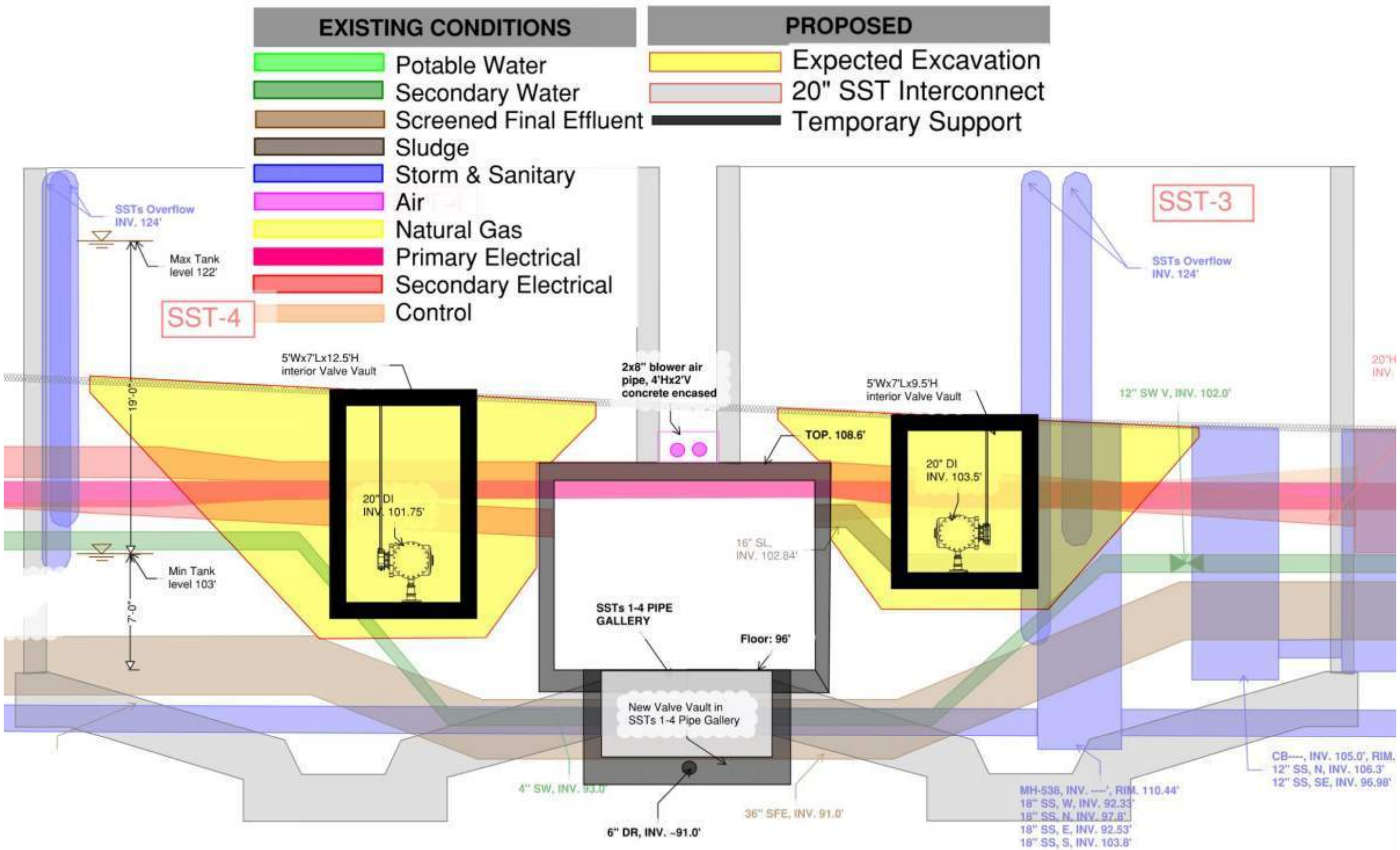

Figure 3-2: Proposed Tank Interconnections Considering Constructability (Section View)

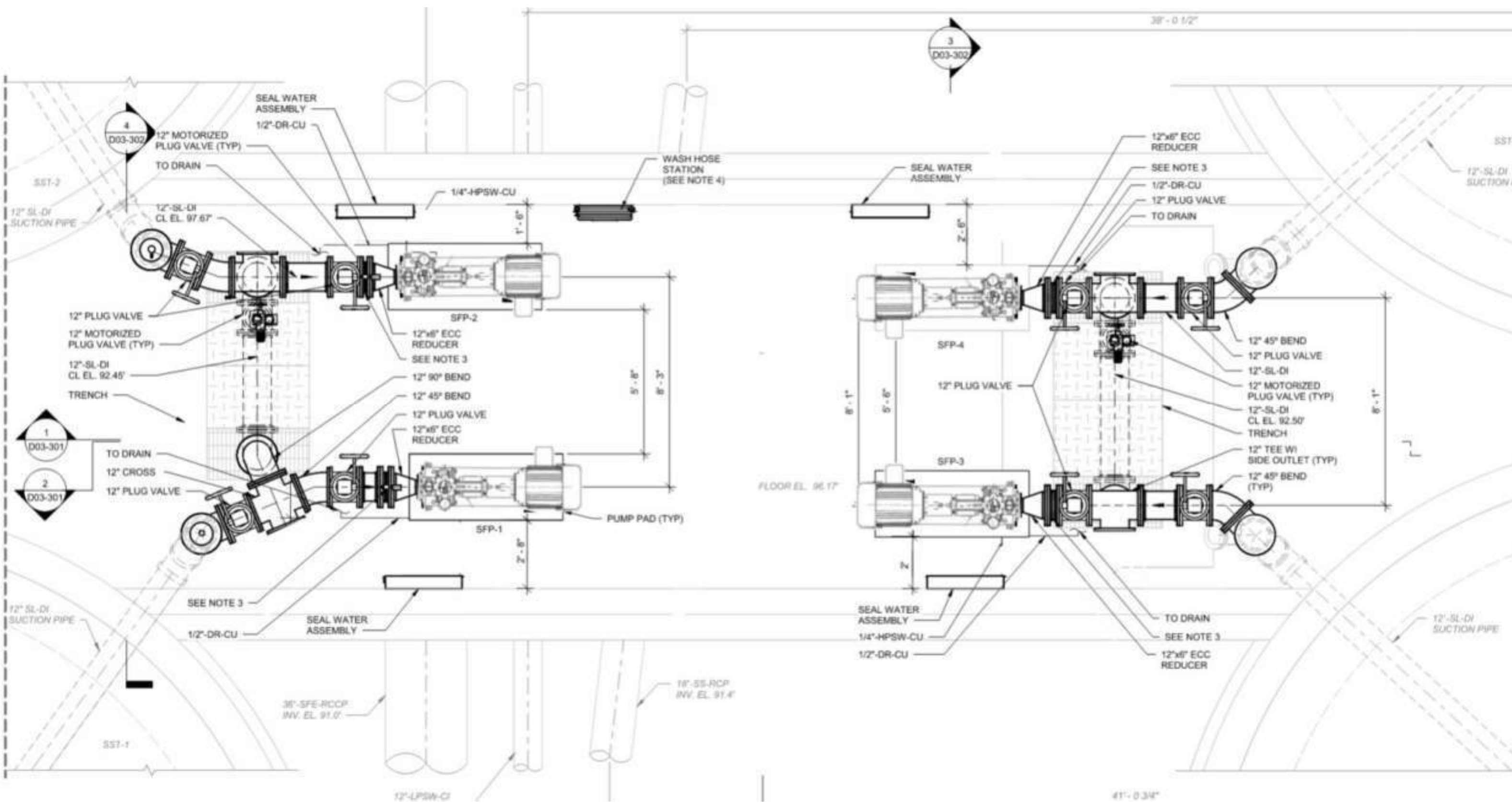

Figure 3-3: Proposed SFPs 1-4 Layout

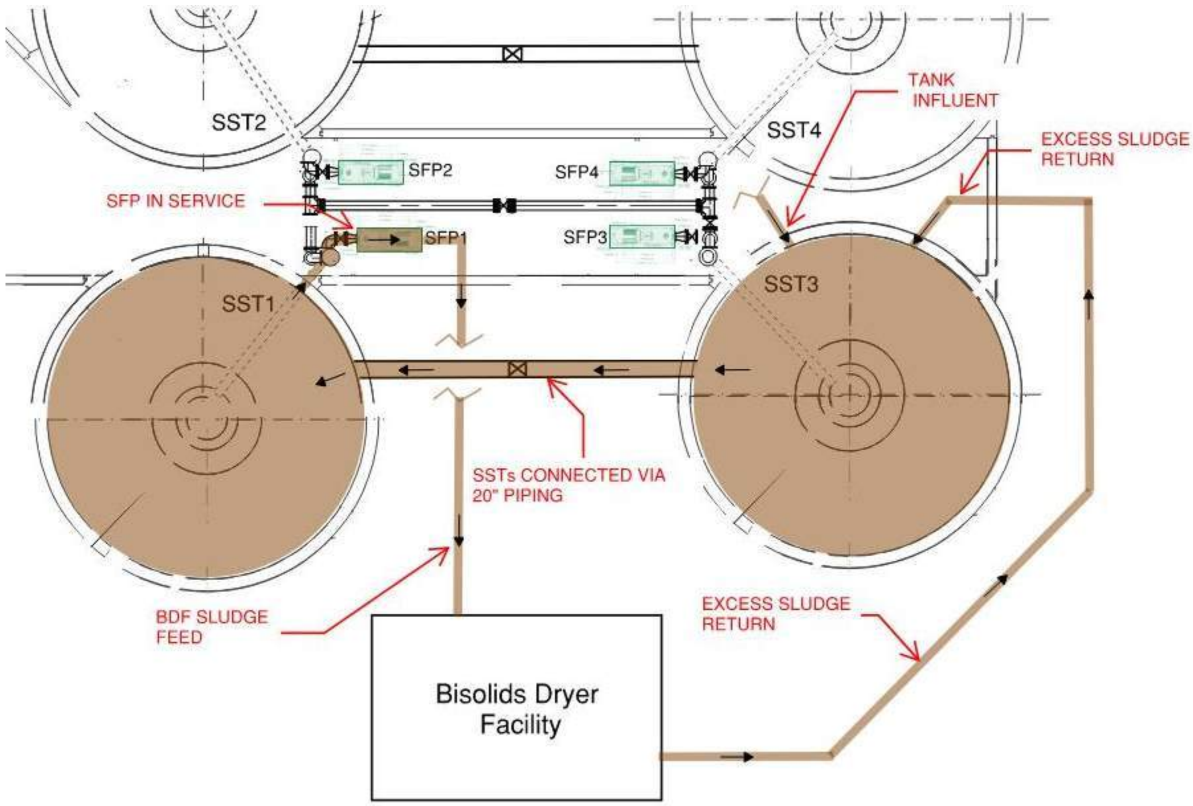

Figure 3-4: Normal Operation Flow Path (Typical)

4.0 SFP Automatic Controls

The originally proposed automatic control strategy for SFP operation included two modes of operation ("Input Mode" and "Maintain Mode"). After further evaluation, it was determined that the "Input Mode" can be eliminated as requested during Workshop 5. When sludge feed is called for by an operator, the Lead pump will automatically start at a preset minimum speed. The control logic displayed in **Figure 4-1** will then be implemented to automatically adjust pump(s) speed and/or start/stop pump(s) as required to maintain the excess sludge return flow range.

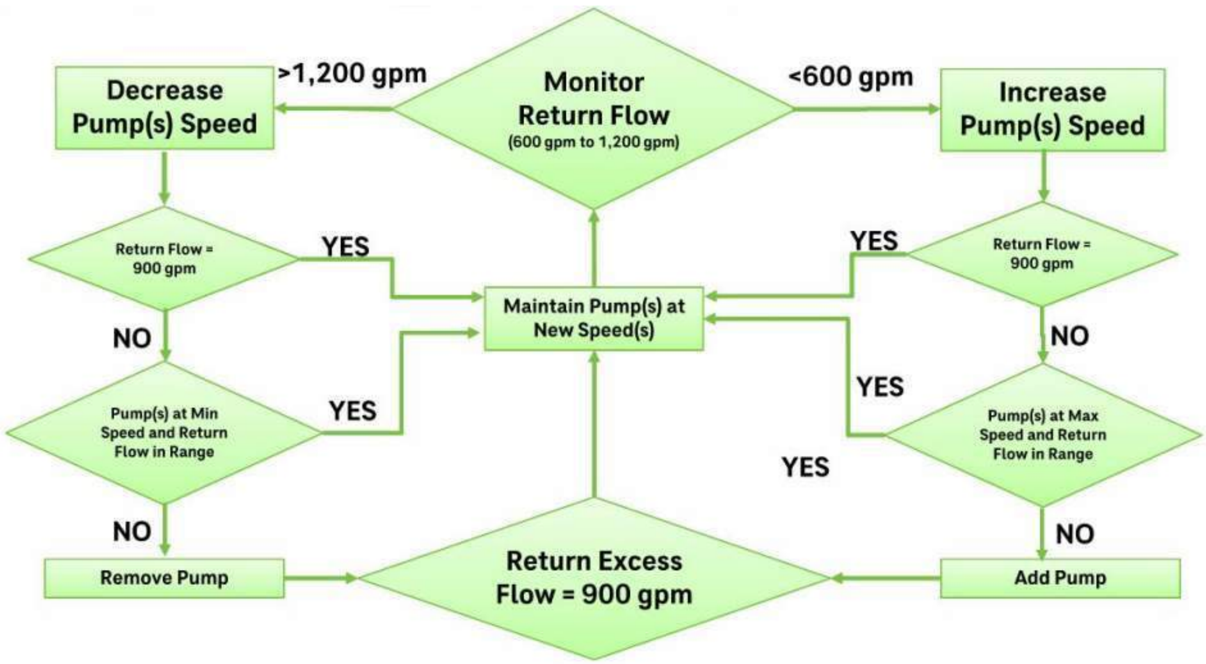

Figure 4-1: Automatic Control Strategy for BDF Feed

- Maintaining the minimum excess sludge return flow is critical to minimize solids settlement within the return sludge piping.
- Maintaining flows below the maximum excess sludge return flow is critical to prevent the sludge loop standpipe from backing up with sludge and overflowing through the standpipe vent.
- The sludge return pipe size in the BDF will be increased to accommodate the higher return flows required by the larger SFPs.

5.0 Recommendation Summary and Anticipated Operating Scenarios

Based on the additional evaluations performed, CDM Smith recommends:

- Increasing the basis of design pump size from 4” to 6” for SFPs 1-4.
- Increasing the BDF return sludge piping size to accommodate higher excess sludge return flows.
- Providing yard piping and valves to interconnect SSTs 1/3 and SSTs 2/4.
- Operating each pair of interconnected SSTs as one tank (1 pair duty, 1 pair standby).
- Eliminating the proposed north/south suction piping in the SSTs 1-4 Pipe Gallery.

- Evaluating the upstream waste activated sludge (WAS) and thickened primary sludge (TPS) processes as part of a separate task/project to determine if the consistency of the sludge blend that is discharged into the SSTs can be improved.
- Eliminating the originally planned "Input Mode" from the SFP automatic control sequence.

Table 5-1 presents the BDF operating scenarios that are anticipated based on the updated design recommendations noted above.

Table 5-1: BDF Operating Scenarios

Flow to Dewatering Equipment (gpm)	Qty. of Dryer Trains in Service[1]	Occurrence Probability	Pumps in Service	Pumps in Standby	Pumped Flow (gpm)	Return Flow Range (gpm)	Feed Header Velocity (ft/s)	Return Line Velocity (ft/s)
250 -800	1-2	13%	1	3	1,400	1,150-600	2.2[2]	1.7-4.9[3]
801-1,400	2-3	71.1%	1	3	2,000	1,200-600	3.2[2]	1.7-.4.9[3]
1,401–1,900	3-4	13.8%	2	2	2,500	1,000-600	4.0[2]	1.7-4.1[3]
1,901–2,400	4	1.8%	2	2	3,000	1,000-600	4.8[2]	1.7-4.1[3]

[1] Dependent on feed sludge percent solids.
[2] 16-inch sludge feed headers.
[3] 12-inch and 10-inch sludge return lines.

Technical Memorandum 6

To: *Jared Buzo, METCO*
Sham Sihabdeen, AECOM
Chris Wilson, GLWA

From: *Steve Wyman, CDM Smith*
Mohsen Sadatiyan, CDM Smith

Date: *December 14, 2023*

Subject: *Great Lakes Water Authority (GLWA)*
Contract No. 2202790 – Water Resource Recovery Facility (WRRF) Improvements to the Sludge Feed System for Solids Processing
TM-6 SSTs 1-4 Drainage and SSTs 1-4 Pipe Gallery Flooding Mitigation

1.0 Purpose and Background

Great Lakes Water Authority (GLWA) owns and operates the Water Resource Recovery Facility (WRRF) located at 9300 W. Jefferson, Detroit, MI 48209. WRRF is a conventional activated sludge plant with a wet weather design capacity of 1,444 million gallons per day (MGD) and serves approximately one-third of the State of Michigan's population. This facility is one of the largest wastewater treatment plants in the world, with the capacity to treat up to 1,700 MGD through primary treatment and 930 MGD through secondary treatment.

Many of the components of the facility are 80 years old. In service for about 50 years, the majority of the process units were built and expanded in the 1970s. Influent pumping and a large portion of preliminary and primary treatment facilities went online in 1940, sludge incineration went online in the 1950s and 1970s, and secondary treatment was started in the 1970s with the advent of the Clean Water Act. The facility was expanded in the 1990s with the construction of Pump Station No. 2 and associated preliminary treatment and was then optimized for wet weather flow in the early 2000s. The Biosolids Drying Facility went online in 2016, allowing the decommissioning of the Complex I incinerators. Disinfection of primary effluent was implemented in 2019.

WRRF generates solids through primary and secondary clarification. Solids handling processes include gravity thickening, blending, storage, dewatering, incineration, and drying treatment processes. Thickened primary sludge (TPS) and thickened waste activated sludge (TWAS) are blended prior to being discharged into six sludge storage tanks (SSTs). The sludge feed system, comprised of sludge feed pumps (SFPs), sludge piping, and flow control equipment, supplies thickened blended sludges from the SSTs to sludge dewatering equipment at three different dewatering facilities. These dewatering facilities include belt filter presses (BFPs) located in Sludge

Dewatering Complex I (C-I); BFPs in Sludge Dewatering Complex II (C-II); and centrifuges (CFGs) in the Biosolids Drying Facility (BDF). Under normal operating conditions, BDF CFGs process 60 to 70 percent of WRRF's solids. BFPs in C-I and C-II are used to dewater the balance of sludge not processed by the BDF or when the BDF equipment is offline for maintenance. C-II is also equipped with CFGs which were discontinued by GLWA prior to 2018 in favor of utilizing the C-I and C-II BFPs to supplement dewatering at the BDF. Dewatered sludge from C-I and C-II is incinerated onsite and dried sludge from BDF is land-applied offsite.

The service life of many of the existing SFPs has been exceeded, and all SFP equipment and piping are oversized for the feed rates required at the dewatering facilities. Additionally, sludge feed piping "dead ends" at each of the dewatering facilities result in sludge feed header pressures that are difficult to maintain within the operating range required for the sludge flow control equipment at each piece of dewatering equipment. The end result of the aged pumping equipment, oversized sludge feed components, dewatering facility locations, and piping configurations is a sludge feed system that is difficult to operate and maintain.

The primary focus of this project, WRRF Improvements to the Sludge Feed System for Solids Processing (the Project), involves making improvements to the dewatering sludge feed pumping systems. This project also includes improving drainage of SSTs 1-4, and mitigating flooding of the SSTs 1-4 Pipe Gallery. The scope includes conducting discipline-specific condition assessments and evaluations in order to recommend cost-effective upgrades and improvements to achieve robust, sustainable, and long-term upgrades while reducing maintenance efforts, improving operational flexibility, and maintaining treatment operations at all times. This assessment and evaluation work will be documented in technical memoranda (TMs). This document is Technical Memorandum 6 and covers the SSTs 1-4 drainage and SSTs 1-4 Pipe Gallery flooding mitigation evaluations performed for the Project.

The purpose of TM-6 is to provide a description of the improvements considered, present advantages and disadvantages of each, and provide CDM Smith's recommendations.

2.0 SSTs 1-4 Drainage Improvements

2.1 Background

SSTs 1-4 are used to store blended thickened primary sludge (TPS) and waste activated sludge (TWAS) prior to it being conveyed to the dewatering facilities for process. The tanks were constructed in 1971 as part of Contract PC-241 and were originally equipped with center supported sludge collection equipment that has since been removed. The tanks are above/below grade, cylindrical, reinforced concrete structures with cone-shaped bottoms **(Figure 2-1)**. The dimensions of each tank and critical elevations are provided in **Table 2-1**.

Figure 2-1: Sludge Storage Tank 3 (typical of SSTs 1 to 4)

Table 2-1: SSTs 1-4 Dimensions

Tank Name	Volume (gal)	Diameter (ft)	Maximum SWD/Elev. (ft)	Minimum SWD/Elev. (ft)	Top of Wall Elev. (ft)	Overflow Inv. Elev. (ft)	Outlet Pipe Inv. Elev. (ft)
SST-1	210,000	35	28/124	11/107[1]	126	124	90
SST-2	210,000	35	28/124	11/107[1]	126	124	90
SST-3	210,000	35	28/124	2/98[1]	126	124	90
SST-4	210,000	35	28/124	2/98[1]	126	124	90

[1] Based on operational data from 5/2020 - 5/2023

2.1.1 In-Tank Piping

Coarse bubble mixing systems are provided in SSTs 1-4 to keep solids in suspense. The air piping and diffuser arrangement varies between SSTs 1/2 and SSTs 3/4 as shown in **Figure 2-2**.

Sludge is conveyed to each SST via an 18-inch blended thickened sludge line. These pipes penetrate the tank walls from the SSTs 1-4 Pipe Gallery and are then routed vertically within the tanks to a discharge elevation of approximately 124 ft.

Each tank contains 12" SFP suction piping encased in the tank floor which slopes upward from the tanks center sludge sump to the SFPs located in the SSTs 1-4 Pipe Gallery. Each tank also includes a 12" wall penetration at elevation 103.5 ft for interconnection piping that connects the two pairs of tanks (SSTs 1/2 and SSTs 3/4). The interconnection piping contains valves and drains located in valve pits in the SSTs 1-4 Pipe Gallery. Operating these valves/drains results in the basement air space being exposed to open sludge. Additionally, plant staff have reported that a previous pipe gallery flooding event was caused by issues operating these drain valves.

Figure 2-2: Mixing Air Piping and Diffuser Arrangement (SST-1 on top / SST-3 on bottom)

2.1.2 Existing Tank Drainage/Cleaning Procedures and Challenges

SSTs 1-4 are currently drained and cleaned biannually. During a tank cleaning, the sludge level within a tank is lowered to approximately 8 feet using the tank's dedicated SFP to feed the downstream dewatering equipment. The remaining 8 feet of sludge is then removed using a crane truck, portable pumps, and temporary piping and/or a vac truck. Sludge is pumped to a nearby sewer that connects to the Oakwood interceptors which convey flows to the headworks at Pumps Station No. 1. Vac trucks when used discharge at the Ash Lagoon located approximately 300 feet west of the SSTs.

Plant staff are currently only able to lower the sludge in the tanks to 8 feet with the SFPs as a result of the elevation difference between the tank floors and the SFP suction at the pumps. The suction piping slopes upward from an invert elevation of 90 ft at the tank sludge sumps to a centerline elevation of 98.27 ft at the pumps. Plant staff have also indicated that the remaining 8 feet of sludge within the tanks typically contains significant amounts of grit and rags which would cause operational challenges if conveyed to downstream equipment.

The existing SSTs 1-4 drainage and cleaning procedures are cumbersome and labor intensive. CDM Smith has been tasked with developing improvement alternatives to consider for implementation on the Project.

2.2 Alternative Evaluation and Shortlisting

2.2.1 Alternative A1 – Portable Submersible Pumps

Alt-A1 considers maintaining the existing tank drainage/cleaning procedures but providing improvements to ease their implementation. Improvements would include providing portable submersible pumps, access walkways that span a pair of tanks, water cannon locations, and monorails to assist in portable pump installation and removal as shown in **Figure 2-3**.

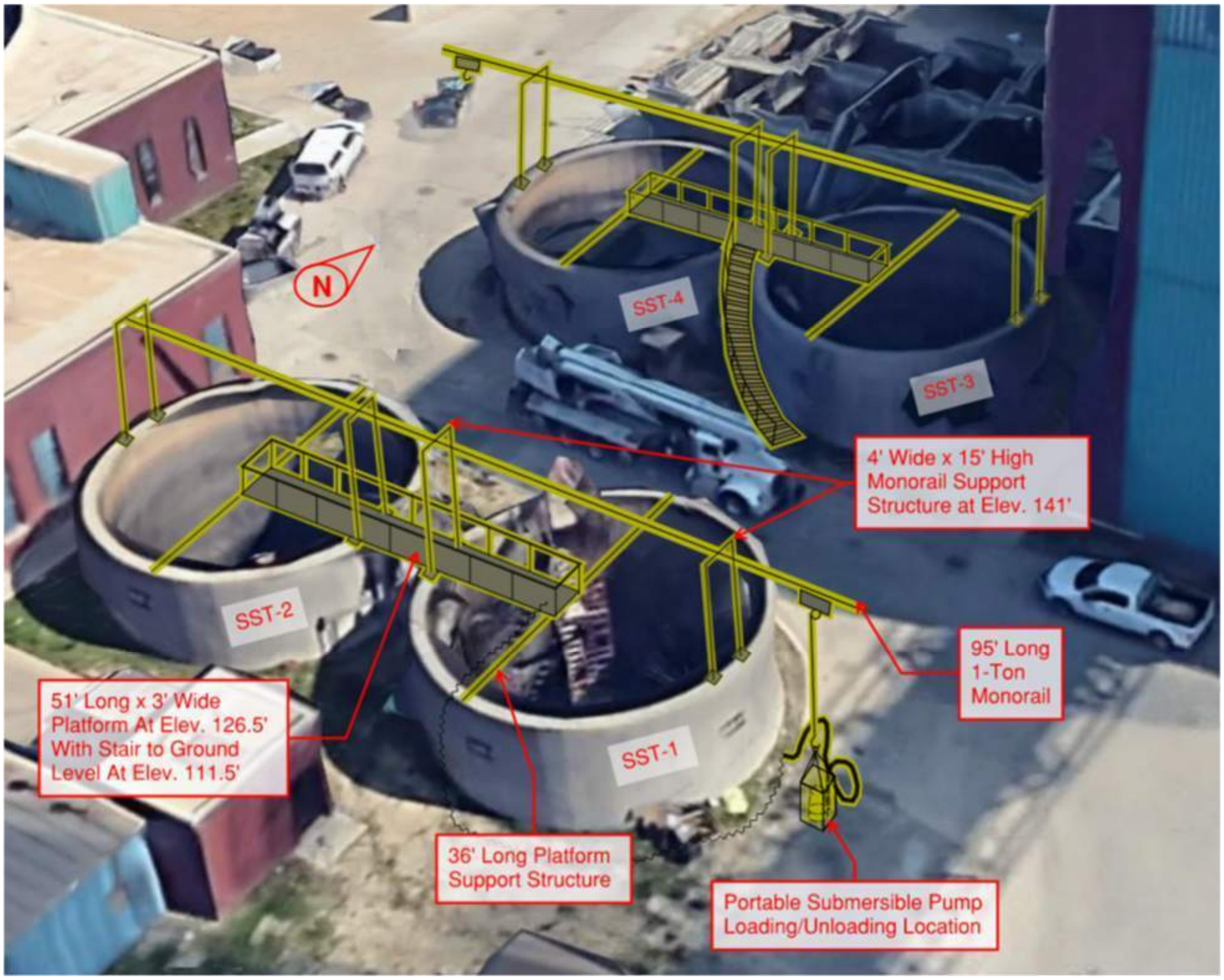

Figure 2-3: Alt-A1 Portable Submersible Pumps (Aerial View)

2.2.1.1 Alt-A1 Process Mechanical Modifications and Considerations

The portable submersible pumps would be equipped with suction cages to prevent binding when exposed to excessive rags. The pumps would discharge through flexible hoses connected to permanent hard-piping connections as shown in **Figure 2-4**. The piping would tie into the existing 18-inch overflow pipes above the ground level to convey the tank contents to the sanitary sewer manhole between SST-1 and SST-3.

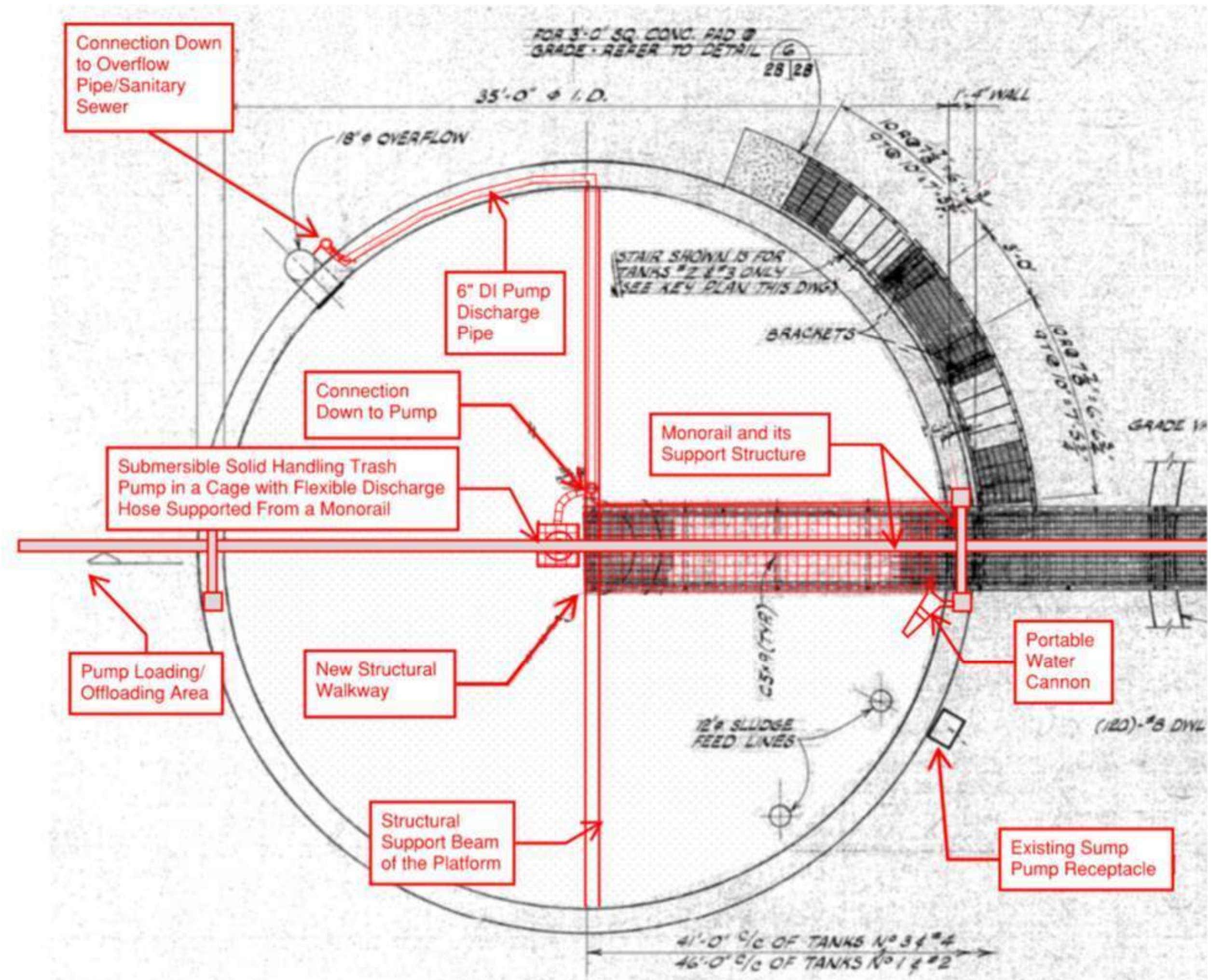

Figure 2-4: Alt-A1 Portable Submersible Pumps (Plan View)

Pumping down (draining) the tanks is expected to be a monitored operation due to the significant amount of grit and rags in the sludge. Periodic raising of the pump to check for rag accumulation on the suction cage and washing solids toward the pump location using water cannons is anticipated. The pump type selection is based on providing a pump capable of handling sludge, grit, and rags. Pump sizing is based on providing a pump with enough capacity to minimize tank drainage time (assumed 2 hours) while being small and light enough to be considered portable and easily moved into and out of the tanks. Based on these parameters, a 9 hp pump similar to Gorman-Rupp SFS4A solids handling trash pump capable of 500 gpm at 45 ft TDH is recommended. This 4-inch discharge pump can pass solids as large as 3-inch diameter sphere.

The pump suction cage would be constructed of perforated metal plates or heavy-duty metal mesh with approximately 1-inch square openings. The pump and suction cage weight would make the pumping assembly more stable when in use to prevent pump movement which could potentially damage the air pipe assemblies at the bottom of the tanks. Minor modifications to some of the air mixing nozzles in SST-3 and SST-4 may be required to provide the required clearance for the drainage pump.

Water cannons would be located on the platform at each tank to assist in agitating solids and moving them towards the drainage pump. The water cannons would be temporarily connected to the existing secondary water fire hydrants SW-H-44 and SW-H-17, (100 ft on the east, and 50 ft on the west side of SSTs 1-4 respectively) when needed. Alternatively, two 4-inch yard hydrants with quick hose connections on both sides of Pump Station Ave could be provided for supplying secondary water to the water cannons. This would eliminate the need for hoses to cross the access roads while in use during tank cleanings. The connection for these proposed yard hydrants could be provided by sleeve tapping the existing 12-inch and 8-inch LPSW lines (typical pressure range of 45 to 70 psi) which are buried near the SSTs at an approximate depth of 9 ft.

2.2.1.2 Alt-A1 Electrical Modifications and Considerations

Under the PC-744 contract, two receptacles were installed for powering sump pumps for SSTs 1/2 and SSTs 3/4. The SSTs 3/4 receptacle location is shown in **Figure 2-5**.

Figure 2-5: Existing SSTs 3/4 Sump Pump Receptacle

Adequate power is available from the existing MCCs to these existing receptacles for the proposed pumps. The existing breakers and conduit/wire were designed to provide 60A of 480V power to the receptacles, which could provide power feed for a pump of up to 20 Hp. Modifications would be made to these receptacles as needed to facilitate the proposed pumps.

2.2.1.3 Alt-A1 Structural Modifications and Considerations

Installation of new steel access walkways at the top of the existing sludge storage tank concrete walls is structurally feasible. The existing 1'-4" thick concrete tank walls would be evaluated for the additional loading due to the walkway; however, the walls were originally designed to support an access bridge and platform similar to what is proposed under this alternative, so no issues are anticipated. The access bridge and platform at the center of the tank would be supported by two steel beams spanning perpendicular to the access bridge, supported at each end by the existing concrete tank wall as shown in **Figure 2-4**.

The installation of new monorails to span over the existing sludge storage tanks is also structurally feasible. The structural support systems of the monorails will depend on the final required capacity and extents of the monorail cantilevered beyond the tank walls. The existing 1'-4" thick concrete tank walls will be evaluated further during detailed design to determine if there is adequate capacity to support the loading from the proposed monorail. If the existing concrete walls cannot support the additional loading, a new structural steel support system with concrete foundations at finished grade adjacent to the existing concrete tank walls will be required.

2.2.1.4 Alt-A1 Shortlist Recommendation

The Alt-A1 concept would maintain the existing tank drainage/cleaning procedures but would provide improvements to make them more operation and maintenance friendly. Accumulation of grit and rags on the tank floor would still remain and the use of a vac truck for their removal may still be required. CDM Smith recommends further consideration of this alternative for implementation on the Project.

2.2.2 Alternative A2 - Raise SSTs 1-4 Concrete Tank Floors and Walls

Alt-A2 considers raising the SSTs 1-4 floors and walls approximately 6'-8" to allow the SFPs to pump more of the tank volume (to downstream dewatering processes) and reduce the remaining volume of sludge within the tanks that needs to be drained. New SFP suction piping would be provided from the new sludge sump elevation to the SFP suction at the pump. Drainage piping would also be provided from the new sludge sump elevation to the sanitary sewer that runs east/west under Pump Station Ave as shown in **Figure 2-6**. This would allow the tanks to be drained directly to the main sanitary sewer.

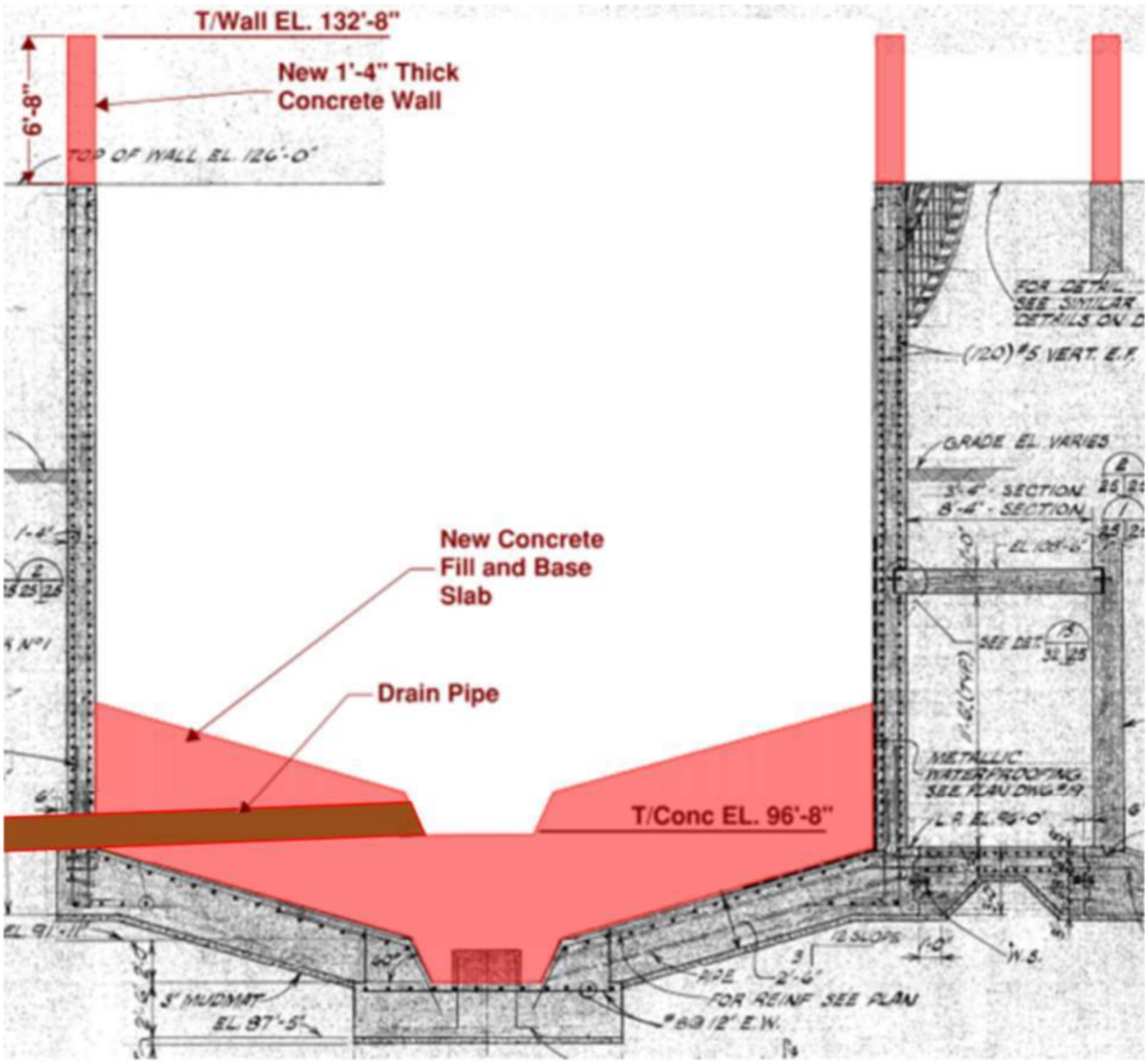

Figure 2-6: Alt-A2 - Raising SSTs 1-4 Concrete Tank Floors and Walls

2.2.2.1 Alt-A2 Process Mechanical Modifications and Considerations

Raising the bottom of the tank 6'-8" would result in a new sludge sump elevation of 96.67 ft. The closest sanitary sewer is an 18" sewer that runs east/west between SSTs 1/2 and 3/4 under Pump Station Ave. Survey data indicates that this sewer's elevation is low enough to accommodate gravity drainage from the SSTs. Routing drain lines from each SST to the 18" sewer poses considerable construction challenges and risks. **Figure 2-7** displays the proposed drain pipe routing and shows that there are major underground piping and utility conflicts in the area.

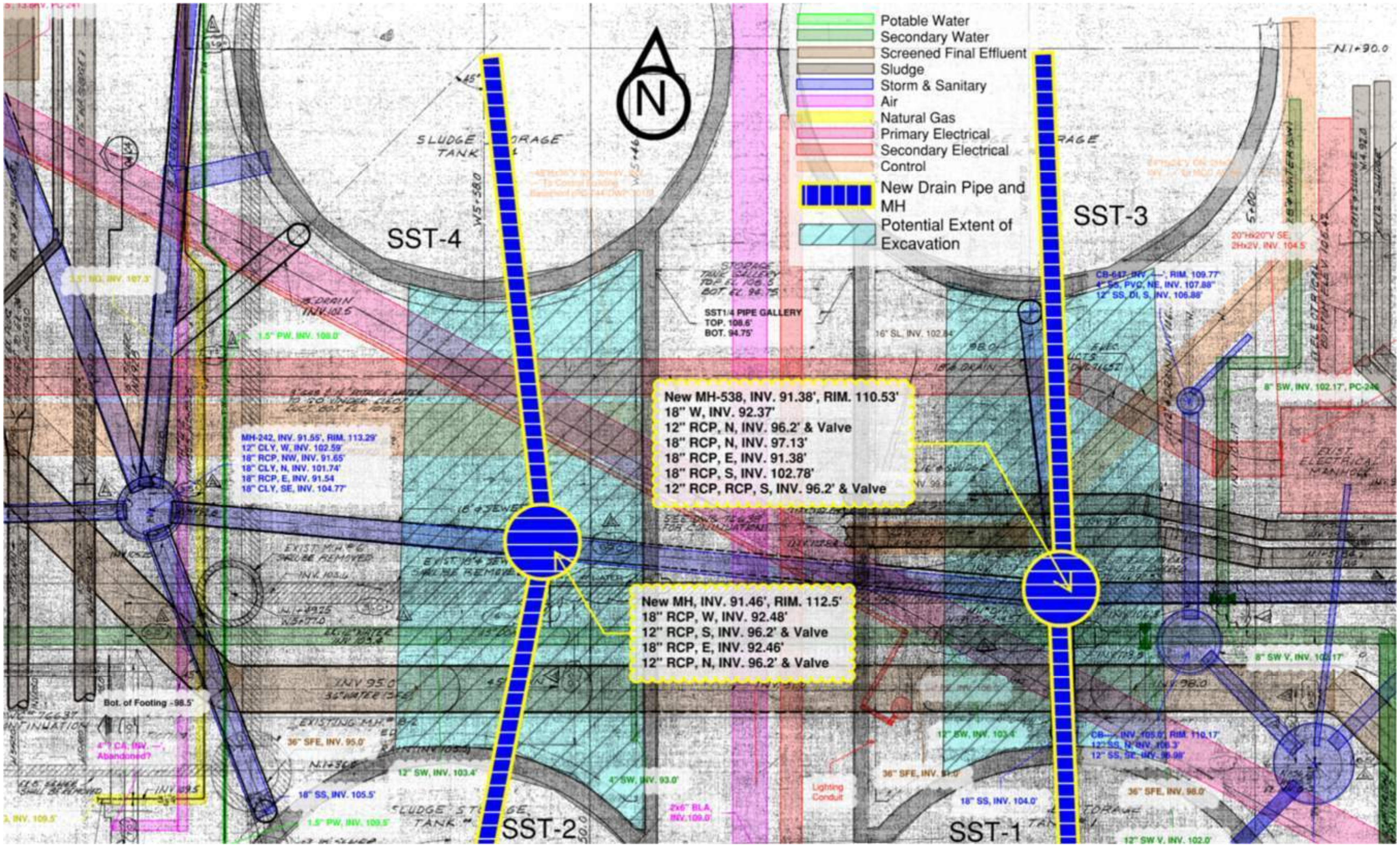

Figure 2-7: Alt-A2 Proposed Drain Pipe Routing and Interferences

It is unlikely that sheet piles or trench boxes could be used during construction due to the congested arrangement of underground piping in the area. Excavation to install the approximately 17 ft deep piping and manholes would likely need to be completed with an open-cut excavation, which may result in issues with exposure of the area around the existing piping and utilities. Additional concerns with keeping electrical ducts operational during excavation would need to be addressed. This would require the contractor to locate the ducts prior to excavation and develop a plan to support the ducts during and after excavation. Alternative drain pipe routings and configurations were explored but no better option has been discovered. Routing the drain piping as shown can be done, but critical piping and utilities located in close proximity would result in significant risks and costs being added to the Project.

In-tank piping would be raised to accommodate the raised tank floors and walls accordingly. This would include the air mixing piping laterals and nozzles, sludge inlet pipe discharge, and overflow piping. Raising the tank floors would allow for replacement of the existing SFP suction piping with improved suction piping designed for the TM-5B proposed pump layouts. Based on preliminary evaluation, raising the tank floors would also result in improved pumping conditions for the existing upstream pumping systems that discharge into the SSTs.

2.2.2.2 Alt-A2 Structural Modifications and Considerations

Raising the concrete tank floors and walls a height of 6’-8” is structurally feasible. The floor would be raised by installing lightweight concrete fill and a new structural concrete topping slab. Sealant would be placed at the edge of the new concrete topping slab to ensure water does not penetrate the joint between the new slab and the existing walls. Preliminary evaluation of the bearing pressure displayed an increase of approximately 25 percent with the addition of the new tank floor and walls. A geotechnical investigation of the proposed site would be required during detailed design to determine the allowable bearing capacity of the soil at the tank locations. If it is determined that the soil is not adequate to withstand the increase in bearing pressure (which is not expected), alternatives to reduce the bearing pressure would be explored. Alternatives could include utilizing geofoam in lieu of lightweight concrete fill or reducing the allowable sludge level within the tanks.

To raise the concrete tank walls, epoxy dowels would be embedded in the top of the wall to ensure adequate development is achieved into the existing tank wall. A retrofit PVC or hydrophilic adhesive waterstop would be centered at the top of the wall around the circumference of the tank to ensure water tightness at the new construction joint.

2.2.2.3 Alt-A2 Shortlist Recommendation

The Alt-A2 concept would result in improved SFP pumping conditions and allow for complete tank drainage via gravity. However, installation of the drain piping as shown would be very challenging and result in significant risks and costs being added to the Project. The accumulation of grit and rags on the tank floor would still remain and the use of a vac truck for their removal may be required. CDM Smith recommends further consideration of this alternative for implementation on the Project.

2.2.3 Alternative A3 – Tank Drainage Sump Located in SSTs 1-4 Pipe Gallery

Alt-A3 considers providing a common drainage sump with drain pumps located in the SSTs 1-4 Pipe Gallery as shown in **Figure 2-8**. New drain piping would be provided to convey sludge from each tank sludge sump to the common drainage sump. The sludge would then be pumped to a nearby sanitary sewer connection for conveyance to the head of the plant.

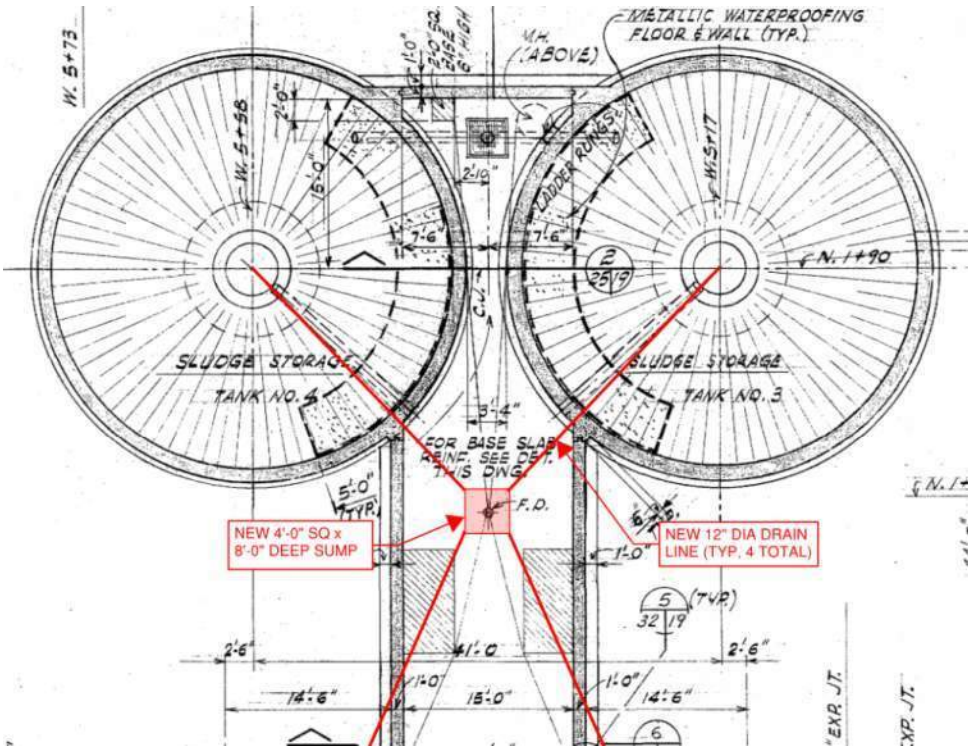

Figure 2-8: Alt-A3 - Tank Drainage Sump Located in SSTs 1-4 Pipe Gallery

2.2.3.1 Alt-A3 Process Mechanical Modifications and Considerations

Alt-A3 would require installation of a new drain pipe from the bottom of each SST to a new drainage sump located in the SSTs 1-4 Pipe Gallery. Open cut excavation of this piping would not be feasible/practical as this piping would be located below the SSTs, pipe gallery, and site utilities. Jack and bore and horizontal directional drilling (HDD) were explored as potential installation methods.

A jack and bore installation would require the use of a sending and a receiving pit at both ends of the pipe installation. A jack and bore machine would be placed in the sending pit and used to cut a hole underground horizontally from the sending pit to the receiving pit. As the machine drills the hole, it would also push the new pipe in place. The limited footprint for a pit in the SSTs 1-4 Pipe Gallery and no practical option for a pit in the SSTs eliminates this installation method.

HDD avoids having to dig large pits to install jacking and boring machines; however, smaller sending and receiving pits are necessary for the return fluid that is used. For HDD, a rig is used to drill a pilot hole and cut a path for the new pipe. The new pipe is installed through the sending pit and then pulled through the cut path at the receiving pit. This method would likely require the use of flexible pipe due to space limitations in the SSTs and pipe gallery and requires space for a drill rig to launch the equipment to install the pipe. The limited footprint for a pit in the SSTs 1-4 Pipe Gallery and no practical option for a pit in the SSTs also eliminates this installation method.

Based on CDM Smith's evaluation, there is no practical method for installing new drain piping from the center of each SST to a drainage sump located in the SSTs 1-4 Pipe Gallery.

2.2.3.2 Alt-A3 Structural Modifications and Considerations

Excavation and installation of a 4 ft wide x 4 ft long x 8 ft deep sump within the SSTs 1-4 Pipe Gallery is structurally feasible for installation of the sump itself; however, a larger excavation would likely be necessary for trenchless installation of the pipe as noted above which will have considerable effect on the integrity of the floor and walls of the SSTs and pipe gallery.

2.2.3.3 Alt-A3 Shortlist Recommendation

Investigation of this alternative has determined that installing the drain piping from each SST to the SSTs 1-4 Pipe Gallery as shown is not feasible/practical. In addition to this, routing sludge from the SSTs to a sump within the SSTs 1-4 Pipe Gallery would change the building's area classification and expose the pipe gallery to additional flooding risks. CDM Smith does not recommend further consideration of this alternative for implementation on the Project.

2.2.4 Alternative A4 – Dedicated Drain Pumps Located in SSTs 1-4 Pipe Gallery

Alt-A4 considers providing pumps in the SSTs Pipe Gallery dedicated to draining the SSTs. The pumps would tie into the SFP suction piping and discharge to a sanitary sewer connection for conveyance to the head of the plant.

2.2.4.1 Alt-A4 Process Mechanical Modifications and Considerations

The Alt-A4 concept is based on providing pumps capable of providing suction lift and running dry without damage so that the remaining contents of the tanks could be pumped to the sanitary sewer. Double disc type pumps as manufactured by Penn Valley can meet these requirements. This style of pump can typically pass 0.5-inch to 2-inch solids, are self-priming, and have a seal-less design (no mechanical seals or seal water required). However, these pumps also have a large footprint and would need to be installed in the SSTs 1-4 Pipe Gallery along with the SFPs as proposed in TM-5B. Installing dedicated drainage pumps in addition to the SFPs in the existing building footprint is not feasible. Expansion of the SSTs 1-4 Pipe Gallery structure is not recommended as discussed in TM-5B.

2.2.4.2 Alt-A4 Shortlist Recommendation

This alternative would require expansion of the SSTs 1-4 Pipe Gallery. Expanding this structure can be done, but critical piping and utilities located in close proximity would result in significant risks and costs being added to the Project. CDM Smith does not recommend further consideration of this alternative for implementation on the Project.

2.2.5 Alternative A5 – SSTs Inlet Screening Nets/Baskets

Alt-5A was developed to explore an alternative for eliminating the rags that currently accumulate within the tanks. Netting systems are commonly used in stormwater applications to remove floatables and large debris from stormwater flows. Alt-A5 considers providing a modified netting or basket assembly supported by a frame approximately 18 inches below the SST tank inlet piping to remove rags and other large debris from the sludge entering the tanks. Pilot testing of this concept could be conducted by installing a temporary netting basket assembly as shown in **Figure 2-9**.

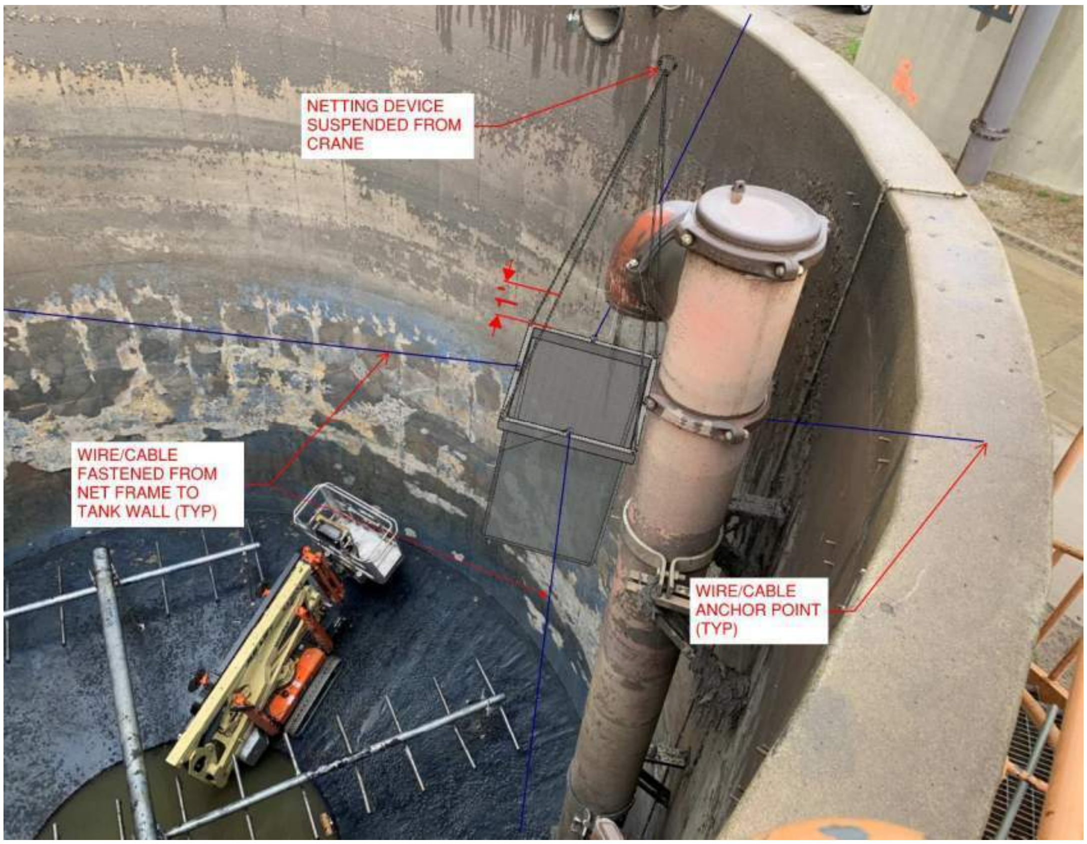

Figure 2-9: Net/Basket Pilot Testing Layout

The volume of rags received by the netting assembly during a pilot test could be used to determine the practicality of this concept. Excessive rags could require frequent replacement or emptying of the nets/baskets. This alternative would not address the actual drainage of the SSTs and would need to be implemented in conjunction with another alternative if implemented.

2.2.5.1 Alt-A5 Shortlist Recommendation

CDM Smith developed a "Test Plan for Rag and Large Object Removal from Influent of Sludge Storage Tanks" dated July 21, 2023, for testing of a netting system at SSTs 1-4. This testing plan was presented to GLWA for discussion and input. Plant staff expressed concerns with the day-to-day monitoring and upkeep associated with the proposed netting system. GLWA also indicated that the rag and grit loads are expected to be reduced over the next few years as upstream improvements are implemented. Based on GLWA feedback received, CDM Smith does not recommend further consideration of this alternative for implementation on the Project.

3.0 SSTs 1-4 Pipe Gallery Flooding Mitigation

3.1 Background

The SSTs 1-4 Pipe Gallery **(Figure 3-1)** houses the pumps, piping, and appurtenances associated with SSTs 1-4 and is located below Pump Station Avenue (between SSTs 1-4). The gallery is accessed via Stair House No. 5 located south of SST-1 and connects to the basement of Sludge Processing Complex A. The SSTs 1-4 Pipe Gallery floor elevation (96.17 ft) is approximately 5.33 ft lower than the basement of the adjacent Sludge Processing Complex A as seen in **Figure 3-2**. The low elevation and relatively small footprint of the SSTs 1-4 Pipe Gallery makes this area prone to flooding due to process failures or leakages in any of the adjacent process areas.

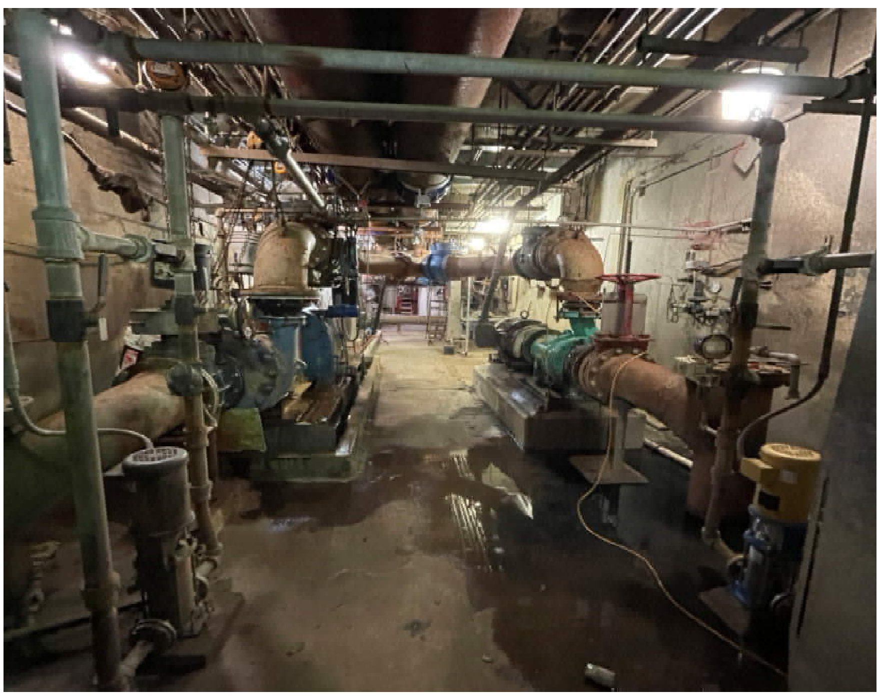

Figure 3-1: SSTs 1-4 Pipe Gallery

Figure 3-2: Ramp from SSTs 1-4 Pipe Gallery to Sludge Processing Complex A Basement

Plant staff indicated that one past flooding event was caused by failure to control the flow while draining an SST using the drain valves located in the interconnection piping valve pit shown in **Figure 3-3**. Flow was initially restricted by plugging in the drain line. When the plug broke free, the sludge flow engulfed the valve pit and the valve was not able to be closed prior to the gallery being flooded.

Figure 3-3: Valve Pit on South End of SSTs 1 to 4 Pipe Gallery

Another reported flooding event was caused by significant sludge leaks from some of the large sludge pipes in the basement of Complex A. Inundation marks on the wall of the SSTs Pipe Gallery display instances of sludge accumulation approximately 5'-6" above the SSTs 1-4 Pipe Gallery finished floor. CDM Smith has been tasked with developing improvement alternatives to mitigate future flooding events in the SSTs 1-4 Pipe Gallery for implementation on the Project.

3.2 Alternative Evaluation and Shortlisting

3.2.1 Alternative B1 – No VFDs Located in SSTs 1-4 Pipe Gallery

Alt-B1 includes locating the new SFP VFDs out of the SSTs 1-4 Pipe Gallery. This is one of the project objectives and will be implemented. TM-5B discusses the electrical modifications and considerations for each pumping alternative being considered. CDM Smith recommends locating the VFDs for the SSTs 1-4 Pipe Gallery in the Complex A basement below the Electrical Room (current location of the SFP-3 and 4 VFDs). This location has ample space for the VFDs and is a suitable atmosphere as displayed by the condition of the existing VFDs installed there.

Alt-B1 will be implemented in combination with other flooding mitigation improvements as determined in this TM-6.

3.2.2 Alternative B2 – Install Local Control Panels and Other Electrical and I&C Items Above Potential Flood Level

Alt-B2 considers installing all electrical and instrumentation components in the SSTs 1-4 Pipe Gallery above the potential flood level elevation. This would include items such as control panels, instruments, receptacles, and appurtenances that are needed in close proximity to the SFPs. During a worst-case flood event, the SSTs 1-4 Pipe Gallery could fill with sludge up to 5.33 ft above the finished floor prior to spilling over into the Complex A basement. At this point the sludge would begin to fill a much larger area and would be less likely to increase significantly in total depth. Installing the electrical and instrumentation items noted above at least 5'-6" above the SSTs 1-4 Pipe Gallery finished floor would reduce the likelihood of these items being damaged should a flooding event occur.

Alt-B2 could be implemented with negligible cost increases to the Project and would reduce the damage caused by future flooding events. Accessibility and operator/maintenance staff comfort levels with components installed above normal installation heights should be considered. CDM Smith recommends further consideration of this alternative in combination with other flooding mitigation improvements for implementation on the Project.

3.2.3 Alternative B3 – Increase Floor Drain and Piping Sizes

Alt-B3 considers increasing the capacity of the SSTs 1-4 Pipe Gallery floor drainage system so that it's capable of conveying flooding event flows. 6-inch existing floor drains are provided in several locations in the pipe gallery as shown in **Figure 3-4**.

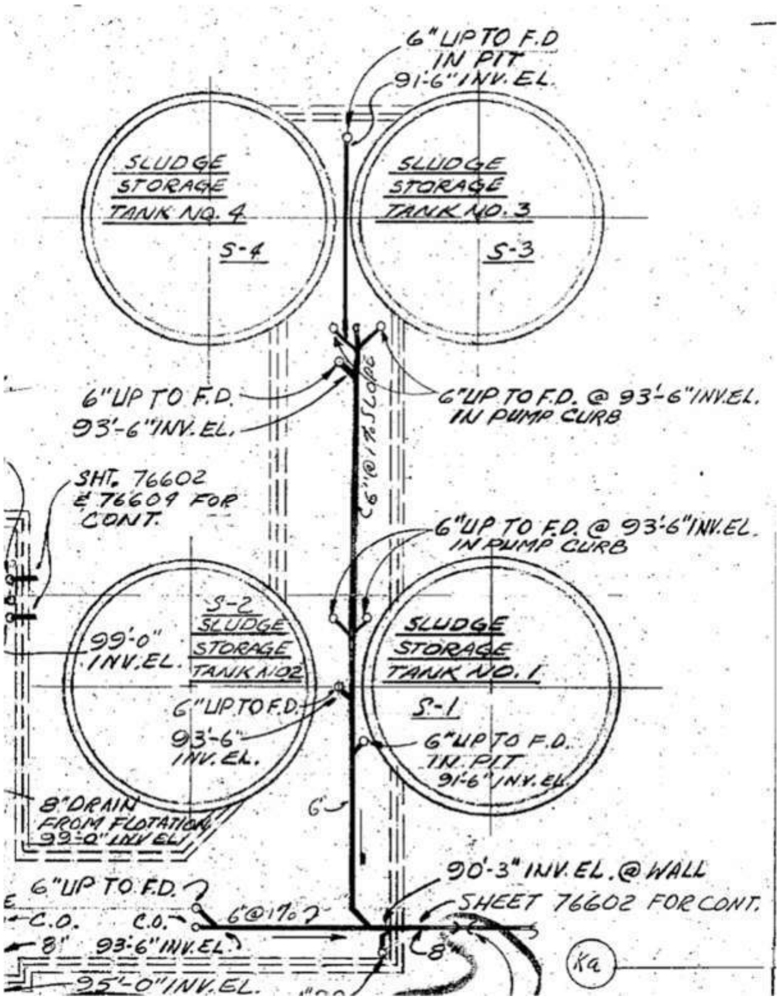

Figure 3-4: SSTs 1-4 Pipe Gallery Floor Drains and Drain Piping

Plant staff have indicated that the existing drains and piping do not function well. This could be caused by clogging and corrosion in the piping or the piping being undersized for its intended use. This alternative would replace the existing 6-inch floor drains and piping with 8-inch to match the downstream piping size. CDM Smith calculated the estimated drainage capacity of the existing 6-inch drainage system to be 480 gpm. This would increase to approximately 800 gpm by enlarging the drain to 8-inch piping.

Based on field measurements and record drawings, the existing 6-inch drain header is installed at an invert elevation sloping from 91.5 ft to 90.5 ft from north to south (5 to 6 ft below the pipe gallery floor). Cutting the concrete floor and excavating to the required depth to remove the existing drain piping and install the new would be challenging especially when considering its implication on maintenance of plant operations (MOPO). Keeping SFPs-3 and 4 (feeding sludge to the BDF) in operation during this construction activity would be extremely challenging. CDM Smith recommends further consideration of this alternative in combination with other flooding mitigation improvements for implementation on the Project.

3.2.4 Alternative B4 – Sump with Duplex Sump Pumps

Alt-B4 considers providing a new sump with duplex sump pumps in the SSTs 1-4 Pipe Gallery. The sump would be located away from the SFPs and piped to discharge to MH-242 as shown in **Figure 3-5**.

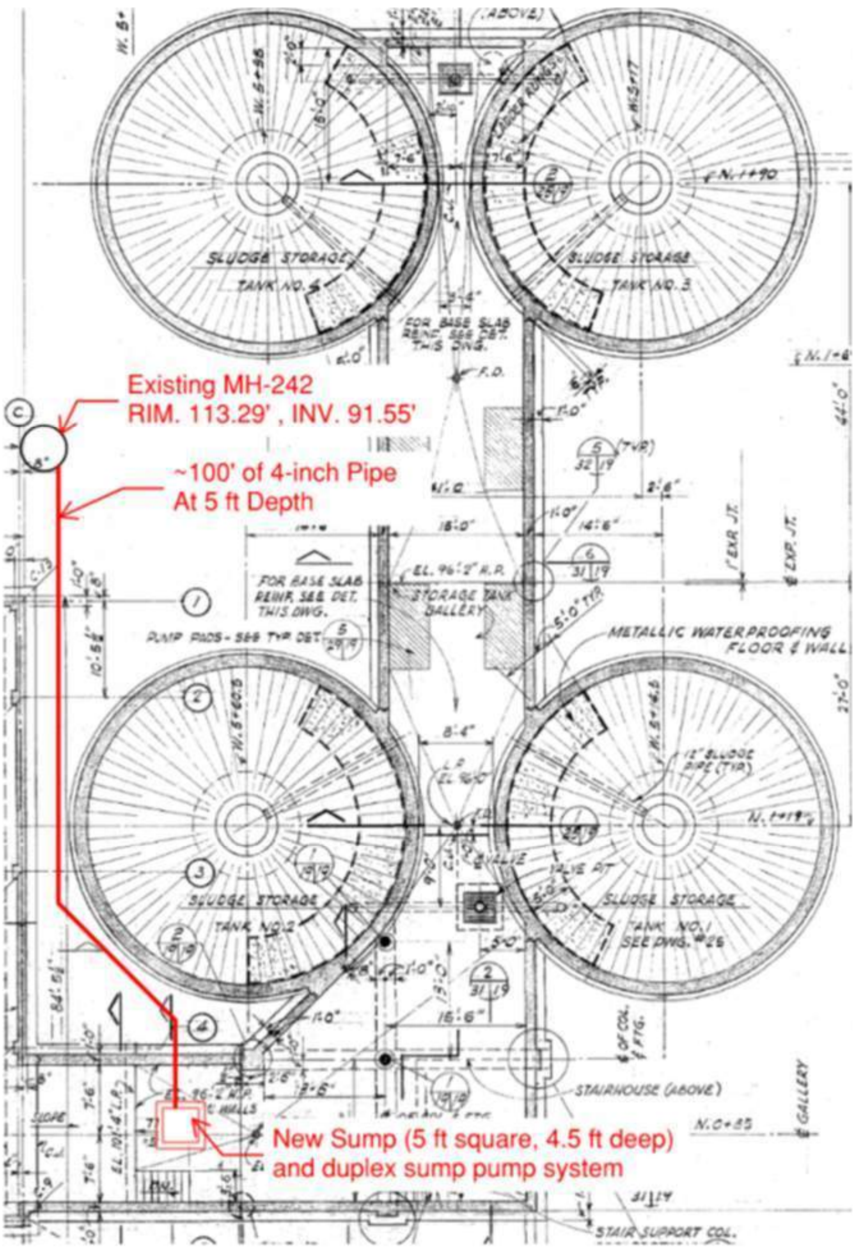

Figure 3-5: Alt-B4 Sump with Duplex Sump Pumps

In this concept, any build-up of sludge or water during a flooding event that exceeded the floor drain capacity would spill into a 5' x 5' x 4.5' deep sump and would then be pumped out of the SSTs 1-4 Pipe Gallery. The duplex pumps would be sized for 200 gpm flow at 30 ft TDH and configured for lead/lag operation resulting in 400 gpm of total pumping capacity. Providing larger pumps could be considered although constructability challenges and risks increase as the required sump dimensions increase (to accommodate larger pumps). CDM Smith recommends further consideration of this alternative in combination with other flooding mitigation improvements for implementation on the Project.

4.0 SSTs 1-4 Drainage Improvements - Final Alternative Comparisons

Two alternatives have been shortlisted for further consideration for the SSTs 1-4 Drainage Improvements (Alt-A1 and Alt-A2). Advantages, disadvantages, and associated lifecycle costs for each alternative were analyzed. Lifecycle cost assumptions include:

- 2023 baseline year
- 20-year lifecycle period
- 4.0% escalation rate
- $0.14 electricity costs ($/kWh)
- 20% Contractor's overhead and profit, including permit costs, insurances, bonds and sales tax
- 30% Contingency
- $150 loaded person-hour labor cost for operation and maintenance staff

4.1 Alt-A1 – Portable Submersible Pumps

4.1.1 Proposed Improvements

Maintain existing tank drainage/cleaning procedures but provide improvements to ease their implementation. Improvements required to implement Alt-A1 include:

- Two portable submersible solids handling pumps with suction cages and flexible discharge hose.
- Two monorails.
- Access walkway modifications.
- Permanent discharge piping from access walkways to tank overflow piping.
- Water cannon washdown stations.

- Two yard hydrants for washdown station water supply.

4.1.2 Lifecycle Costs

A lifecycle cost analysis was performed to determine the present-day costs of implementing the Alt-A1 improvements. A breakdown of the cost items is presented below.

- Walkway, Stair, and Monorail Improvements $1,250,000
- Equipment and Piping Improvements $360,000
- Electrical and Automation $50,000
- **Total Capital Cost $1,660,000**
- Lifecycle Operational Cost $385,000
- Lifecycle Preventative Maintenance Cost $90,000
- Lifecycle Rehab Maintenance Cost $25,000
- **Total Lifecycle Cost $2,160,000**

4.1.3 Advantages

Advantages of Alt-A1 include the following:

- Lowest lifecycle cost.
- Relatively easy and low risk constructability.
- Minimal MOPO impacts.
- Plant staff are familiar with current tank drainage/cleaning procedures.
- Improves ease of current tank drainage/cleaning procedures.

4.1.4 Disadvantages

Disadvantages of Alt-A1 include the following:

- Labor intensive (similar to existing procedures).
- Highest O&M costs.
- Does not address excessive grit and rag accumulation. Vac trucks may still be required.
- Does not improved SFP suction conditions.
- Includes portable equipment and piping requiring setup and takedown for each cleaning.

4.2 Alt-A2 – Raise SSTs 1-4 Concrete Tank Floors and Walls

4.2.1 Proposed Improvements

Raise the SSTs 1-4 tank floors and walls approximately 6'-8" to allow the SFPs to pump more of the tank volume. Provide direct drain lines from each tank to the sanitary sewer. Improvements required to implement Alt-A2 include:

- Lightweight structural fill and concrete tank slab in each SST (6'-8").
- SST tank wall structural extensions (6'-8").
- Modifications to existing piping to accommodate the raised floor and wall elevations (air mix piping, sludge inlet piping, tank interconnection piping, and overflow piping).
- Modifications to existing electrical and instrumentation to accommodate raised tank floor and wall elevations.
- Access walkway modifications.
- New SFP suction piping and valves.
- New SST drainage piping, valves, and manholes.
- Water cannon washdown stations.
- Two yard hydrants for washdown station water supply.

4.2.2 Lifecycle Costs

A lifecycle cost analysis was performed to determine the present-day costs of implementing the Alt-A2 improvements. A breakdown of the cost items is presented below.

- Structural Tank Floor and Wall Modifications $2,755,000
- Access Walkway and Piping Improvements $1,180,000
- Electrical and Automation $50,000
- **Total Capital Cost** **$3,985,000**
- Lifecycle Operational Cost $0
- Lifecycle Preventative Maintenance Cost $0
- Lifecycle Rehab Maintenance Cost $0
- **Total Lifecycle Cost** **$3,985,000**

4.2.3 Advantages

Advantages of Alt-A2 include the following:

- Tanks drain via gravity. Water cannons are only added equipment.
- Improves SFP suction conditions.
- Minimal labor required (for tank washdowns).
- Lowest O&M cost.

4.2.4 Disadvantages

Disadvantages of Alt-A2 include the following:

- Highest lifecycle cost.
- Challenging and high-risk constructability.
- Moderate MOPO impacts.
- Does not address excessive grit and rag accumulation. Vac trucks may still be required.

5.0 SSTs 1-4 Pipe Gallery Flooding Mitigation - Final Alternative Comparisons

Four alternatives have been shortlisted for further consideration for the SSTs 1-4 Pipe Gallery Flooding Mitigation (Alt-B1, Alt-B2, Alt-B3, and Alt-B4). Advantages, disadvantages, and associated lifecycle costs for each alternative were analyzed. Lifecycle cost assumptions include:

- 2023 baseline year
- 20-year lifecycle period
- 4.0% escalation rate
- $0.14 electricity costs ($/kWh)
- 20% Contractor's overhead and profit, including permit costs, insurances, bonds and sales tax
- 30% Contingency

5.1 Alt-B1 – No VFDs Located in SSTs 1-4 Pipe Gallery

5.1.1 Proposed Improvements

The VFDs for the new SFPs will be located in the Complex A basement below the Electrical Room (current location of the SFP-3 and 4 VFDs). Locating these VFDs out of the SSTs 1-4 Pipe Gallery is one of the project objectives. This alternative will be implemented to meet the project goals and therefore lifecycle costs were not evaluated. This alternative requires combination with other alternatives to adequately mitigate an SSTs 1-4 Pipe Gallery flooding event.

5.2 Alt-B2 – Install Local Control Panels and Other Electrical and I&C Items Above Potential Flood Level

5.2.1 Proposed Improvements

All electrical and instrumentation items located in the SSTs 1-4 Pipe Gallery will be installed at an elevation above the potential flood level (5'-6" above finished floor) where possible. This will include control panels, instruments, receptacles, and appurtenances. Lifecycle costs for this alternative are anticipated to be negligible. This alternative requires combination with other alternatives to adequately mitigate an SSTs 1-4 Pipe Gallery flooding event.

5.2.2 Advantages

Advantages of Alt-B2 include the following:

- Low-cost improvement.
- Easily constructable.
- No impact on MOPO.
- Reduces risk of equipment damage should a flooding event occur.

5.2.3 Disadvantages

Disadvantages of Alt-B2 include the following:

- Does not mitigate flooding events.
- Reduces accessibility of items.

5.3 Alt-B3 – Increase Floor Drain and Piping Sizes

5.3.1 Proposed Improvements

Replace the SSTs 1-4 Pipe Gallery 6-inch floor drains and drain piping with 8-inch floor drains and drain piping.

5.3.2 Lifecycle Costs

A lifecycle cost analysis was performed to determine the present-day costs of implementing the Alt-B3 improvements. A breakdown of the cost items is presented below.

- Drain and Drain Piping Improvements $790,000
- **Total Capital Cost** **$790,000**
- Lifecycle Operational Cost $0

- Lifecycle Preventative Maintenance Cost $0
- Lifecycle Rehab Maintenance Cost $0
- **Total Lifecycle Cost** **$790,000**

5.3.3 Advantages

Advantages of Alt-B3 include the following:

- Provides mitigation of some flooding events.
- Lowest O&M cost of mitigation alternatives.
- Provides flooding mitigation without additional equipment (gravity drains).

5.3.4 Disadvantages

Disadvantages of Alt-B3 include the following:

- Highest lifecycle cost of mitigation alternatives.
- May not prevent all flooding events (limited drainage capacity).
- Challenging and high-risk constructability.
- Significant MOPO challenges.

5.4 Alt-B4 – Sump with Duplex Sump Pumps

5.4.1 Proposed Improvements

Provide a new sump with duplex sump pumps in the SSTs 1-4 Pipe Gallery. Provide piping to discharge from the sump pump to sanitary manhole MH-242.

5.4.2 Lifecycle Costs

A lifecycle cost analysis was performed to determine the present-day costs of implementing the Alt-B4 improvements. A breakdown of the cost items is presented below.

- Sump, Equipment, and Piping $405,000
- Electrical and Automation $150,000
- **Total Capital Cost** **$555,000**
- Lifecycle Operational Cost $0
- Lifecycle Preventative Maintenance Cost $40,000
- Lifecycle Rehab Maintenance Cost $10,000

- **Total Lifecycle Cost** **$605,000**

5.4.3 Advantages

Advantages of Alt-B4 include the following:

- Provides mitigation of some flooding events.
- Lowest lifecycle cost of mitigation alternatives.
- No significant constructability challenges.
- Minimal MOPO impacts.

5.4.4 Disadvantages

Disadvantages of Alt-B4 include the following:

- Highest O&M cost of mitigation alternatives.
- May not prevent all flooding events (limited pumping capacity).

6.0 Recommendations

CDM Smith developed multiple alternatives for improving the process of draining SSTs 1-4 and to mitigate flooding of the SSTs 1-4 Pipe Gallery. Each alternative was evaluated to determine its feasibility, potential challenges, and associated advantages and disadvantages.

CDM Smith recommends implementing Alt-A1 - Portable Submersible Pumps to improve the drainage and cleaning procedures associated with SSTs 1-4. This alternative will maintain the existing tank drainage/cleaning procedures and provide improvements to ease the tasks associated with them. Alt-A2 - Raise SSTs 1-4 Concrete Tank Floors and Walls offers some advantages over this alternative which includes improving the SFP suction conditions. However, the higher lifecycle costs and constructability challenges and risks are not justifiable considering that the drainage and cleaning of the tanks is only done on a biannual basis.

To mitigate SSTs 1-4 Pipe Gallery flooding events, CDM Smith recommends implementing the following alternatives and improvements:

- Alt-B1 – No VFDs Located in SSTs 1-4 Pipe Gallery
- Alt-B2- Install Local Control Panels and Other Electrical and I&C Items Above Potential Flood Level
- Alt-B4- Sump with Duplex Sump Pumps
- Remove drainage valves from interconnection piping in valve pits.

Implementing Alt-B1 and Alt-B2 would prevent the VFDs, local control panels, and other electrical and I&C items from being damaged should a flooding event occur. Providing a sump with duplex sump pumps (Alt-B4) would mitigate flooding caused by minor to moderate piping/tank failures and leakages. However, these improvements will not mitigate flooding caused by a catastrophic pipe or tank failure. Providing improvements capable of mitigating a catastrophic failure flooding event is likely not practical and would add significant project costs, constructability challenges, and risks to the project. Lastly, CDM Smith recommends discontinuing use (blind flange) of the interconnection piping drain valves located in the two valve pits in the SSTs 1-4 Pipe Gallery. Opening these valves results in sludge (and sludge gasses) being discharged into the valve pit within the gallery prior to draining. This process affects the building's area classification rating and increases the risk of additional future flooding events.

7.0 Final Design Decisions and Additional Evaluation

The Great Lakes Water Authority (GLWA), NEFCO, and CDM Smith team held Workshop 2 for the GLWA WRRF Improvements to the Sludge Feed System for Solids Processing project on November 6, 2023, in person and via Teams. The team vetted the alternatives presented in this TM and made selections. Selected alternatives and final design decisions are the following:

- SSTs 1-4 Drainage: GLWA tasked CDM Smith with providing additional evaluation and to consider SST mixing improvements that could mitigate the accumulation of rags and grit. This additional evaluation is presented in subsequent sections of this TM-6.
- SSTs 1-4 Pipe Gallery Flooding Mitigation:
  - Alt-B1 – No VFDs Located in SSTs 1-4 Pipe Gallery. VFDs to be located at grade level.
  - Alt-B2 - Install New Local Control Panels and Other New Electrical and I&C Items Above Potential Flood Level.
  - Alt-B4- Sump with Duplex Sump Pumps.

7.1 SSTs 1-4 Drainage Additional Evaluation

CDM Smith was tasked with evaluating improvements to the SSTs 1-4 mixing systems to reduce grit and rag accumulation and improve ease of tank drainage and cleaning. Equipment vendors were contacted to find a suitable mixing system for this application. Pumped recirculation is a mixing system alternative worth considering based on initial vendor input. These systems use chopper pumps and a series of internal mixing nozzles mounted on the bottom or side of the tank to continuously recirculate media. This type of system is typically used for mixing sludge holding tanks and digesters. Vaughan is the primary supplier with their RotaMix® system. CDM Smith coordinated with Vaughan to determine if their typical mixing system could be modified to address both the tank mixing and tank drainage requirements of the Project.

7.1.1 Alternative A6 – Pumped Recirculation Mixing

Alt-A6 considers providing a pumped recirculation mixing system in each SST. Each mixing system would include a submersible chopper pump, mixing nozzles, and piping as shown in **Figure 7-1**. Access walkways would be modified to accommodate the new mixing systems and washdown cannons would be provided for use during tank draining/cleaning.

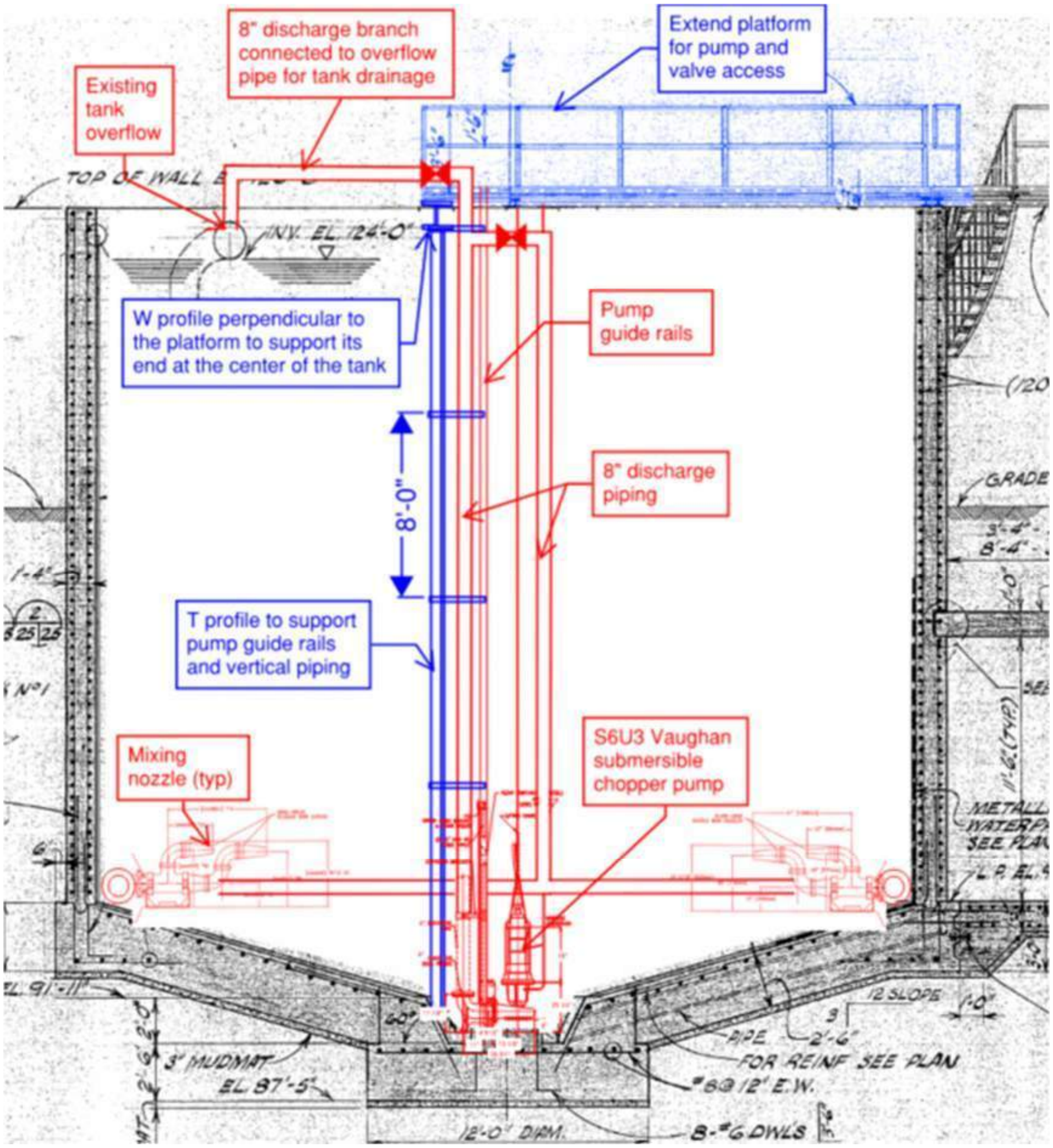

Figure 7-1: Alt-A6 Pumped Recirculation Mixing (RotaMix)

7.1.1.1 Alt-A6 Process Mechanical Modifications and Considerations

The existing in-tank air mixing piping and nozzles would be removed. The pumped recirculation mixing system would include one submersible chopper pump, four nozzles, and 8" ductile iron piping. The pump discharge piping would be routed up to the modified access platform and equipped with valving to divert flow to either the mixing nozzles or to a connection with the 18-inch overflow pipe for draining the tank.

Guide rails would be provided for periodic raising of the pump for maintenance and to check for rag accumulation. Washing solids toward the pump location using water cannons is anticipated to be required during tank drainage. 15 hp submersible chopper pumps capable of 1,200 gpm at 30 ft TDH is recommended. This 6-inch discharge pump can pass solids as large as 3-inch diameter and would allow for drainage of the remaining 8-feet of sludge within the tank in less than an hour (not including washdown or periodic rag removal time). A spare standby pumped would be provided and kept in storage for use should any of the duty pumps within the tanks fail. Raising/lowering of the pumps would be accomplished using the WRRF's crane truck in tandem with the pump guide rail systems.

Water cannons would be located on the platform at each tank to assist in agitating solids and moving them towards the pump during tank drainage. The water cannons would be temporarily connected to the existing secondary water fire hydrants SW-H-44 and SW-H-17, (100 ft on the east, and 50 ft on the west side of SSTs 1-4 respectively) when needed. Alternatively, two 4-inch yard hydrants with quick hose connections on both sides of Pump Station Ave could be provided for supplying secondary water to the water cannons. This would eliminate the need for hoses to cross the access roads while in use during tank cleanings. The connection for these proposed yard hydrants could be provided by sleeve tapping the existing 12-inch and 8-inch LPSW lines (typical pressure range of 45 to 70 psi) which are located near the SSTs at an approximate depth of 9 ft.

7.1.1.2 Alt-A6 Electrical Modifications and Considerations

The SST mixing pumps would be controlled via VFDs. The VFDs would be located with the new VFDs for the sludge feed pumps, SFP-1 thru SFP-4. The pumps would be provided power from the same MCCs that would power the SFPs. The locations and power sources are discussed in subsequent sections of this TM-6.

7.1.1.3 Alt-A6 Structural Modifications and Considerations

Extending the steel access walkways at the top of the existing sludge storage tank concrete walls is structurally feasible. The existing 1'-4" thick concrete tank walls would be evaluated for the additional loading due to the walkway; however, the walls were originally designed to support an access bridge and platform similar to what is proposed under this alternative, so no issues are anticipated. The access bridge and platform would be supported at the center of the tank by a steel wide-flange beam spanning perpendicular to the access bridge, supported at each end by the existing concrete tank wall. A vertical column would be installed, spanning from the tank floor to the access platform at the top of the tank for use in supporting the pump guide rails and vertical piping. The existing 3-foot diameter, 1.5-feet tall concrete base located in the center of the sump would be removed to allow for installation of the mixing system pump. This concrete base was used for supporting the center column of the sludge collection equipment which has been removed and is therefore no longer needed. The new vertical column will be supported at the base by the existing 3'-0" thick concrete tank base slab.

7.1.2 Lifecycle Costs

A lifecycle cost analysis was performed to determine the present-day costs of implementing the Alt-A6 improvements. A breakdown of the cost items is presented below.

▪ Demolition, Structural Mods, Equipment, and Piping	$1,345,000
▪ Electrical and Automation	$250,000
▪ **Total Capital Cost**	**$1,595,000**
▪ Lifecycle Operational Cost	$785,000
▪ Lifecycle Preventative Maintenance Cost	$300,000
▪ Lifecycle Rehab Maintenance Cost	$75,000
▪ **Total Lifecycle Cost**	**$2,755,000**

7.1.3 Advantages

Advantages of Alt-A6 include the following:

- Improves mixing and provides method to drain the tanks.
- Provides continuous processing (chopping) of rags in the tanks.
- Eliminates need for blowers. Blower Building could be used for electrical equipment or other purposes.
- No significant constructability challenges.
- Minimal MOPO impacts.

7.1.4 Disadvantages

Disadvantages of Alt-A6 include the following:

- High O&M cost.
- High maintenance requirements.

- May require increased maintenance and monitoring during periods of excessive rag loads.
- May not eliminate need for vac truck during tank cleaning.

7.2 SFPs 1-4 VFD Installation Location

During Workshop 2 it was determined that the SFP 1-4 VFDs should be installed at a location at grade level. CDM Smith has identified and evaluated two locations for consideration.

7.2.1 Alt-C1 New Electrical Room in Complex A Storage Room

Alt-C1 considers constructing a new Electrical Room located in the Complex A Storage Room to house the SFP 1-4 VFDs and SSTs 1-4 mixing pump VFDs (if this improvement is implemented). The room would be approximately 18 ft long x 10 ft wide, constructed of concrete masonry units (CMUs) doweled into the existing concrete fill and floor slab, and provided with standalone HVAC systems as shown **Figure 7-2**. The 10 ft width of the room would line up with the existing Women's Bathroom wall. The 18 ft length would locate its north wall on the existing floor beam and provide adequate room for the VFDs, lighting panels, and HVAC panels. The existing Storage Room windows would be bricked closed to provide more wall space for electrical equipment.

SFP-1 thru SFP-4 VFDs would be powered from MCC-A3 and MCC-A4 as described in TM-5. SST-1 thru SST-4 mixing pump VFDs would be powered from these same MCCs.

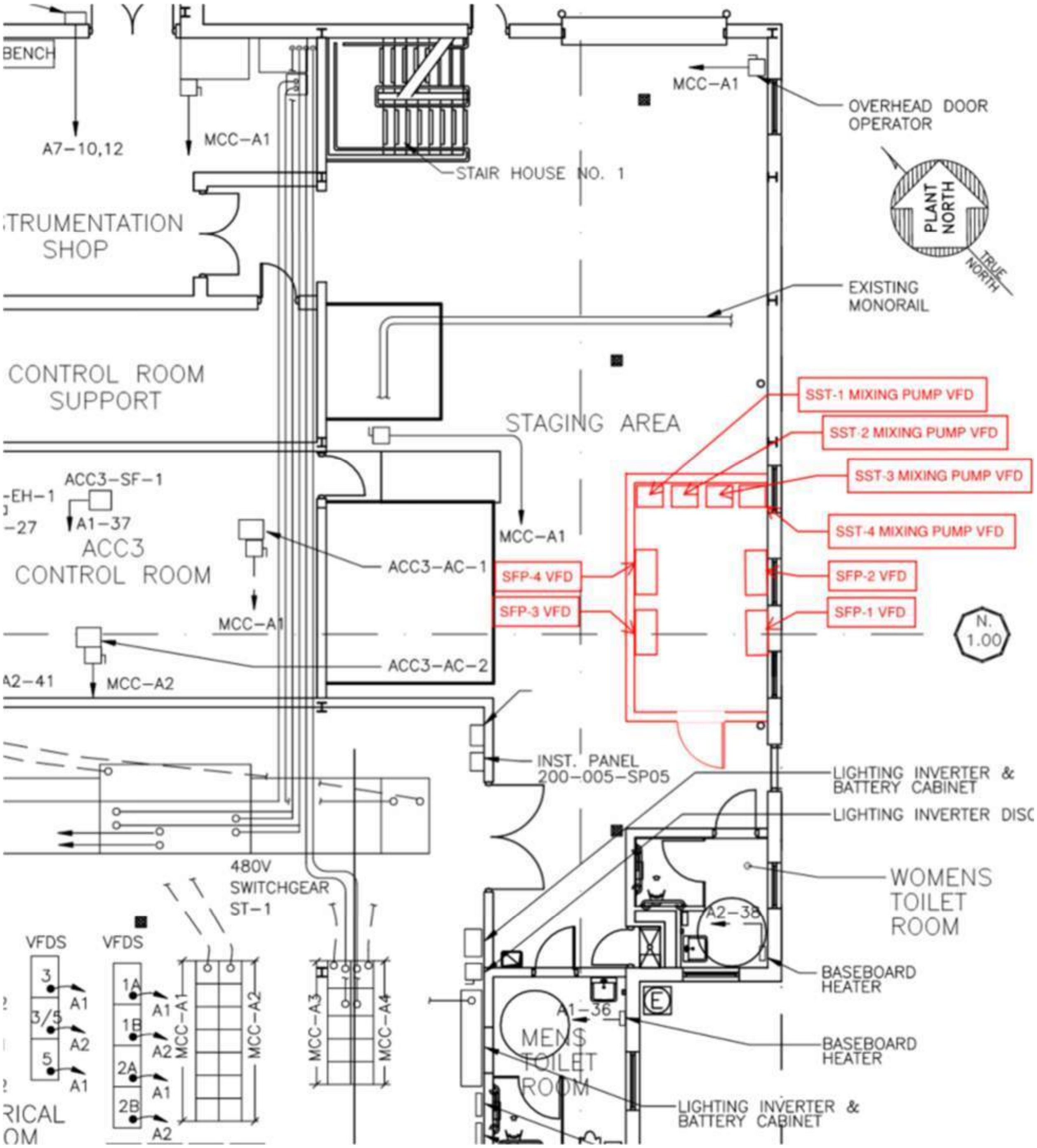

Figure 7-1: Alt-C1 Electrical Room Layout in Sludge Processing Complex A Storage Room

7.2.1.1 Advantages

Advantages of Alt-C1 include the following:

- Locates VFDs at grade level.
- Located near existing Complex A Electrical Room and Control Room.
- New room/layout can be sized to optimize equipment layout.
- Locates VFDs closer to equipment than Alt-C2.

7.2.1.2 Disadvantages

Disadvantages of Alt-C2 include the following:

- Located in travelling bridge crane envelope of travel.

7.2.2 Alt-C2 Convert SSTs 1/2 Blower Building into Electrical Building

Alt-C2 considers converting the SSTs 1/2 Blower Building into an Electrical Building as shown in **Figure 7-3**. If Alt-A6 is implemented, the blowers in this building will no longer be needed and the building can be repurposed. The building would be provided with new standalone HVAC systems.

The SFP and SST mixing pumps would be powered from MCC-BB1 located in the Blower Building. The age and condition of the MCC would require additional evaluation; however, initial recommendation is to replace the MCC to ensure adequate capacity for new VFDs and the existing loads in the SSTs 5/6 Blower Building which are also fed from MCC-BB1. It is recommended to provide a second source of power from Substation ST-1 (Main Bus B) to provide redundancy for the SFPs and mixing systems. Providing the redundant power source would require installing a new MCC and associated conduits and cables. Further improvement of the building including adding insulation and making the building weathertight may be needed to make it suitable for installing new electrical equipment.

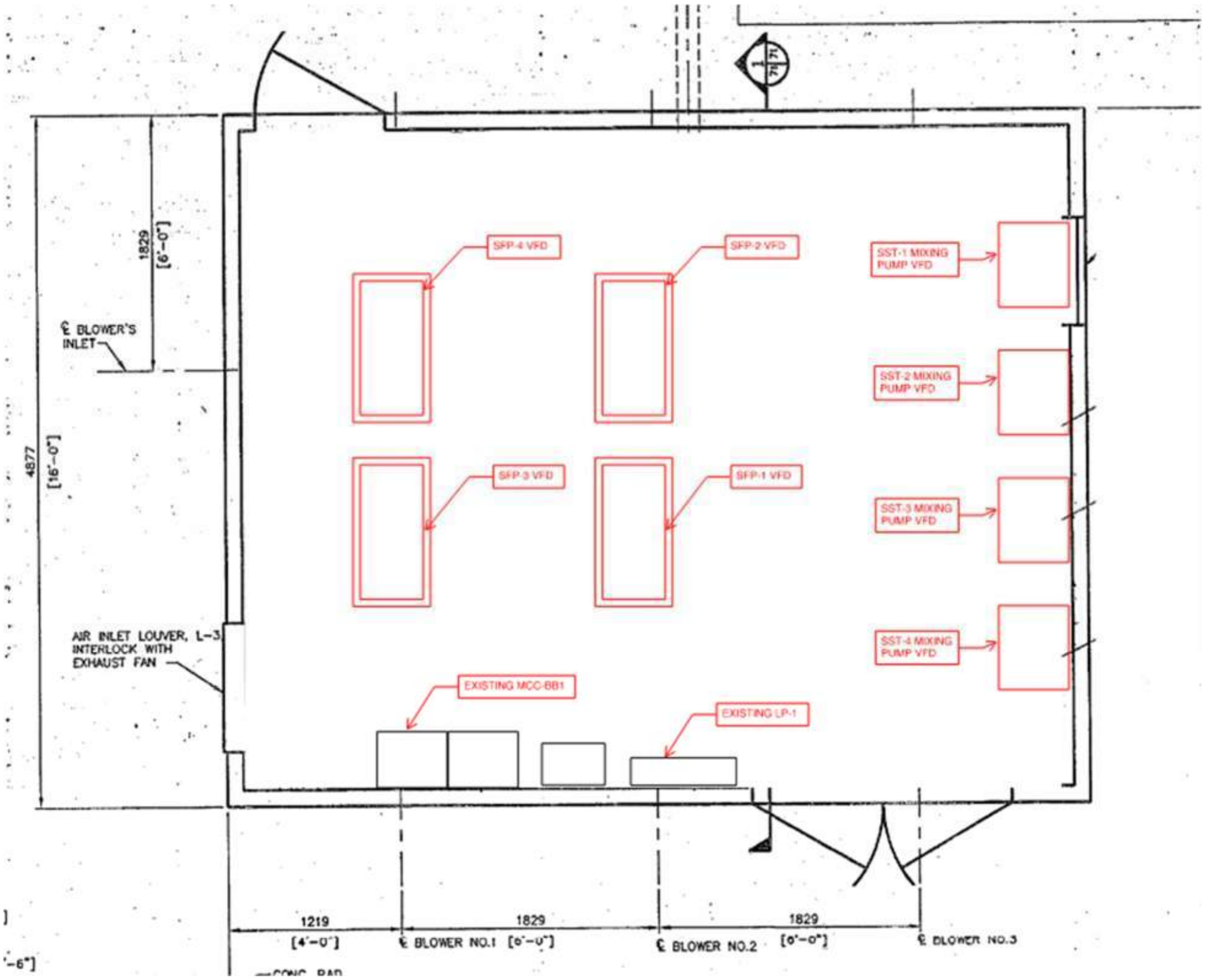

Figure 7-3: Alt-C2 Electrical Room Layout in SST 1/2 Blower Building

7.2.2.1 Advantages

Advantages of Alt-C2 include the following:

- Locates VFDs at grade level.
- Repurposes existing building that is no longer needed.
- Provides more working space in and around VFDs.

7.2.2.2 Disadvantages

Disadvantages of Alt-C2 include the following:

- Building may require upgrades/repairs to make suitable for electrical equipment.

- Locates VFDs farther from equipment than Alt-C1.

7.2 Additional Evaluation Recommendations

Based on the additional evaluation performed, CDM Smith recommends implementing Alt-A6 – Pumped Recirculation Mixing to improve the drainage and cleaning procedures associated with SSTs 1-4. This alternative would improve the mixing of the sludge within the tanks, provide a means to drain the tanks, and provide additional processing (chopping) of the rags. If Alt-A6 is implemented, CDM Smith also recommends Alt-C2 Converting the SSTs 1/2 Blower Building into an Electrical Building. Utilizing this space for housing the SFP 1-4 and mixing pump VFDs will allow the Complex A Storage Room space to be maintained and eliminate the need for a room to be constructed in the travelling bridge crane operating envelope.

7.3 Workshop 2B and Final Design Decisions

The Great Lakes Water Authority (GLWA) and CDM Smith team held Workshop 2B for the GLWA WRRF Improvements to the Sludge Feed System for Solids Processing project on December 1, 2023, via Teams. The team vetted the additional alternatives presented, discussed miscellaneous project input needs, and made selections. Selected alternatives and final design decisions are the following:

- SSTs 1-4 Drainage: GLWA will continue with the current procedures for draining and cleaning the SSTs. No drainage/mixing improvements to the SSTs will be provided on this project.
- SFPs 1-4 VFD Location: The VFDs will be located at grade level in the existing Complex A Instrumentation Shop. This location was reviewed and confirmed by CDM Smith engineers and GLWA staff onsite on 12/5/2023.
- BDF Sludge Loop Piping Condition: The piping is anticipated to be in good condition and will not be assessed/cleaned during the construction phase of this project.
- The primary sludge piping in the SSTs 5/6 Pump Building and in the yard outside the building is abandoned and can be removed.

cc: File