DELMAS WWTP UPGRADE PRELIMINARY DESIGN REPORT – MEMBRANE BIOREACTOR

MCCAIN FOODS (SOUTH AFRICA) (PTY) LTD.

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TABLE OF CONTENTS

1 INTRODUCTION 1

1.1 Report Overview 1

2 DESIGN BASIS 2

2.1 Description of Existing Process 2

2.2 Process Wastewater Design Basis 2

Anaerobic DIgester Design Basis 3

3 UNIT PROCESS DESIGN 5

3.1 Equalization Tank 5

3.2 Primary Clarifier 5

Upflow Anaerobic Sludge Blanket Reactor (UASB) 5

3.3 Activated Sludge and membrane bioreactor 7

3.3.1 Activated Sludge Process 7

3.3.2 Membrane Technology Overview 7

3.3.3 MBR Activated Sludge System Overview 8

3.3.4 Process Overview 8

3.3.5 MBR Design values 9

3.3.6 Phosphorus Removal 10

3.3.7 Sludge Handling 11

3.4 Anaerobic Digester 11

Waste COllection 11

3.4.1 White Waste Acidification 11

3.4.2 Anaerobic Digester 12

3.4.3 Biogas Handling 13

4 GEOTECHNICAL INVESTIGATION 14

5 ENVIRONMENTAL PERMITTING 15

6 CLOSURE 16

TABLES

Table 1: Primary Clarifier Effluent Entering WWTP Expansion 2
Table 2: WWTP Effluent Compliance Targets for Sewer Discharge 3
Table 3: Typical WWTP Effluent Quality Targets for Water Recycle or Environmental Discharge 3
Table 4: Summary of Daily Operating Conditions at 18 TPH 4
Table 5: Key Design Parameters for the Equalization Tank 5
Table 6: Key Design Parameters for the UASB System 6
Table 7: Advantages and Disadvantages of an MBR, Compared to a Secondary Clarifier 8
Table 8: Design Assumptions for the Activated Sludge System 10
Table 9: Design Values for the Activated Sludge System 10
Table 10: Key Design Parameters for the White Waste System 12
Table 11: Key Design Parameters for the Anaerobic Digester 12

FIGURES

Figure 1: Borehole and Test Pit Locations 14

APPENDICES

Appendix A Design Basis Memo
Appendix B Preliminary P&IDs
Appendix C Preliminary Layout
Appendix D Site Geotechnical Report

1 INTRODUCTION

1.1 REPORT OVERVIEW

McCain Foods (South Africa) (Pty) Ltd. (McCain) owns and operates a potato processing plant in Delmas, South Africa. The plant currently operates two (2) 10 tonne per hour (TPH) french fry lines with a total production capacity of 20 (2 x 10) TPH as finished product. It is WSP E&I's understanding that in the future, the plant will be expected to operate one line at 9 TPH and the second line at 7.5 TPH (with an upgrade to 9 TPH at a later date). WSP E&I previously submitted a revised design basis based on a single 15 TPH line to provide additional operational capacity for the WWTP in the event of any additional changes to production capacity as well as a Conceptual Design Report providing a summary of the key design parameters for each of the unit processes within the new expanded WWTP, based on that 15 TPH design basis. The previous design report provided design parameters for the treatment system with a secondary clarifier configuration.

This report serves to further develop the existing Delmas WWTP Upgrade Conceptual Design Report and provide further design information on the implementation of an MBR system as an alternative. It will provide an updated summary of the design criteria, provide a technological and operational overview of a membrane bioreactor configuration in this application, and provide the key design inputs and sizing figures.

2 DESIGN BASIS

The following section provides information on the basis of design used to prepare the Preliminary Design for the wastewater treatment processes. Please refer to the Design Basis Memo and Conceptual Design Report appended to this report for more detailed information and historic design development information.

2.1 DESCRIPTION OF EXISTING PROCESS

The existing WWTP at Delmas includes a rotary screening reel and primary clarifier. Clarified effluent from the primary clarifier is discharged to the sewer. An oily water treatment system also exists, comprised of an oily water screen, separation tank, dissolved air flotation (DAF) unit, and a separate oil storage tank. This system provides treatment for oily water in the facility fryer areas. Fryer caustic sanitation is intended to be bypassed around the oily water system.

2.2 PROCESS WASTEWATER DESIGN BASIS

The anticipated water quality leaving the primary clarifier and acting as the influent for the upgraded WWTP was determined based on estimated influent water quality data and assumed primary clarifier and DAF performance. The WWTP will be designed to handle the feed water quality shown in Table 1.

Table 1: Primary Clarifier Effluent Entering WWTP Expansion

PARAMETER	UNITS	DESIGN VALUE
Peak Design Flow	m^3/day	3,457[1]
Instantaneous Peak Flow	m^3/hour	179
pH	-	5 - 6
Temperature	deg. C.	20 - 30
FOG	mg/L	<100
Chemical Oxygen Demand (COD)	mg/L	6,390
	kg/d	22,090
Total Suspended Solids (TSS)	mg/L	822
	kg/d	2,841
Total Kjeldahl Nitrogen (TKN)	mg/L	197
	kg/d	681
Total Phosphorus	mg/L	83
	kg/d	287

Notes
1. Represents a 20% increase from the previous design proposal for 15 TPH

The local municipality in Delmas, SA has specified compliance discharge targets for the facility. The proposed WWTP upgrade design will ensure that the effluent will meet these targets, as described in Table 2.

Table 2: WWTP Effluent Compliance Targets for Sewer Discharge

PARAMETER	UNITS	LIMIT
Electrical Conductivity (EC)	ms/m	<500
Total Suspended Solids (TSS)	mg/L	<1,000
Total Dissolved Solids (TDS)	mg/L	<3,250
Ammonia (NH3)	mg/L as N	<50
Ortho-Phosphate (O-PO_4)	mg/L as P	<10
pH	pH Units	6.0-10.0
Fats, Oil and Grease (FOG)	mg/L	<500
Chemical Oxygen Demand (COD)	mg/L	<5,000

While these represent the compliance targets for the local municipality, it is understood that McCain wishes to maintain the option to discharge directly to the environment or further treat the effluent to recycle water into the facility in the future. As such, the wastewater treatment plant will be designed to achieve more stringent effluent quality targets given below.

Table 3 provides effluent quality requirements that would be suitable for direct discharge to the environment, or for recycle to potable water quality for plant use.

Table 3: Typical WWTP Effluent Quality Targets for Water Recycle or Environmental Discharge

PARAMETER	UNITS	LIMIT
Total Suspended Solids (TSS)	mg/L	<20
Ammonia (NH_3)	mg/L as N	<0.2
Total Phosphorus	mg/L as P	<10
Nitrate	mg/L as N	<10
pH	pH Units	6.0-10.0
Fats, Oil and Grease (FOG)	mg/L	0
Chemical Oxygen Demand (COD)	mg/L	<50

The existing wastewater treatment infrastructure at the site cannot reliably meet the requirements in Table 2 or Table 3. The proposed upgrades to the wastewater treatment plant have been designed to meet the requirements of Table 3.

ANAEROBIC DIGESTER DESIGN BASIS

The upgrade will include an anaerobic digestion process to process the solid wastes produced by the facility in order to reduce disposal costs and allow for on-site biogas production and use. Solid wastes from the plant, including slivers, nubbins, cubes, peel, trimmings and waste potatoes are currently captured and disposed of off-site. McCain will anaerobically digest the combined solid waste to generate biogas. To generate biogas from the solid potato wastes, the wastes are first slurried and pumped to an anaerobic digester which breaks down the organic loading present in the slurry and produces a biogas that can be scrubbed and combusted in either a boiler or a generator. The digestate is then passed through a centrifuge to remove any remaining solids, which would then be disposed of off-site. Centrate from the centrifuges would be pumped to the activated sludge reactors.

The monthly data summary for each waste stream to be included in the daily loading for the design of the new Solids Waste Anaerobic Digester is summarized in Table 4.

Table 4: Summary of Daily Operating Conditions at 18 TPH

WASTE STREAM	AVG. DAY OF MAX MONTH	PEAK	SOLIDS	COD CONTENT
	kg/day	kg/day	%	kg COD/kg
Solid Production Waste[1]	84,233	94,650	18%	0.38
Liquid Production Waste[2]	19,784	13,436	5%	0.006
Potato Waste[3]	13,001	12,535	25%	0.56
Primary Clarifier Sludge[4]	-	284,160[5]	4%	~0.05

Notes:
1. Solid production waste estimated using a distribution of 50% screening waste, 39% peels waste, 11% fried and frozen waste.
2. Liquid production waste composition is unknown but is expected to be low in solids.
3. Estimate from effluent treatment plant design basis of 0.56 kg COD/tonne of raw potato.
4. Calculated based on assumed primary clarifier performance outlined in design basis. Not based on recorded data.
5. Based on average COD value estimated in effluent treatment plant design basis and an assumed 40% COD removal in the primary clarifier.

3 UNIT PROCESS DESIGN

3.1 EQUALIZATION TANK

To provide additional equalization and normalization of flows through the wastewater treatment plant, a new coated concrete equalization tank will be designed and constructed. The equalization tank will intercept the existing feed to the primary clarifier and provide equalization volume to reduce flow variability. New equalization lift pumps will pump from the equalization tank to the existing primary clarifier. A new submersible mixer will be provided to ensure the equalization tank contents remain homogenous and to limit the potential for the development of odours.

Table 5 presents the key design parameters for the equalization tank.

Table 5: Key Design Parameters for the Equalization Tank

PARAMETER	UNITS	VALUE
Retention Time	Hours	~4
Peak Instantaneous Flow	m^3/hr	179
Volume	m^3	720
Dimensions	m	12 (L) x 12 (W) x 5 (D)

The equalization tank will be installed as physically close to the existing primary clarifier as possible to ensure the hydraulics of the existing system are preserved. The equalization tank will be operated based on level, with the primary clarifier feed pumps operating at a fixed flowrate until specific level setpoints, when pump speed will be increased. This will reduce surging in the primary clarifier. A mixer will be installed to prevent settling of material before the primary clarifier.

3.2 PRIMARY CLARIFIER

The existing primary clarifier will be retained. No modifications to the existing primary clarifier are planned. The feed to the primary clarifier will be intercepted and directed into the new equalization tank, and new primary clarifier feed pumps will be installed. The primary clarifier sludge will be directed to the new anaerobic digestion system, as discussed below.

UPFLOW ANAEROBIC SLUDGE BLANKET REACTOR (UASB)

An upflow anaerobic sludge blanket reactor (UASB) system will be installed upstream of the main biological treatment process to reduce COD loading and generate biogas. Anaerobic pretreatment is an efficient means of reducing the required size of the downstream aerobic processes and provides some amount of biogas as a by-product. The UASB system is a compact sized anaerobic system with high specific COD loading rate that utilizes granular anaerobic biomass to digest soluble feedstocks and produce methane as a by-product. UASB systems are utilized extensively in McCain and provide a robust pre-treatment for potato processing wastewater. Higher rate systems are available on the market but are not recommended unless site conditions dictate, as they tend to be less robust in operational stability. The UASB consists of the following unit processes:

- UASB Feed Tank

- UASB Feed Pumps
- UASB Reactor
- UASB Sludge Tank
- UASB Sludge Pumps

The UASB will be provided as a packaged system by a specific vendor, which may include other components as deemed necessary by the vendor. A pumped bypass will be included to allow a controlled stream of wastewater to bypass the UASB and ensure the aerobic treatment system has sufficient COD. In addition, a gravity bypass from the UASB feed tank will also be installed to allow the UASB to be completely bypassed and for the treatment system to flow entirely by gravity if required. The UASB sludge tank will be used for storing excess sludge, to allow the system to be reseeded if required. The UASB system will also include chemical dosing pumps for pH adjustment and micronutrient dosing.

Table 6 presents the key design parameters for the UASB system.

Table 6: Key Design Parameters for the UASB System

PARAMETER	UNITS	VALUE
UASB Feed Tank Retention	Hours	~6
UASB Feed Tank Working Volume	m^3	794
UASB Feed Tank Dimensions	m	8.5 (D) x 13 (H)
UASB Design Flow	m^3/d	2,938
UASB Design Inlet COD	mg/L	6,390
UASB Loading Rate	kg COD/m^3 d	7.0
UASB Upflow Velocity	m/h	0.8 - 0.9
UASB COD Destruction		80% - 90%[1]
Estimated UASB Reactor Working Volume	m^3	2,886
UASB Reactor Dimensions	m	14 (D) x 22 (H)
Sludge Tank Working Volume	m^3	100
Sludge Tank Dimensions	m	4.5 (D) x 6.5 (H)
Estimated Biogas Produced	m^3/d	8,460
Biogas Methane Content	%	70%

Notes:
1. 80% COD removal assumed for bioreactor sizing. 90% COD removal is assumed for sizing biogas handling.

The sizing of the UASB reactor is primarily based on a target loading rate and upflow velocity. Based on WSP E&I's previous experience with UASBs at other McCain sites, lower loading rate systems (UASB) are preferable as the material in McCain wastewater is less available and takes longer to break down than in other applications. Higher rate anaerobic systems (Internal Circulation (IC) and Expanded Bed Granular Reactors (EGSB)) tend to have a less robust operation, are more susceptible to upsets and have generally poorer COD removal and biogas generation than UASB systems, which results in increased load on the activated sludge system.

3.3 ACTIVATED SLUDGE AND MEMBRANE BIOREACTOR

3.3.1 ACTIVATED SLUDGE PROCESS

The aerobic treatment system provides COD, phosphorus, and nitrogen removal in a four-stage Bardenpho process configuration, utilizing a pre-anoxic zone, aerobic zone, post-anoxic zone, and re-aeration zone. This form of activated sludge system allows for efficient nitrification-denitrification by providing mixed pre- and post-anoxic zones where denitrification occurs. The aerobic zone allows for the growth of aerobic bacteria, which consume COD and ammonia. This approach requires a more complicated design than a typical single-stage aeration basin but is required when low effluent total nitrogen is required.

Effluent from the activated sludge plant requires clarification to separate the biomass solids in the mixed liquor and allow for discharge. This separation also allows for the creation of Return Activated Sludge (RAS) and Waste Activated Sludge (WAS) streams. The RAS returns the activated sludge biomass to the beginning of the process to maintain the population of microorganisms that allow for adequate treatment. The RAS system allows the operator to control the mass of biomass in the treatment systems and operate the system at a steady state condition. This can be achieved through gravity settling in a secondary clarifier, as was previously presented in the Conceptual Design Report, or using a membrane bioreactor (MBR) system. The MBR was selected as the preferred alternative for clarification and is described further in the following sections.

3.3.2 MEMBRANE TECHNOLOGY OVERVIEW

An MBR uses a membrane to provide a positive barrier to solids and provide effluent clarification following the activated sludge treatment. Effluent from the activated sludge system is collected in the membrane tank and is drawn through the membranes using MBR effluent pumps. Solids are retained on the outside surface of the membrane and clarified water is discharged to the final discharge point.

The membranes are backpulsed for very short periods of time by pumping clarified effluent in reverse through the membranes. This causes the film of solids that has built up on the membrane to dislodge into the bulk volume of the tank, where it can either be recycled as RAS or sent to sludge storage and thickening for disposal as WAS. Air scour blowers are also required to provide scouring of the membranes to ensure optimal performance.

The membrane tank can either be above ground or below ground. For this system it is likely that an inground concrete tank would be used, allowing the tank to be fed by gravity. Biogas generated in the UASB and anaerobic digesters will be used to power generators, which will allow for backup power to be provided to some critical wastewater treatment plant infrastructure, to ensure the plant can continue to operate during load shedding events and brownouts/blackouts. An emergency overflow will be provided, which would allow the contents of the membrane tank to overflow by gravity to the final discharge point in the event of a failure of the backup generators.

Table 7 summarizes the major advantages and disadvantages of using an MBR, compared to a secondary clarifier.

Table 7: Advantages and Disadvantages of an MBR, Compared to a Secondary Clarifier

ADVANTAGES	DISADVANTAGES
– Provides a positive barrier to solids, eliminating the possibility of upset conditions due to variable flow or changes in bacteria growth in the activated sludge system – Allows for a significantly higher influent MLSS concentration, reducing the required size of the activated sludge system – Effluent quality would allow for environmental discharge or direct feed into a water recycle system with no modifications	– More operationally complex and requires additional infrastructure, such as backpulse pumps and air scour blowers – Relies on vendor-supplied membranes, which will need to be periodically maintained and replaced – Cannot operate in low- or no-power conditions; untreated effluent from the activated sludge system would discharge by gravity to the sewer

3.3.3 MBR ACTIVATED SLUDGE SYSTEM OVERVIEW

The membrane bioreactor is designed using a four-stage Bardenpho process, consisting of a pre-anoxic zone, aerobic zone, post-anoxic zone, and re-aeration zone. This form of activated sludge system allows for a higher degree of total nitrogen removal, by providing mixed pre- and post-anoxic conditions where denitrification can occur.

Similar to the secondary clarifier-based design, the main aerobic treatment zone primarily provides biodegradable COD oxidation and nitrification, while also up-taking small quantities of phosphorus and nitrogen for cell growth and maintenance, while the anoxic zone provides an environment for denitrifying bacteria, enabling the biological reduction of nitrate to elemental nitrogen. The final re-aeration zone is used to strip elemental nitrogen from the mixed liquor, provide oxygen to reoxygenate the biomass, and to remove any excess carbon source material added to promote denitrification.

Altering the process from a secondary clarifier based activated sludge system to a membrane bioreactor will maintain the same key treatment mechanisms at each stage. To maximize the operation of the membranes, there are several key configurational changes to the recycle flows, and solids concentration that affect the overall operation of the activated sludge system.

3.3.4 PROCESS OVERVIEW

The influent to the activated sludge system is combined in an influent splitting chamber, with a chamber and connection provided to allow for a future treatment train, if required. In this chamber, the UASB effluent, UASB bypass, RAS, and mixed liquor recycle (MLR) are combined and fed into the activated sludge treatment system. The combined influent flows through overflow weirs in the walls of the activated sludge system in the following order: pre-anoxic zone, aerobic zone, post-anoxic zone, re-aeration zone.

Mixed liquor recycle pumps will withdraw mixed liquor containing nitrified water from the outlet of the aerobic zone and return it to the influent splitting chamber for denitrification in the pre-anoxic zone. The MLR pumps will be housed outdoors adjacent to the aeration basin and will pump at approximately two (2) times the influent flowrate to the system.

The aerobic and re-aeration zones will contain removeable fine bubble diffusers, with air provided by external hybrid aeration blowers. The membrane tank will also consist of a designated blower set for periodic membrane cleaning. The diffuser grids in this configuration must be removeable to facilitate diffuser maintenance. A flanged connection will be provided at the blowers for additional future blowers and connection to future aeration grids if required.

The pre- and post-anoxic zones do not have aeration grids and must be maintained in a well-mixed state. Removeable submersible mixers will be installed in the basins providing complete mixing of each tank.

Mixed liquor from the re-aeration basin is fed into the membrane tank by gravity, from which it is drawn through the membranes through two (2) MBR permeate pumps to a final effluent tank, before overflowing and being discharged by gravity to the sewer. The permeate pumps will be reversing rotary lobe-style pumps and will also function as backpulse pumps. The membranes are frequently backpulsed for short periods of time, which causes accumulated sludge on the membrane surface to dislodge and enter the tank as mixed liquor. The residual mixed liquor will concentrate and pass to the recycle system where it will be pumped to the influent splitting chamber. A portion of the sludge from the MBR tank is removed from the system as waste activated sludge (WAS) to maintain the desired biological composition in the reactor tanks.

ALTERNATIVE DESIGNS

The configuration described above is known as a "pump from" MBR, where effluent from the re-aeration zone is fed by gravity into a below-grade membrane tank and RAS is pumped from this tank back to the influent chamber of the activated sludge system. In this configuration, the MBR cassettes are housed in below-ground concrete tanks. Due to the climatic conditions in South Africa, it may also be possible to configure the system as a "pump to" system, where effluent from the re-aeration basin is pumped to above ground stainless steel membrane tanks, and RAS overflows by gravity back to the influent of the activated sludge system. This arrangement minimizes below ground concrete tanks and allows for a more modular and packaged MBR system.

3.3.5 MBR DESIGN VALUES

The COD, TKN and TP values for the MBR influent were developed from the design assumptions and expected performance of the upstream unit operations. These assumptions are summarized in the above design basis section and are further expanded in Appendix A. Following the primary clarifier, the COD is expected to be primarily soluble with the non-soluble fraction expected to be colloidal in nature.

The size of the activated sludge reactor stages is primarily based on the operating mixed liquor suspended solids (MLSS) concentration, which is dependent on a variety of other design assumptions. This is the concentration of biomass and other suspended solid material in the activated sludge system, which must be separated from the water by the membrane. The maximum operating MLSS is determined by the ability of the solids to separate from liquid to produce a compliant effluent. Due to the ability to efficiently separate solids from mixed liquor using a membrane, an operating MLSS of 8,000 mg/L is achievable with minimal solids concerns in the effluent.

The first anoxic zone is the first denitrification zone that uses an anoxic environment and recycled nitrified water to reduce nitrate loading by 80% of the total influent, with the remainder of the nitrate loading will be treated in the second anoxic zone. To assist with this reduction, up to 15% of the UASB feed can be bypassed to the influent distribution chamber to provide a readily biodegradable carbon source to maintain denitrification efficiency.

The first aeration zone is the primary nitrification and COD oxidation zone that uses an aerobic environment to oxidize ammonia to nitrate. This basin is designed for complete nitrification and will target a minimum dissolved oxygen concentration of 2 mg/L to facilitate fully aerobic conditions.

The second anoxic zone will denitrify the remainder of the nitrified water to within the desired targets. This design uses conservative design values to achieve effluent nitrate concentrations below 10 mg/L as N under

design conditions. Diverting 25 – 50 m^3/day of UASB bypass to the second anoxic zone will facilitate increased nitrate removal to ensure nitrate concentrations in the effluent meet the required concentrations by providing a readily biodegradable carbon source. An external carbon source may also be used.

The re-aeration zone is sized with an approximate 1-hour HRT to allow adequate re-aeration for optimal separation in the membrane tank downstream, as well as strip gaseous nitrogen from denitrification from the mixed liquor and provide removal of excess COD added in the form of bypass.

Table 8 shows the key design assumptions for this system, while Table 9 shows the keys design output values.

Table 8: Design Assumptions for the Activated Sludge System

PARAMETER	UNITS	VALUE
Influent Flowrate (UASB Effluent and UASB Bypass)	m^3/d	4,054[1]
Max UASB Bypass	%	15%
Combined Influent COD Concentration	mg/L	2,187
Combined Influent TKN Concentration	mg/L	228
Combined Influent TP Concentration	mg/L	86
Target F:M Range	lb BOD/d/lb MLVSS	0.12-0.15
Target SRT	days	17
Target MLSS	mg/L	8,000
RAS Recycle Flow	m^3/d	16,200 (4 x Influent Flow)
MLR Recycle Flow	m^3/d	16,200 (4 x Influent Flow)
DO Setpoint for Aerated Stages	mg/L	2.0

Notes:
1. Includes a peak centrate flow of 605 m^3/d from digestate and WAS dewatering.

Table 9: Design Values for the Activated Sludge System

PARAMETER	UNITS	VALUE
HRT	hours	47
MLVSS%	%	50
Total Required Volume	m^3	7,920
1st Anoxic Stage Volume	m^3	2,180
1st Aeration Stage Volume	m^3	4,210
2nd Anoxic Stage Volume	m^3	1,170
2nd Aeration Stage Volume	m^3	360
Activated Sludge Tank Depth	m	6
WAS Removal Rate	m^3/d	373
WAS Solids Content	mg/L	10,000

3.3.6 PHOSPHORUS REMOVAL

Chemical phosphorus treatment is required to reach the targeted effluent values, as microbial phosphorus uptake will only constitute a small portion of the required removal. This can be conducted with either iron (ferric) or aluminum (alum) salts to precipitate insoluble phosphorus. The precipitated phosphorus sludge is unable to pass through the membrane and will be removed in the waste activated sludge line. Similar McCain facilities have seen an optimal Metal:Phosphorus molar dosing ratio at around 1.0 which is assumed for the design at this stage. Chemical phosphorus removal produces an inert suspended solid in the activated sludge basins, resulting in an overall volume increase to maintain biological treatment functionality.

3.3.7 SLUDGE HANDLING

As the treatment bacteria in the activated sludge process grow, an equivalent amount of mixed liquor must be removed to maintain the mass of biomass in the system. This excess mixed liquor is removed as waste activated sludge. The WAS is transferred to a sludge storage tank, where it is fed to a centrifuge for thickening. The same centrifuge will be used for thickening both WAS and digestate from the anaerobic digester. Cake from the centrifuge will discharge into the existing sludge conveyance system and hoppers for off-site disposal. Nutrient-rich centrate from the sludge thickening process will be sent back to the influent equalization chamber for further treatment.

3.4 ANAEROBIC DIGESTER

The anaerobic digestion system provides a means of managing and extracting value from COD-containing wastes on-site, such as fryer waste, slivers, and other materials that are collected in the main wastewater screen and oily water screen. The anaerobic digester converts the COD into biogas, which can be used to either generate power or displace natural gas in plant boilers.

WASTE COLLECTION

White waste is collected mainly at the existing wastewater screen and at the oily water screen. Some other waste streams on-site may be sent to the anaerobic digester on a periodic basis, as required. The existing main wastewater screen and oily water screen will be retained and are assumed to be in good condition. A new reversing conveyor will be installed, which will allow screenings to be directed either to the hammermill for maceration or to a truck for disposal.

3.4.1 WHITE WASTE ACIDIFICATION

The anerobic digestion process begins with the processing of the white waste and other digestible materials into a slurry with a concentration of approximately 8 - 12%. White waste from the screens is directed into a feed hopper above the hammermill, which macerates the white waste to form a paste. To maintain the slurry concentration, typically dilution water or other materials are added to reduce the solids concentration leaving the hammermill. In this case, primary clarifier sludge along with the liquid production waste stream will be pumped into the hammermill feed hopper to reduce the solids concentration leaving the hammermill to approximately 8%. The material discharged from the hammermill is continuously pumped to the acidification tank for pre-acidification before being fed to the digesters.

The acidification tank feed pumps discharge at a fixed flowrate and dilution water connection is added to the hammermill based on slurry pump discharge pressure. As the slurry is shear thinning material, the discharge pressure on the acidification tank feed pumps will be higher at start-up and will decrease as the velocity in the pipe increases. As the slurry concentration is expected to be around 8% with the primary clarifier sludge, it is anticipated that dilution water would be required at start-up and flushing only.

The acidification tank is continuously mixed and provides an environment that allows for partial breakdown of the material to be digested, making the COD more accessible and increasing COD destruction and biogas yield in the digesters.

Table 10 presents key design parameters for the white waste system, including the hammermill and acidification tank.

Table 10: Key Design Parameters for the White Waste System

PARAMETER	UNITS	VALUE
Hammermill Feed Rate	m^3/d	385
	m^3/hr	16
Acidification Tank Retention Time	hr	24
Acidification Volume	m^3	397
Acidification Tank Dimensions	m	5.0 (D) x 9.5 (H)
Acidification Tank Freeboard	m	0.6
Total Volume	m^3	397
Acidification Tank Mixing Pump Flow	m^3/hr	20
Digester Feed Batches	per day	6
Digester Feed Batch Duration	hrs	1.5
Digester Feed Pump Flowrate	m^3/hr	22

3.4.2 ANAEROBIC DIGESTER

The anaerobic digester is fed from the acidification tank in batches and is continuously mixed by a jet mixing system. Jet mixing pumps are mounted outside the digester on an equipment pad and discharged through a jet mixing header inside the digester. Heat is added to the mixing stream to maintain temperature in the digester, as well as caustic, micronutrients and a defoaming agent, as needed. COD in the waste material is digested and converted into biogas, which is collected in the headspace of the digester tank.

The digester will have a double membrane roof, which collects biogas and discharges it to the biogas handling system. A fresh air blower is used to pressurize one side of the membrane, which maintains pressure on the inside of the digester and pushes biogas out and into the biogas piping. The gas collection cover has an emergency pressure relief to prevent damage to the internal membrane.

Digestate pumps remove digestate from the digester in batches, in coordination with the feed pumps. Typically, digestate is removed before the digester is fed from the acidification tank. Digestate is sent to the sludge holding tank, where it will be dewatered as described above.

The key design parameters for the anaerobic digester are summarized in Table 11.

Table 11: Key Design Parameters for the Anaerobic Digester

PARAMETER	UNITS	VALUE
Digester Feed COD	kg/d	54,131
Digester Feed Total Solids	kg/d	30,759
Digester Feed Flow	m^3/d	385
Digester Feed Solids Concentration	-	7.7 - 10%
Target COD Loading Rate	kg COD/m^3	6
Digester COD Destruction	%	80 – 90%
HRT	d	25 - 31
Total Digestion Volume	m^3	9,074
Gas Space	m	1
Digester Tank Dimensions	m	19 (D) x 17 (H)
Digester Tank Volume	m^3	4,820
Number of Digester Tanks	-	2
Digester Decant Pump Flowrate	m^3/hr	22
Estimated Biogas Produced	m^3/d	31,000
Biogas Methane Content	%	55%

Notes:

1. 80% COD removal assumed for bioreactor sizing. 90% COD removal is assumed for sizing biogas handling.

3.4.3 BIOGAS HANDLING

Biogas from the anaerobic digester and the UASB will be discharged into a common biogas handling system for treatment and use in either power generation or to displace natural gas in the plant boilers. The biogas from the digester and UASB will be analyzed and measured individually, before being combined in a common header and drawn through a condensate trap to remove excess moisture. Biogas blowers will feed the combined biogas to the H_2S scrubber system for desulfurization. Following the scrubber, the biogas will be discharged either to the factory boilers or to a biogas engine. A biogas flare is provided for combusting excess biogas either in an emergency or when there is more biogas being generated than is required at the end use.

4 GEOTECHNICAL INVESTIGATION

WSP E&I retained Gleam Hydro to conduct a geotechnical investigation of the site, and to consult on environmental permitting considerations for the project. WSP E&I received the geotechnical investigation and has considered the findings in the preliminary layout of the equipment on the site. Test pits and boreholes were completed in the North-East portion of the site, as shown in the figure below.

Figure 1: Borehole and Test Pit Locations

Nine test pits (labelled TP1 – TP9) were excavated on-site using an excavator. The majority of the site is overlain by fill comprising very loose to medium dense chert gravel, cobbles, boulders, building rubble and domestic waste in a matrix of silty to clayey sand. The fill is thickest in the vicinity of TP6 – TP9. The fill was absent from TP3 and TP4, and very thin at TP2. The fill is underlain by a transported layer of very loose to very dense silty to clayey sand with gravel. All of the underlain materials had a pinholed soil structure typical of collapsible soils.

Boreholes were drilled to further investigate the material underneath the fill and underlaying material (labelled RG1 – RG5). Boreholes RG1, RG2, and RG3 intersected fill from surface to depths between 0.8 m and 8 m, over hard rock chert to depths of 17 m to over 60 m.

Water levels in all of the boreholes ranged from 24 m below ground to 36 m below ground.

Based on the findings of the geotechnical investigation, it was decided to focus construction in the areas to the North-East of the site, with only roadways being constructed in the areas with the most fill in the South-West to West.

The complete Geotechnical Investigation Report is attached in Appendix D for additional information.

5 ENVIRONMENTAL PERMITTING

WSP E&I engaged with Gleam Hydro and their legal counsel, along with McCain staff, on the environmental permitting requirements for the proposed upgrades to the wastewater treatment system. Gleam has advised that the Environmental Impact Assessment regulations in South Africa require that all required EIA authorizations are in place and have been issued.

Based on an initial assessment, Gleam believes that the following will apply to this project:

- The Wastewater Treatment Plant will require EIA approval, as the throughput of the plant is greater than 2,000 m^3 per day. This requires a Basic Assessment, which typically takes 12 – 18 months from the submission of the application to receipt of permit.
- The anaerobic digester will require a full EIA process, as the quantity of "stored material" is greater than 100 tonnes. This process could take 2 – 3 years from submission of application to completion.

WSP E&I and McCain are continuing to review these requirements with Gleam, to determine if there is any opportunity to reduce permitting requirements and improve timelines. Particular focus is being given to the definition of "stored material", as it pertains to the anerobic digester.

6 CLOSURE

We trust that the content of this report has met your expectations and provided a suitable overview of the design and operation of an MBR within Delmas' proposed new WWTP.

Should you have any questions or comments, please contact the undersigned.

Yours sincerely,

Prepared by:

Dave Mazzoccoli

Dave Mazzoccoli
Process Designer

Reviewed by:

Bill Malyk, P.Eng.
Principal Engineer

Appendix A

Design Basis Memo

MEMO

TO:	Itanje Seymore, Regional Environmental Manager
COMPANY:	McCain Foods South Africa
FROM:	Dave Mazzoccoli, WSP E&I Jack Hinds, WSP E&I Bill Malyk, WSP E&I
DATE:	April 17, 2023
CC:	Jacques Rousseau, McCain Foods Ansie van Wijk, McCain Foods Mark Cook, McCain Foods Linea Miller, WSP E&I
PROJECT NO.:	WW23032001
SUBJECT:	Delmas WWTP Design Basis and Assumptions

1 BACKGROUND

This document provides the wastewater treatment and digester design basis for the proposed treatment systems upgrades at the McCain facility in Delmas, South Africa. To proceed with the process design for the treatment system, the volumes and mass loadings of key parameters need to be clearly defined and agreed by all parties. The estimated influent flows and loadings to the treatment system are based on historical data and a mass balance developed using typical McCain wastewater loadings on a per unit of raw material basis. Data for solid waste material is based on provided historical data as well as information from anaerobic digester designs at other McCain factories.

Within the dataset, each month was classified into one of several operating scenarios. The most prevalent ones are the regular and loadshedding operations. The loadshedding scenario occurs because of reduced power availability to the processing facility, requiring reduced production, while regular operation occurs when the plant is running without any significant external influences on production. The operation under these two key scenarios is a key factor in establishing the basis for the design of the plant to ensure there is sufficient treatment flexibility.

2 WASTEWATER DATA REVIEW

The existing WWTP at Delmas has both inlet screening and primary sedimentation before discharging effluent to the sewers. An oily water treatment system is also in place, which provides treatment for oily water in the facility fryer areas. Fryer caustic sanitation will be bypassed around the oily water system. Preliminary characterization of the WWTP was completed with data provided by McCain on their existing process as well as experience with similar McCain facilities. Sixty months of monthly operating data was provided, with varying levels of data completion in the dataset for the following parameters from 2018.

- Totalized monthly production tonnage
- Totalized monthly water usage
- COD, TSS, Ammonia, Orthophosphate, FOG concentrations at primary clarifier influent and effluent[1]
- pH and electrical conductivity at primary clarifier influent and effluent

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Effective September 21, 2022, Wood Environment & Infrastructure Solutions Canada Limited is now operating as WSP E&I Canada Limited. No other aspects of our legal entity, contractual terms or capabilities have changed in relation to this report submission.

[1]There are varying levels of data completion in the dataset, with nutrients data only being collected in 2018. It is not specified whether any of the entries represent a grab or composite sample or the conditions which they were taken.

2.1 ASSUMPTIONS

WSP E&I Canada Limited (WSP E&I) has made several assumptions regarding the existing treatment unit operations and the wastewater generated by the facility. They are broken down into process assumptions and data development assumptions and are expanded further below.

PROCESS ASSUMPTIONS

- Effluent to comply with Industrial Effluent Discharge Permit issued June 17, 2022.
- Nitrification and denitrification to occur to completion.
- Chemical phosphorus precipitation will be required in the activated sludge system.
- Major treatment units in WWTP upgrade will include the following:
  - UASB Anaerobic Treatment
  - Activated Sludge Treatment
  - Secondary Clarification or MBR
- Existing DAF is operating at optimal treatment capacity:
  - Fats, Oil and Grease (FOG) concentrations entering primary clarifier to be consistently minimized (<100mg/L).
- Existing primary clarifier is operating at optimal treatment capacity and achieving removals typical of other McCain primary clarifiers (~80% TSS removal).
- Flow equalization tank will be included upstream of primary clarifier to improve influent flow consistency.
- Sufficient backup generator capacity for process critical equipment will be included to maintain operational flexibility during loadshedding events.

DATA DEVELOPMENT ASSUMPTIONS

- Flow and production data provided captures the current operation at the facility.
- Phosphorus data provided captures the current operation at the facility. Total nitrogen value to be developed through raw potato loading figures.
- COD and TSS data provided captures the current operation at the facility.

2.1.1 PROCESS ASSUMPTIONS

EXISTING DAF IS OPERATING AT OPTIMAL TREATMENT CAPACITY.

FOG data was extracted for the primary clarifier effluent (2018-2022) and separated according to the plant operating scenario for the specified month. FOG levels entering the WWTP are typically targeted below 100 mg/L with lower values being more optimal. The data shows a high amount of variability for both operating scenarios with the <100 mg/L threshold being achieved in only 58% of the regular operating data and 77% of the loadshedding data. Some of the key percentiles of the value distribution are indicated in Table 1. Preliminary calculations indicate that the DAF is sized appropriate for the expected influent.

Table 1: Distribution of Primary Clarifier Effluent FOG Values

PRIMARY CLARIFIER EFFLUENT FOG (MG/L)	REGULAR OPERATION	LOADSHEDDING OPERATION
25th Percentile	21.4	13.3
50th Percentile	80	23.2
Design Basis Value (58th Percentile)	100	-
75th Percentile	146	88.7
Design Basis Value (77th Percentile)	-	100
100th Percentile	1490	240

The effective removal of FOG is important for the optimal function of downstream biological treatment units. FOGs have low biodegradability and can cause foaming, scum formation and biological interference, reducing operational efficiency in the UASB and aerobic treatment processes. O&G impacts to UASB systems can be severe and result in system failure.

EXISTING PRIMARY CLARIFIER IS OPERATING AT OPTIMAL TREATMENT CAPACITY.

The existing treatment facility includes a primary clarifier for primary solids separation following the screen. This decreases the TSS concentration, but also removes a significant portion of the COD and a small amount of TKN and TP. Based on the operational data provided and knowledge of other McCain facilities, the primary clarifier is not operating as would be typical at other facilities with respect to the removal of TSS and COD. Preliminary calculations indicate that the primary clarifier is sized appropriate for the expected influent. For the design basis, the influent primary clarifier data will be used and include an assumption of removal efficiency instead of using the historical primary effluent data provided. A summary of the assumed removal efficiencies compared to operational data is shown in Table 2 and serves as a reference target.

Table 2: Primary Clarifier Removal Efficiencies

PARAMETER	CHEMICAL OXYGEN DEMAND (COD)	TOTAL SUSPENDED SOLIDS (TSS)	TOTAL KJELDAHL NITROGEN (TKN)	TOTAL PHOSPHORUS (TP)
Average Historical Removal Efficiency – Regular	24%	23%	8%	6%
Average Historical Removal Efficiency – Loadshedding	30%	15%	-[1]	-[1]
Design Basis Removal Efficiency	40%	80%	20%	20%

Note:
[1]No loadshedding data available

2.1.2 DATA DEVELOPMENT ASSUMPTIONS

FLOW AND PRODUCTION DATA PROVIDED CAPTURES THE CURRENT OPERATION OF THE FACILITY.

Flow and production tonnage values from the full range of data were assessed and sorted based on the plant operating scenario classification for the specified month. The flow values had minimal outliers with the 95th percentile of values being included for the design peak monthly flow for both regular and loadshedding operations. Peak flow is nearly identical between both operating modes.

Similarly, the water usage values had minimal outliers with the 95th percentile being included for peak water use for regular operation and the 90th percentile accepted for loadshedding operation. The regular operation water usage closely matches water use observed for other McCain processing facilities, with the loadshedding usage values being higher on a per tonne basis, as expected.

The production values for both regular and loadshedding converged to their respective peak values recorded in the data with no observed outliers. The key values are summarized in Table 3.

Table 3: Expected Facility Flow, Water Usage and Production Tonnage During Operation

PARAMETER	UNITS	REGULAR OPERATION	LOADSHEDDING OPERATION
Median Monthly Flow [4]	m^3/day [1]	2,538	2,807
Peak Monthly Flow Regular	m^3/day [1]	3,223 [2]	3,222 [2]
Median Monthly Water Use [4,5]	m^3/raw tonne	3.96	6.08
Peak Monthly Water Use [5]	m^3/raw tonne	5.08 [2]	6.65 [3]
Median Monthly Production [4]	tonne/day [1]	362	255
Peak Monthly Production	tonne/day [1]	416	294

Notes:
[1] 320 days of operation a calendar year
[2] 95th percentile of historical data
[3] 90th percentile of historical data
[4] 50th percentile of historical data
[5] 55% product yield

PHOSPHORUS DATA PROVIDED CAPTURES THE CURRENT OPERATION AT THE FACILITY. TOTAL NITROGEN VALUE TO BE DEVELOPED THROUGH RAW POTATO LOADING FIGURES.

Historical nutrient values were observed in the dataset but were only recorded in 2018 and only for the ammonia and orthophosphate fractions of their respective nutrients. Due to this limited data, assumptions were made, based on experience with previous McCain facilities, to create nutrient loading estimates for the design basis. Significant loadshedding occurred starting April 2021; there is no relevant historical data for this operating scenario with respect to nutrient loading.

For total nitrogen, loading is based on a typical average estimate of 1.0 kg/tonne of raw potato input and a maximum of 1.25 kg/tonne of raw potato input. The recorded ammonia data indicates an ammonia loadings of 0.55 and 0.83 kg/tonne of raw potato input for the average and 100th percentile of data, respectively. If typical total nitrogen loadings from other McCain facilities are assumed, this puts the average ammonia fraction at 55% of total nitrogen and the maximum ammonia fraction at 66% of total nitrogen, which is conservatively within the expected range of values.

For total phosphorus, loading is based on a typical average estimate of 0.25 kg/tonne of raw potato input and a maximum of 0.3 kg/tonne of raw potato input. The recorded orthophosphate data is slightly higher than this typical total phosphorus estimate at 0.3 and 0.41 kg/tonne of raw potato input for the median and max (80th percentile) respectively. This more conservative phosphorus loading estimate was used, with the assumption that the total phosphorus consists primarily of orthophosphate following primary clarification, to generate data for both regular and loadshedding operations.

The influent nutrient concentrations calculated from the above loadings are shown in Table 4.

Table 4: Expected Influent Nutrient Concentrations in Primary Influent

PARAMETER	UNITS	REGULAR OPERATION	LOADSHEDDING OPERATION
Median TP [1]	mg/L	42	27
Peak TP [1]	mg/L	58	38
Median TN [2]	mg/L	143	91
Peak TN [2]	mg/L	179	114

Notes:
[1] Captured from historical data

[2] Developed through potato loading figures

COD DATA PROVIDED CAPTURES THE CURRENT OPERATION AT THE FACILITY.

Historical COD and TSS values were extracted from the full range of data (2018-2022) and separated according to the plant operating scenario classification for the specified month. The dataset displayed highly variant data for COD and no consistent relationship with production tonnage. Due to this wide range, a conservative estimate using the 95th percentile of data was used for determining the peak design load for both scenarios.

The TSS data showed minimal outliers with the 90th percentile being accepted for determining the peak design load for regular operation and the 95th percentile for loadshedding operation. These TSS concentration figures were similar to those seen in other McCain facilities. Table 5 shows the expected COD and TSS concentrations in primary effluent.

Table 5: Expected COD and TSS Concentrations in Primary Influent

PARAMETER	UNITS	REGULAR OPERATION	LOADSHEDDING OPERATION
Median Monthly COD	mg/L	7,800	8,145
Peak Monthly COD	mg/L	12,688	12,285
Median Monthly TSS	mg/L	2,134	1,648
Peak Monthly TSS	mg/L	3,885	2,374

3 PROCESS WASTEWATER DESIGN BASIS

The anticipated water quality leaving the primary clarifier and entering the extended WWTP was determined based on estimated influent water quality data and assumed primary clarifier and DAF performance as presented above. The WWTP will be designed to handle the feed water quality shown in Table 6 and

Table 7. Designing to these values will ensure adequate treatment under both loadshedding and regular loading scenarios.

Table 6: Expected Concentrations and Loadings Entering WWTP Expansion

PARAMETER	CHEMICAL OXYGEN DEMAND (COD)	TOTAL SUSPENDED SOLIDS (TSS)	TOTAL KJELDAHL NITROGEN (TKN)	TOTAL PHOSPHORUS (TP)
Units	mg/L	mg/L	mg/L	mg/L
Design Concentration	7,612	777	143	46
Units	kg/day	kg/day	kg/day	kg/day
Design Loading	24,536	2,504	461	150

Table 7: Expected Operational Values for Flows Entering WWTP Expansion

PARAMETER	UNITS	DESIGN VALUE
Average Design Flow	m^3/day	2,538
Peak Design Flow	m^3/day	4,000 [1]
pH	pH Units	5-6
Temperature	Deg C	20-30
FOG	mg/L	<100

Note:
[1] Using 1.24 daily peaking factor

The local municipality in Delmas, SA has specified compliance discharge targets for the facility. The proposed WWTP upgrade design will ensure that the effluent will meet these targets, as described in Table 1Table 8.

Table 8: WWTP Effluent Compliance Targets

PARAMETER	UNITS	LIMIT
Electrical Conductivity (EC)	ms/m	<500
Total Suspended Solids (TSS)	mg/L	<1,000
Total Dissolved Solids (TDS)	mg/L	<3,250
Ammonia (NH3)	mg/L as N	<50
Ortho-Phosphate (O-PO_4)	mg/L as P	<10
pH	pH Units	6.0-10.0
Fats, Oil and Grease (FOG)	mg/L	<500
Chemical Oxygen Demand (COD)	mg/L	<5,000

4 DIGESTER DESIGN BASIS

The upgrade will include an anaerobic digestion process to handle the solid wastes produced by the facility in order to reduce disposal costs and allow for on-site biogas production and use. Solid wastes from the plant, including slivers, nubbins, cubes, peel, trimmings and waste potatoes are currently captured and disposed of off-site. McCain will anaerobically digest the combined solid waste to generate biogas. To generate biogas from the solid potato wastes, the wastes are first slurried and pumped to an anaerobic digester which breaks down the organic loading present in the slurry, and produces a biogas that can be scrubbed and combusted in either a boiler or a generator. The digestate is then passed through a centrifuge to remove any remaining solids, which would then be disposed of off-site. Centrate from the centrifuges would be pumped to an activated sludge tank.

The 2018-2022 Monthly Disposal data and 2018-2021 Daily Waste Reports provided by McCain indicated loadings for various waste sources generated by the plant. These include:

- Solids Production Waste
- Liquid Production Waste
- Packing Waste
- Primary Filter Cake
- DAF and Clarifier Scum
- Potato Waste

The solids waste digester will not be fed the packing waste, and DAF and clarifier scum waste, while the liquid production waste would need to be further examined before inclusion in the digester feed. From this, the maximum monthly waste loading and monthly average loading for the various waste sources were determined. The monthly data summary for each waste stream to be included in the daily loading for the design of the new Solids Waste Anaerobic Digester is summarized in Table 9.

Table 9: Solids Waste Digester Feed Loadings

WASTE STREAM	MONTHLY AVERAGE Tons/month	MONTHLY MAXIMUM Tons/month
Solid Production Waste[1]	1,813	2,491
Liquid Production Waste[2]	116	586
Primary Filter Cake[3]	146	267
Potato Waste[2]	143	385

Notes:

[1] Values extracted from Daily Waste Reports (July 2018 - April 2021)

[2] Values extracted from Monthly Solids Disposal data (September 2018 - November 2022)
[3] Values generated based on effluent treatment plant design basis values for TSS (AVG: 2,134 mg/L, MAX: 3,885) and primary clarifier TSS removal (80%)

WSP E&I performed a data analysis of July 2018-April 2021 daily operational data from the McCain Delmas daily waste reports to determine a daily waste load peaking factor. From the analysis, a peaking factor of 1.21 is representative of the 95th percentile load (daily peak). The solids waste loadings for the current operating conditions and the methods used to calculate the daily loadings from the monthly data are summarized in Table 10.

Table 10: Summary of Daily Operating Conditions

WASTE STREAM	AVERAGE[1] kg/day	95TH PERCENTILE[2] kg/day	AVERAGE DAY OF MAXIMUM MONTH[3] kg/day
Solid Production Waste	62,153	103,329	85,561
Liquid Production Waste	3,985	24,316	20,096
Primary Filter Cake	5,005	11,075	9,153
Potato Waste	4,907	15,979	13,206

Notes:
[1] For all waste streams, average day loading is calculated using average monthly loads (metric tonnes/month) listed in Table 9, making the unit conversion to kgs/month and dividing with 29.17 days per month (for 350 days of plant operation per year).
[2] The 95th percentile day loadings are assumed to be 21% higher (i.e. calculated by multiplying the maximum month average day loadings with 1.21) for all waste streams based on data analysis of 2018-2021 daily operation data.
[3] For all waste streams, average day of the maximum month loading is calculated using maximum monthly loading (metric tonnes/month) listed in Table 2, making the unit conversion to kgs/month and dividing with 29.17 days per month (for 350 days of plant operation per year).

The daily 95th percentile loadings will be used for sizing of all equipment upstream of the digester for digester biogas flow to the biogas engine and biogas safety equipment. The average day of the maximum month will be used for digester tank and digester equipment sizing. Table 11 summarizes the design basis in equivalent yearly loadings (for 350 days of plant operation per year) of all waste streams.

Table 11: Summary of Design Basis Waste Streams

WASTE STREAM	AVERAGE MASS FLOW tonnes/year	SOLIDS %	COD tonnes/year
Solid Production Waste [1]	21,754	18%	8,427
Liquid Production Waste [2]	1,395	95%+	Unknown
Primary Filter Cake [3]	1,387	25%	2,534
Potato Waste [4]	1,718	20%	962

Notes:
[1] Numbers estimated using an estimated distribution of 50% screening waste, 39% peels waste, 11% fried and frozen waste
[2] Unknown composition, expected to be low in solids
[3] Based on average COD value estimated in effluent treatment plant design basis (7,800 mg/L) and an assumed 40% COD removal in the primary clarifier
[4] Estimate from effluent treatment plat design basis of 0.56 kg COD/tonne of raw potato

McCain staff should confirm that the above design basis information is representative of the waste streams to be treated and advise if any changes or additions are required.

5 ADDITIONAL MONITORING

To further improve the dataset and refine the process modelling, the following additional monitoring can be undertaken. This is not required to complete the preliminary process sizing.

- Increase sampling of FOG, COD from monthly to weekly or daily
- Increase recording of flow rate from monthly to daily
- Conduct additional sampling for TKN and TP on a weekly basis
- Ensure the primary clarifier is operating optimally and achieving design TSS removal by checking for mechanical damage, scum and sludge buildup, and other potential upset causing materials entering.
- Ensure the DAF unit is operating optimally and achieving design FOG removal . Until the DAF effluent is consistently recording values below 100 mg/L, increase sampling from for FOG from monthly to daily

6 CLOSURE

We trust the content of this memo meets your expectations. Following acceptance of this memo and its contents, WSP E&I will proceed with the design of the wastewater treatment upgrades using the design basis information presented above.

If you have any questions, please do not hesitate to contact the undersigned.

Yours sincerely,

Prepared by:

Dave Mazzoccoli

Dave Mazzoccoli
Project Designer

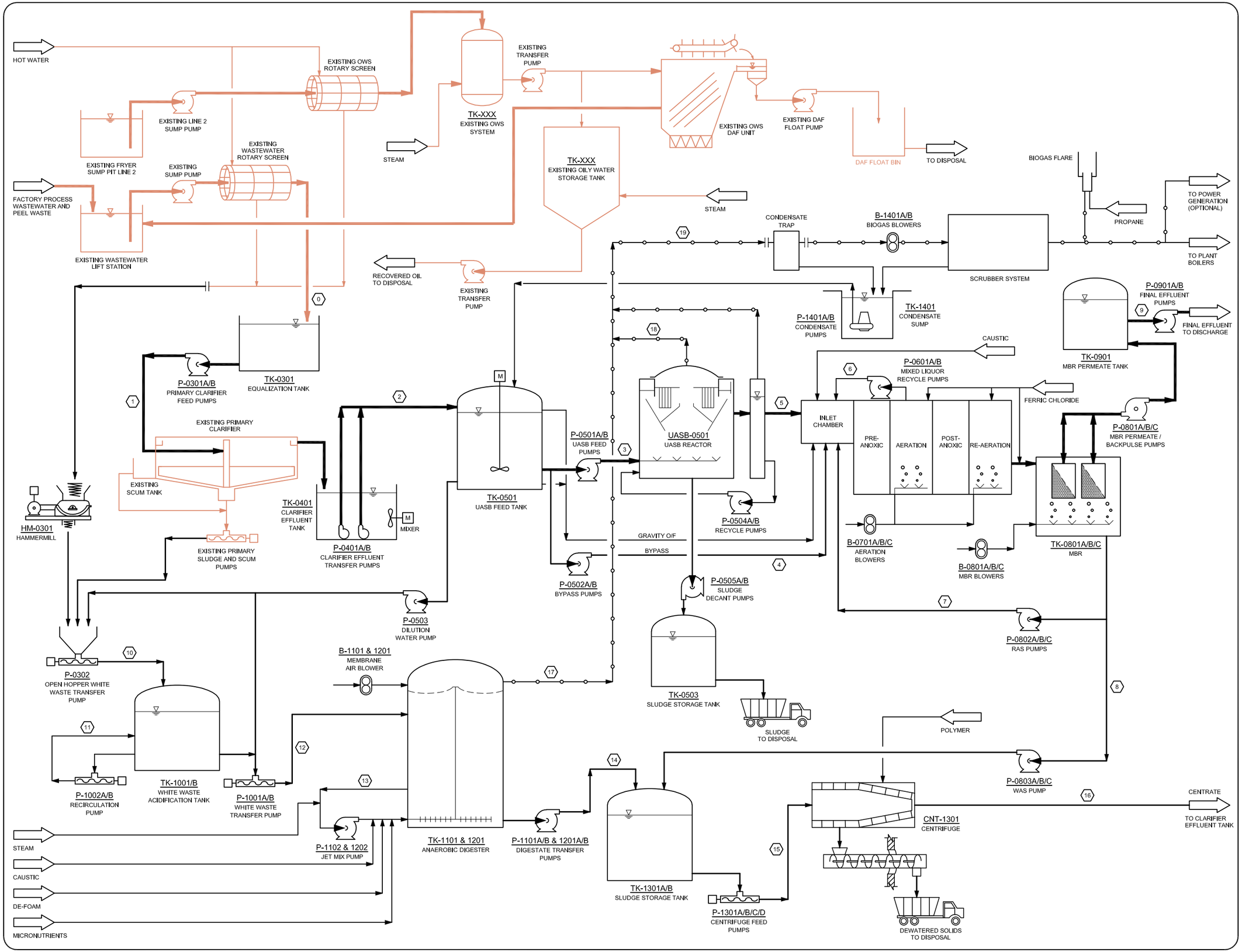
Reviewed by:

Jack Hinds, P.Eng.
Project Manager

Bill Malyk, P.Eng.
Principal Engineer

Appendix B

Preliminary P&IDs



LEGENDS:

- BIOGAS
- PRIMARY
- SECONDARY
- SERVICE
- EXISTING

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NO.	DATE	REVISION	BY
A			

REFERENCE DWGS.

Dwg No	DWG. TITLE	BY

- ☑ PRELIMINARY - NOT FOR CONSTRUCTION
- ☐ APPROVED FOR CONSTRUCTION
- ☐ SUPERSEDES ALL PREVIOUS ISSUES

McCAIN FOODS (SA) (PTY) LTD

WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: PROCESS FLOW DIAGRAM

DRN. BY	DATE	SCALE
PRV	MARCH 2023	
SHT. SIZE: A1	SHT. No: 1 of 2	N.T.S.

DWG. NO. WW23032001-8500-E600A REV A

			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
			EQ TANK FEED	PRIMARY CLARIFIER FEED	PRIMARY CLARIFIER EFFLUENT	UASB FEED	UASB BYPASS	UASB EFFLUENT	MIXED LIQUOR RECYCLE	RAS	WAS	FINAL EFFLUENT	WHITE WASTE	ACIDIFICATION TANK MIXING	DIGESTER FEED	DIGESTER MIXING	DIGESTER DECANT	CENTRIFUGE FEED	CENTRATE	DIGESTER BIOGAS	UASB BIOGAS	BIOGAS HEADER
			GRAVITY	PUMPED	PUMPED	PUMPED	PUMPED	GRAVITY	PUMPED	PUMPED	PUMPED	PUMPED	PUMPED	PUMPED	PUMPED	PUMPED	PUMPED	PUMPED	GRAVITY	-	-	-
FROM			PLANT	EQ TANK	PRIMARY CLARIFIER EFFLUENT TANK	UASB FEED TANK	UASB FEED TANK	UASB	AERATION BASIN	MBR TANK	MBR TANK	MBR PERMEATE TANK	HAMMERMILL	ACIDIFICATION TANK	ACIDIFICATION TANK	DIGESTER	DIGESTER	DIGESTATE TANK	CENTRIFUGE	DIGESTER	UASB	DIGESTER & UASB
TO			EQ TANK	PRIMARY CLARIFIER	UASB FEED TANK	UASB	INLET CHAMBER	INLET CHAMBER	INLET CHAMBER	INLET CHAMBER	SLUDGE HOLDING TANK	DISCHARGE POINT	ACIDIFICATION TANK	ACIDIFICATION TANK	DIGESTER	DIGESTER	DIGESTER TANK	CENTRIFUGE	EQ TANK	BIOGAS HEADER	BIOGAS HEADER	SCRUBBER SYSTEM
DESIGN VOLUMETRIC FLOWRATE	QD	m3/DAY	3,646	3,646	3,457	2,938	519	2,938	16,200	16,200	373	3,682	385	960	385	-	385	1,484	1,390	31,000	8,500	39,500
DESIGN VOLUMETRIC FLOWRATE	QD	m3/s	0.042	0.042	0.040	0.034	0.006	0.034	0.188	0.188	0.004	0.043	0.004	0.011	0.004	-	0.004	0.017	0.016	0.359	0.098	0.457
DESIGN VOLUMETRIC FLOWRATE	QD	m3/h	151.9	151.9	144.0	122.4	21.6	122.4	675.0	675.0	15.5	153.4	16.0	40.0	16.0	-	16.0	61.8	57.9	1291.7	354.2	1645.8

MASS BALANCE TABLE

wsp

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McCAIN FOODS (SA) (PTY) LTD

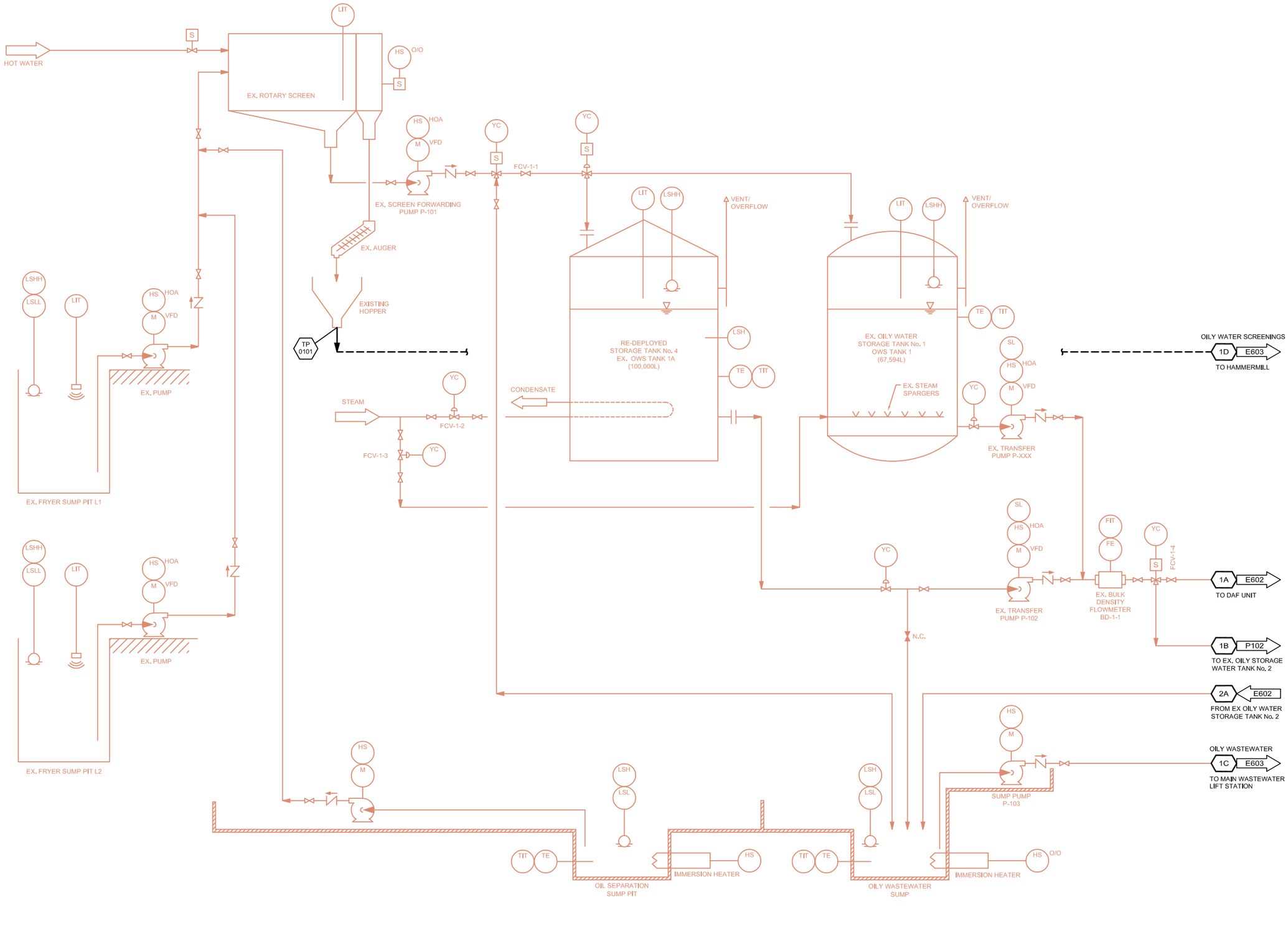
WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: MASS BALANCE TABLE

DRN. BY	DATE
PRV	MARCH 2023

SHT. SIZE	SHT. No	SCALE
A1	1 of 1	N.T.S.

DWG. NO. WW23032001-8500-E600B REV A



wsp

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NO.	DATE	REVISION	BY
A			

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Dwg No	DWG. TITLE	BY

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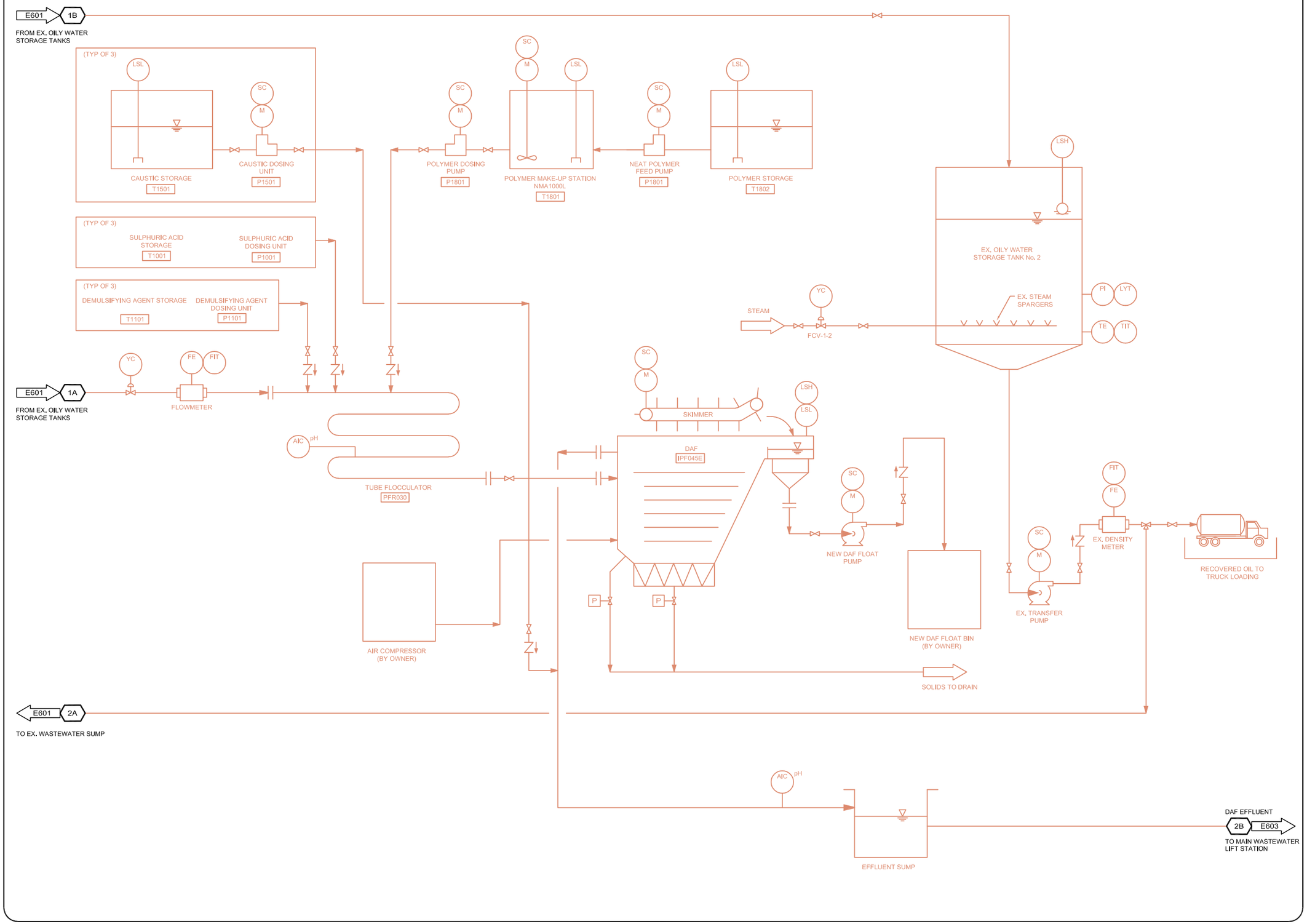
McCain FOODS (SA) (PTY) LTD

PROJECT TITLE
WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE
P&ID
OILY WATER SEPARATION

DWN. BY	PRV	DATE	MAY 2023
SHT. SIZE	A1	SHT. No	1 of 1
SCALE	N.T.S.		

DWG. NO. WW23032001-8500-E601 REV A



wsp

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NO.	DATE	REVISION	BY
A			

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Dwg No	DWG. TITLE	BY

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McCain FOODS (SA) (PTY) LTD

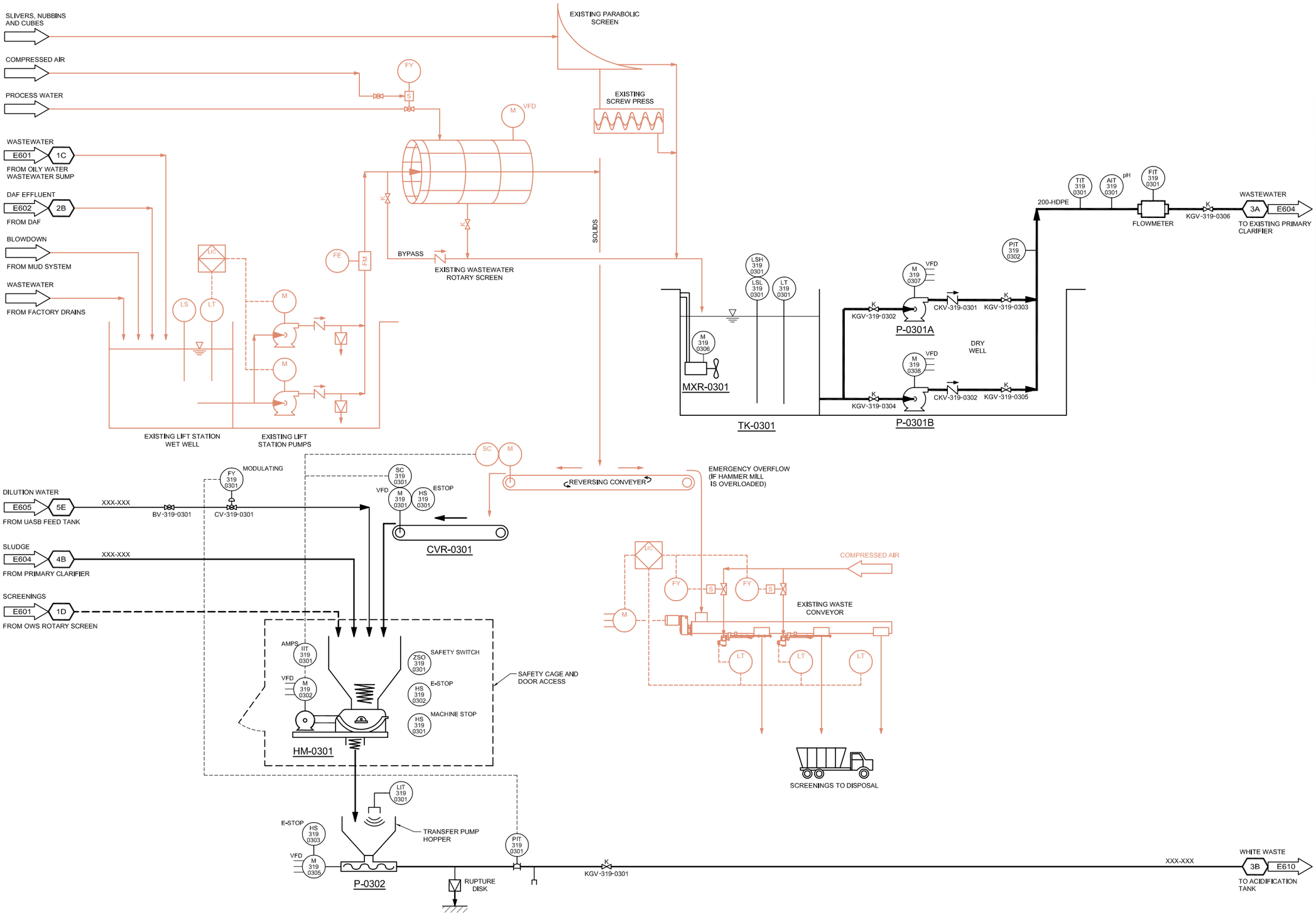
PROJECT TITLE
WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE
P&ID
OILY WATER SEPARATION

DWN. BY	DATE
PRV	MAY 2023

SHT. SIZE	SHT. No	SCALE
A1	1 of 1	N.T.S.

DWG. NO. WW23032001-8500-E602 REV A



HM-0301
HAMMERMILL GRINDER
ONE OPERATING
CAPACITY:
MOTOR:

P-0302
WHITE WASTE TRANSFER PUMP
ONE OPERATING
CAPACITY:
TYPE: PROGRESSIVE CAVITY
MOTOR:

CVR-0301
CONVEYOR
TYPE:
MOTOR:

MXR-0301
EQ TANK MIXER
TYPE: SUBMERSIBLE
MOTOR:
C/W RAIL SYSTEM

TK-0301
EQ TANK
SIZE:
CAPACITY:
MATERIAL:

P-0301A/B
PRIMARY CLARIFIER FEED PUMPS
ONE OPERATING, ONE STANDBY
CAPACITY:
TYPE: SUBMERSIBLE
MOTOR:

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REVISIONS

NO.	DATE	REVISION	BY
1			

REFERENCE DWGS.

Dwg No	DWG. TITLE	BY

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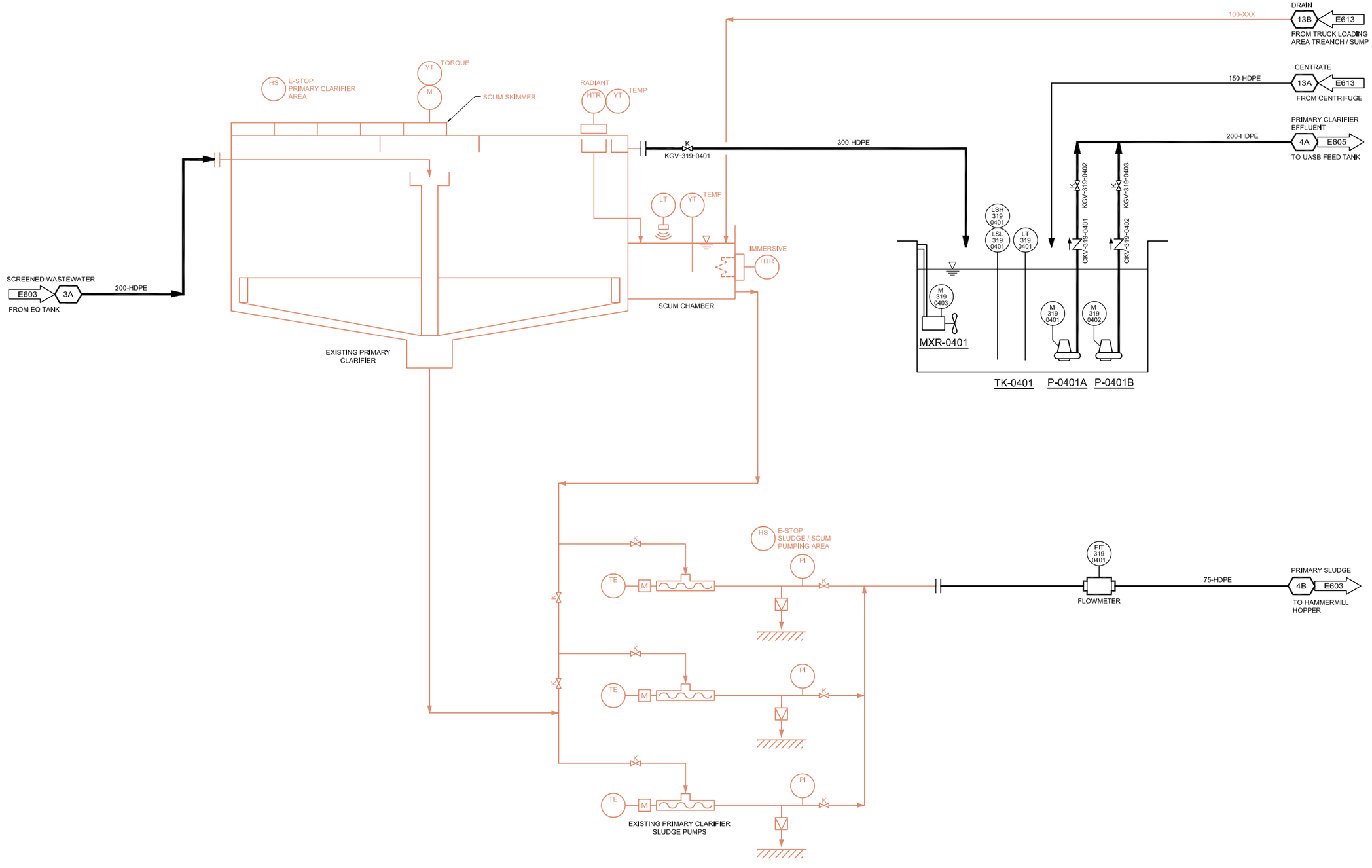
McCAIN FOODS (SA) (PTY) LTD

WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: P&ID
ROTARY SCREEN SYSTEM, EQUALIZATION AND WHITE WASTE ACIDIFICATION

DWN. BY	DATE	SHT. SIZE	SHT. No	SCALE
PRV	MAY 2023	A1	1 of 1	N.T.S.

DWG. NO. WW23032001-8500-E603 REV A



MXR-401
CLARIFIER EFFLUENT TANK MIXER
TYPE: SUBMERSIBLE
MOTOR:
C/W RAIL SYSTEM

TK-401
CLARIFIER EFFLUENT TANK
SIZE:
CAPACITY:
MATERIAL:

P-401A/B
CLARIFIER EFFLUENT PUMPS
ONE OPERATING, ONE STANDBY
CAPACITY:
TYPE: SUBMERSIBLE
MOTOR:

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REVISIONS

NO.	DATE	REVISION	BY

REFERENCE DWGS.

Dwg No	DWG. TITLE	BY

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McCAIN FOODS (SA) (PTY) LTD

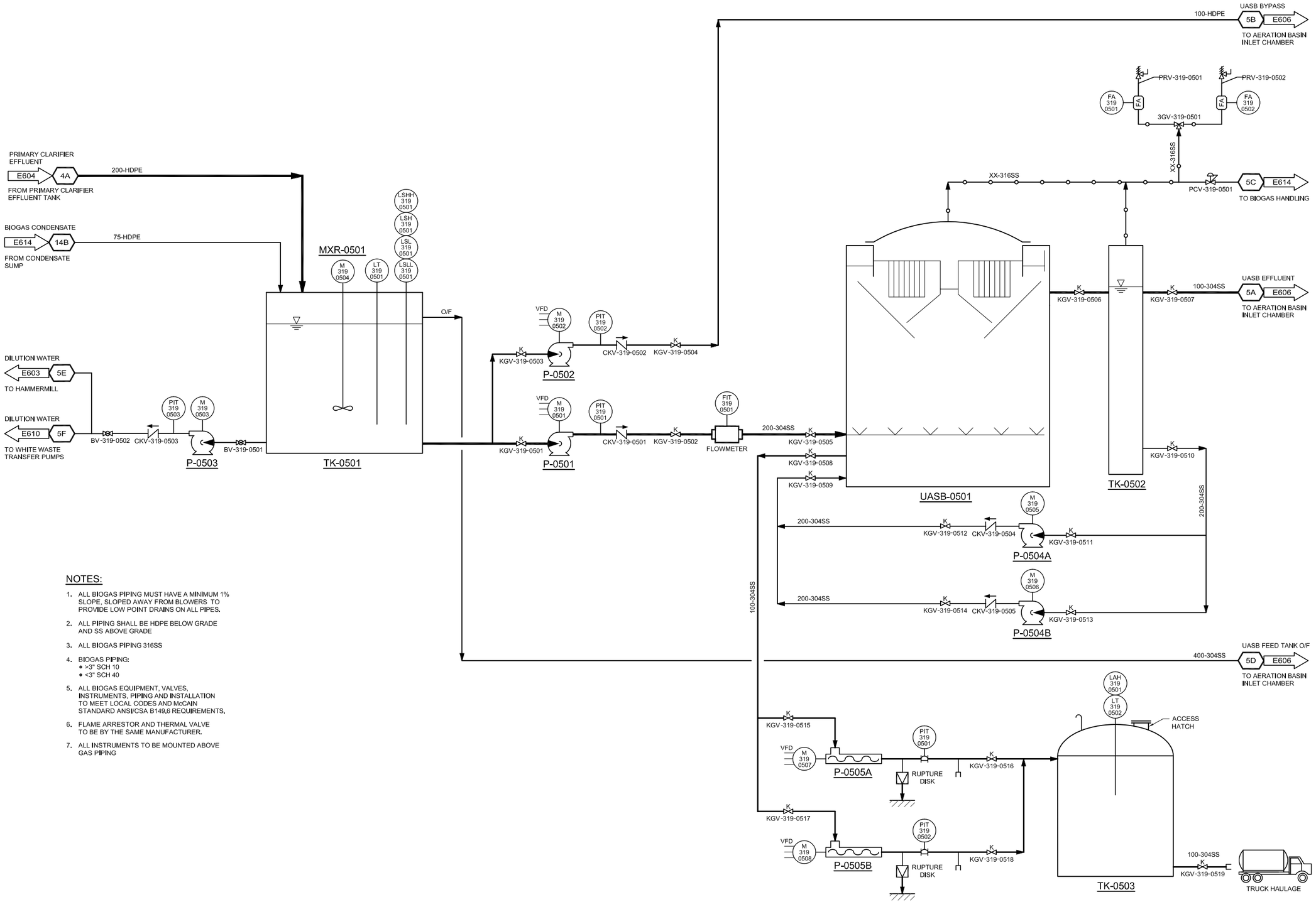
WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: P&ID
EXISTING PRIMARY CLARIFIER

DWN. BY	DATE	
PRV	MAY 2023	

SHT. SIZE	SHT. No	SCALE
A1	1 of 1	N.T.S.

DWG. NO. WW23032001-8500-E604 REV A



NOTES:

1. ALL BIOGAS PIPING MUST HAVE A MINIMUM 1% SLOPE, SLOPED AWAY FROM BLOWERS TO PROVIDE LOW POINT DRAINS ON ALL PIPES.
2. ALL PIPING SHALL BE HDPE BELOW GRADE AND SS ABOVE GRADE
3. ALL BIOGAS PIPING 316SS
4. BIOGAS PIPING:
   - >3" SCH 10
   - <3" SCH 40
5. ALL BIOGAS EQUIPMENT, VALVES, INSTRUMENTS, PIPING AND INSTALLATION TO MEET LOCAL CODES AND McCAIN STANDARD ANSI/CSA B149,6 REQUIREMENTS.
6. FLAME ARRESTOR AND THERMAL VALVE TO BE BY THE SAME MANUFACTURER.
7. ALL INSTRUMENTS TO BE MOUNTED ABOVE GAS PIPING

P-0503
DILUTION WATER PUMP
ONE OPERATING
CAPACITY:
TYPE: CENTRIFUGAL
MOTOR:

MXR-0501
UASB FEED TANK MIXER
TYPE: MOUNTED
MOTOR:

TK-0501
UASB FEED TANK
SIZE:
CAPACITY:
MATERIAL:

P-0501
UASB FEED PUMP
ONE OPERATING
CAPACITY:
TYPE: CENTRIFUGAL
MOTOR:

P-0502
UASB BYPASS PUMP
ONE OPERATING
CAPACITY:
TYPE: CENTRIFUGAL
MOTOR:

P-0505A/B
UASB SLUDGE PUMPS
ONE OPERATING, ONE STANDBY
CAPACITY:
TYPE: PROGRESSIVE CAVITY
MOTOR:

TK-0501
UASB FEED TANK
SIZE:
CAPACITY:
MATERIAL:

TK-0503
UASB SLUDGE HOLDING TANK
SIZE:
CAPACITY:
MATERIAL:

TK-0502
UASB EFFLUENT TANK
SIZE:
CAPACITY:
MATERIAL:

P-0504A/B
UASB RECYCLE PUMPS
ONE OPERATING, ONE STANDBY
CAPACITY:
TYPE: CENTRIFUGAL
MOTOR:

wsp

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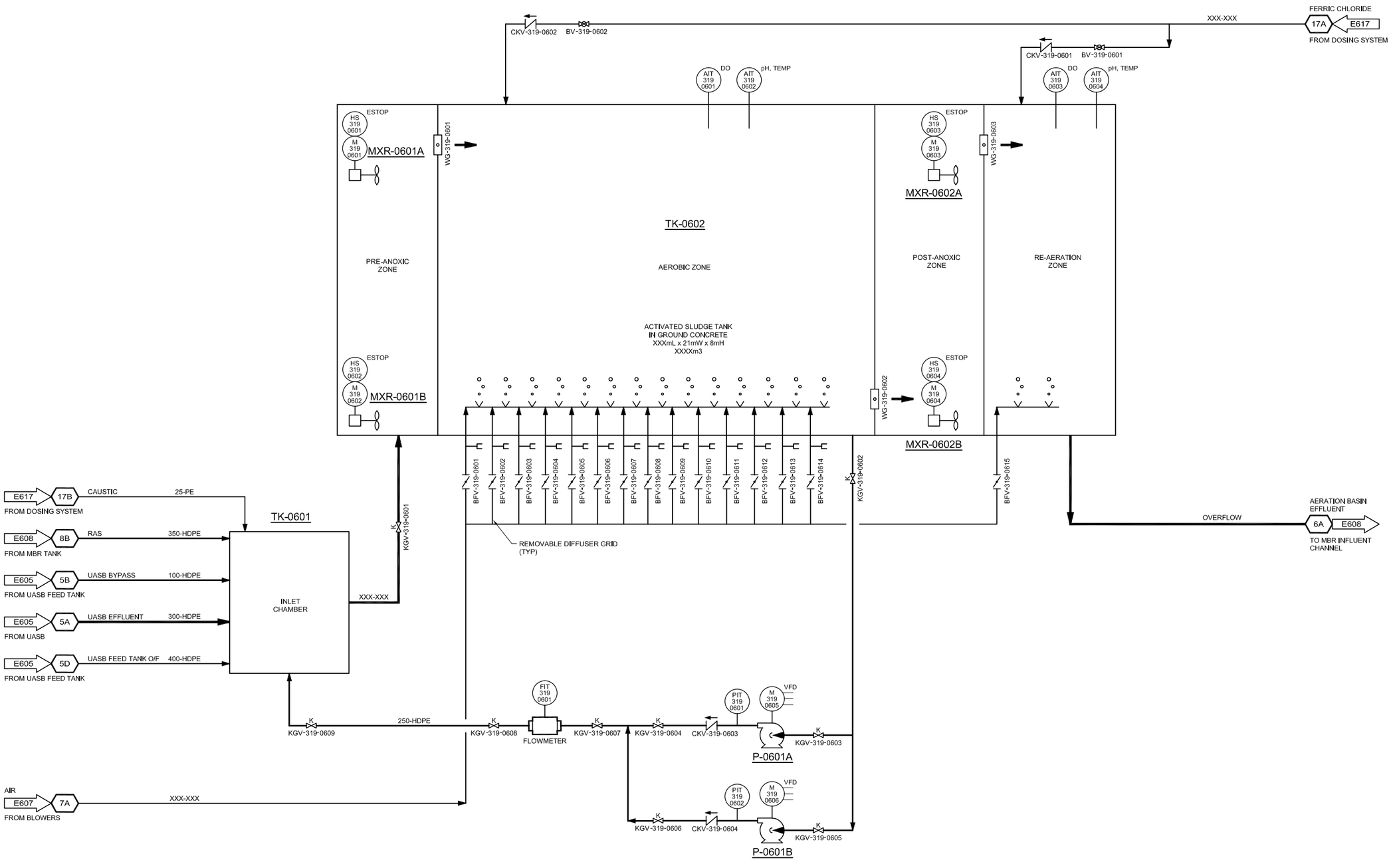
McCain FOODS

McCain FOODS (SA) (PTY) LTD

WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: P&ID
UASB REACTOR

DWN. BY	PRV	DATE	MAY 2023
SHT. SIZE	A1	SHT. No	1 of 1
SCALE	N.T.S.		
DWG. NO.	WW23032001-8500-E605	REV	A



BLR-0601A/B
AERATION BASIN BLOWERS
ONE OPERATION, ONE STANDBY
CAPACITY: XXXm3/hr @ XXm TDH
MOTOR: XX HP EACH
C/W ACOUSTIC ENCLOSURE

TK-0601
AERATION BASIN INLET STRUCTURE
SIZE: XXm x XXm x XXm DEEP
CAPACITY:
MATERIAL: CONCRETE

MXR-0601A/B
PRE-ANOXIC ZONE MIXER
TYPE: SUBMERSIBLE
MOTOR:
C/W RAIL SYSTEM

TK-0602
AERATION BASIN
SIZE: XXm x XXm x XXm DEEP
CAPACITY:
MATERIAL: CONCRETE

P-0601A/B
MIXED LIQUOR RECYCLE PUMPS
ONE OPERATING, ONE STANDBY
CAPACITY:
TYPE: CENTRIFUGAL
MOTOR:

MXR-0602A/B
POST-ANOXIC ZONE MIXER
TYPE: SUBMERSIBLE
MOTOR:
C/W RAIL SYSTEM

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NO.	DATE	REVISION	BY
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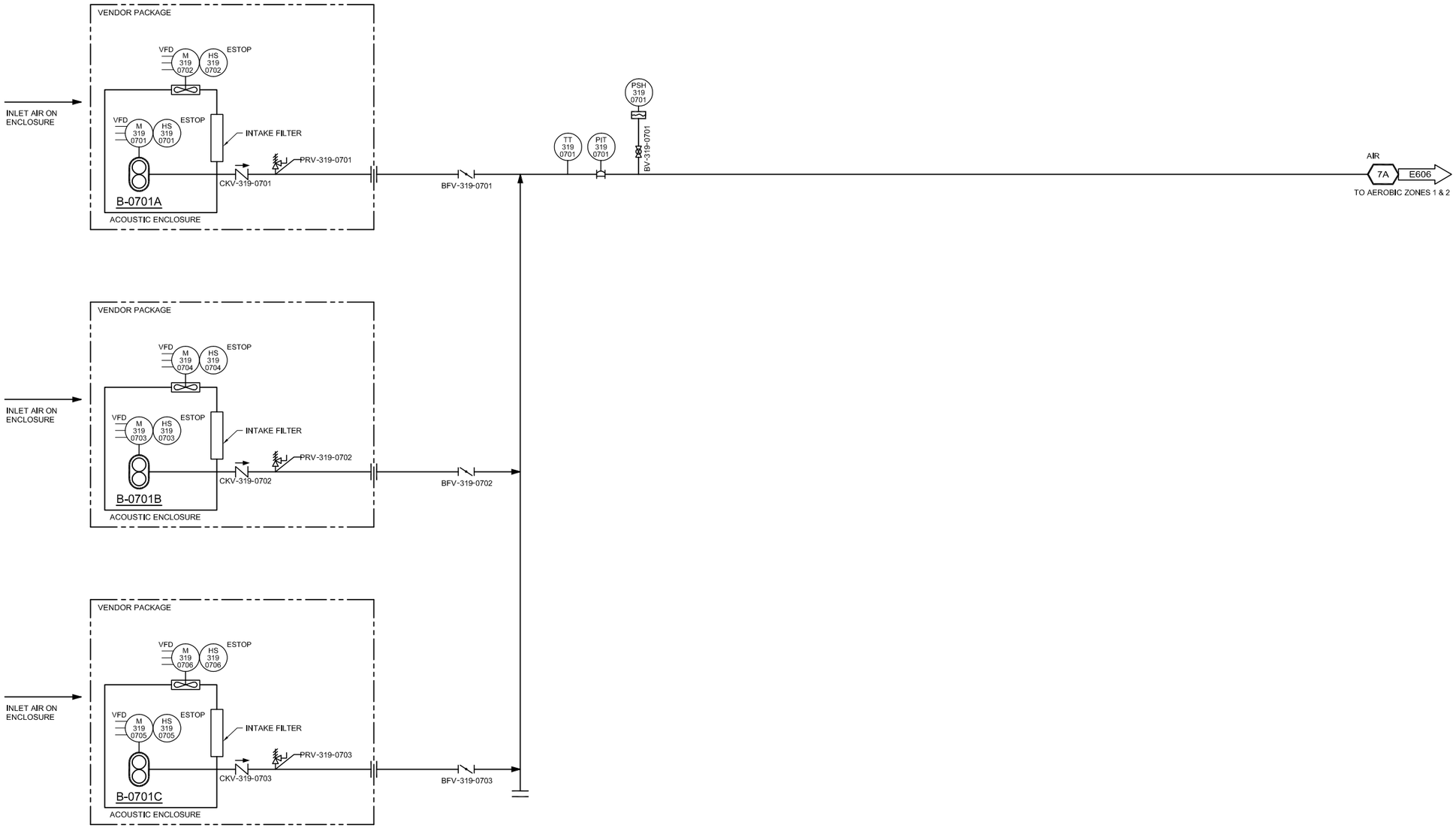
WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: P&ID
AERATION BASIN

DRN. BY	DATE	SHT. SIZE	SHT. No	SCALE
PRV	MAY 2023	A1	1 of 1	N.T.S.

DWG. NO. WW23032001-8500-E606 REV A



B-0701A/B/C
AERATION BASIN BLOWERS
ONE OPERATING, ONE STANDBY
XX HP EACH
XXXm3/hr @ XX m TDH

wsp

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1			
NO.	DATE	REVISION	BY

REFERENCE DWGS.		
Dwg No	DWG. TITLE	BY

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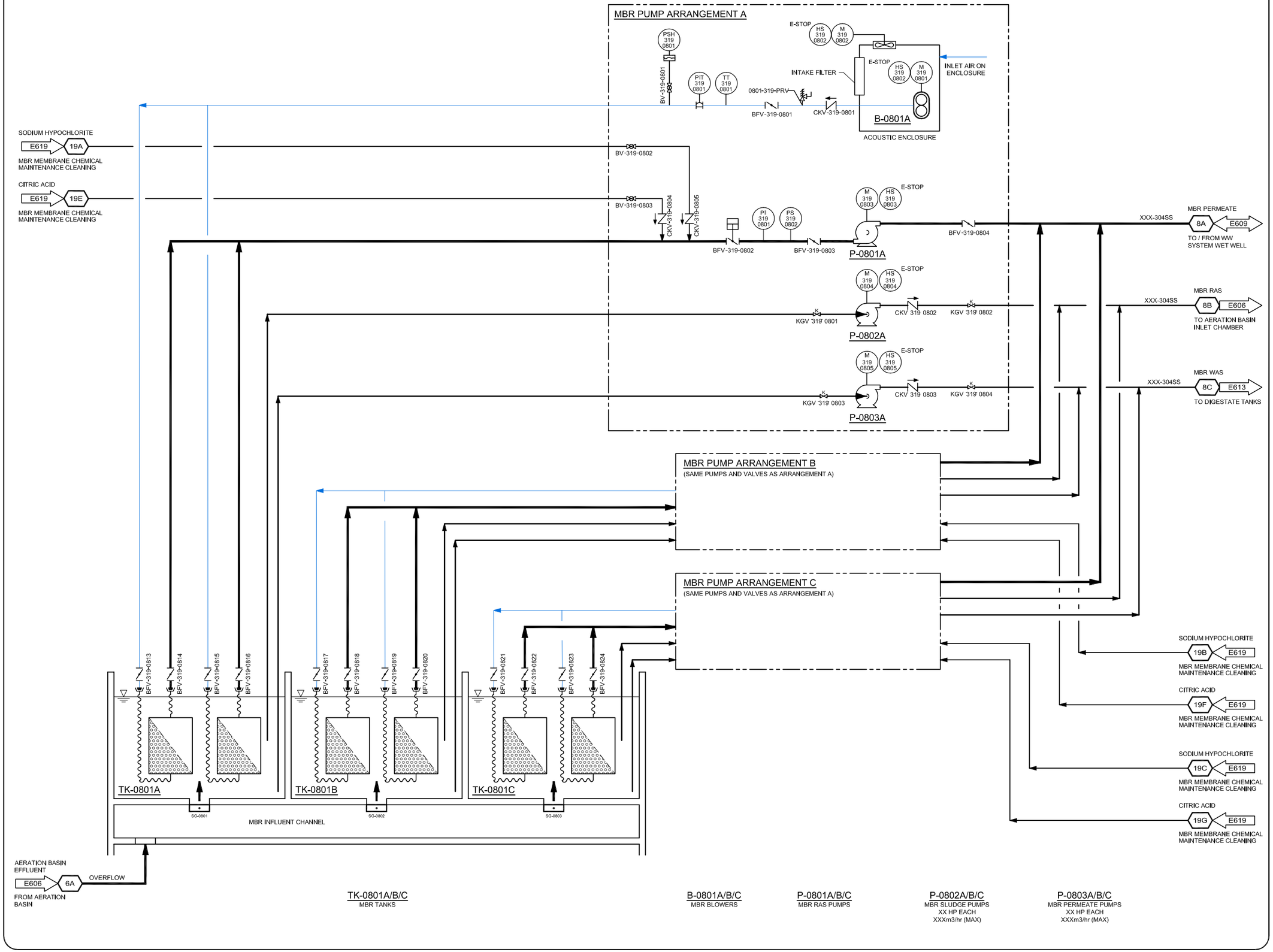
McCain FOODS (SA) (PTY) LTD

WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: P&ID
AERATION BASIN BLOWERS

DWN. BY	PRV	DATE	MAY 2023
SHT. SIZE	A1	SHT. No	1 of 1
SCALE	N.T.S.		
DWG. NO.	WW23032001-8500-E607	REV	A



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REFERENCE DWGS.

Dwg No	DWG. TITLE	BY

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McCAIN FOODS (SA) (PTY) LTD

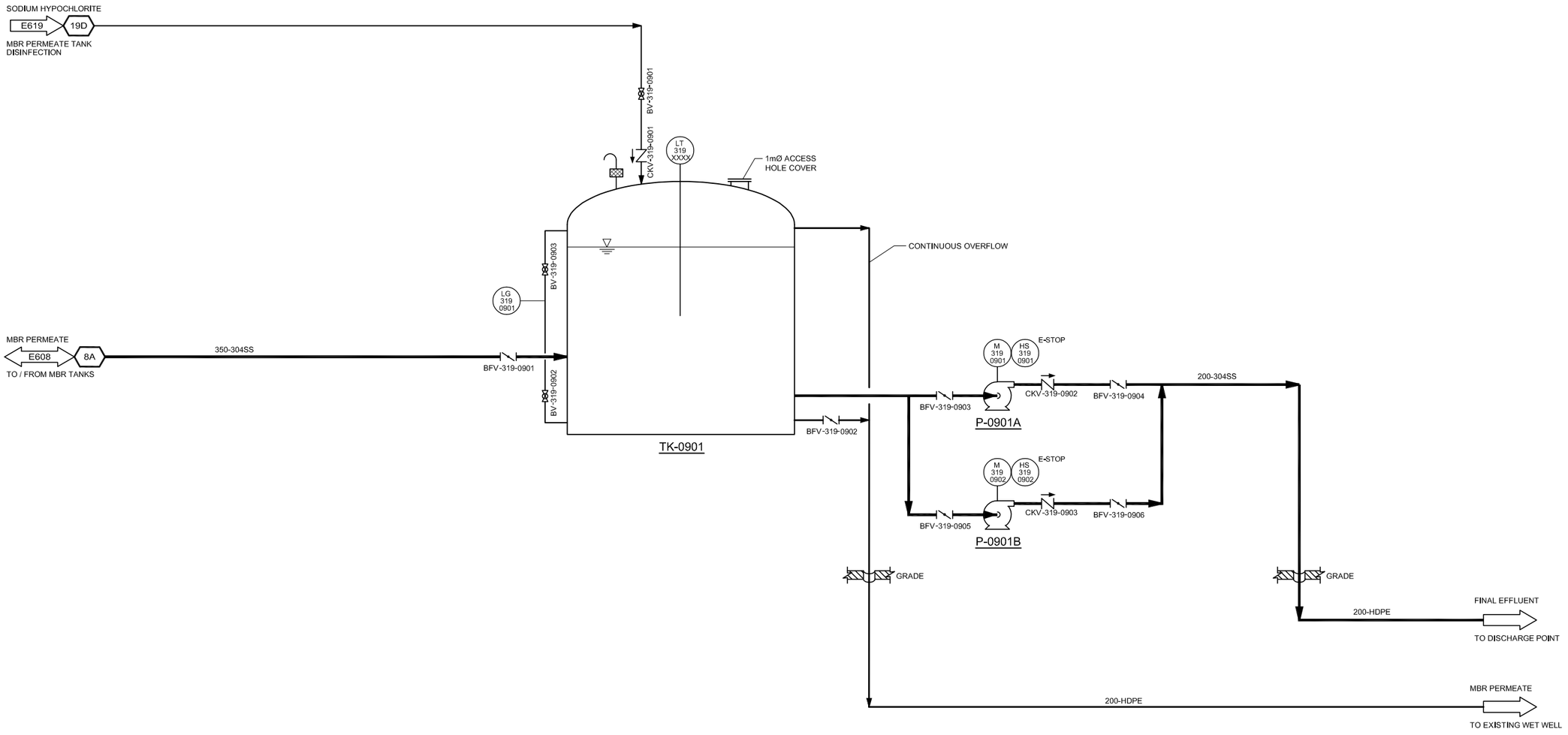
WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: P&ID
MBR SYSTEM

DRN. BY	DATE	
PRV	MAY 2023	

SHT. SIZE	SHT. No	SCALE
A1	1 of 1	N.T.S.

DWG. NO. WW23032001-8500-E608 REV A



TK-0901
MBR PERMEATE/BACKPULSE TANK
TYPE: ABOVE GROUND FRP
SIZE: XXXmL x 21mW x 8mH
CAPACITY: XXXXm3

P-0901A/B
MBR PERMEATE TRANSFER PUMPS
ONE OPERATING, ONE STANDBY
XX HP EACH
XXXm3/hr @ XX m TDH

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REVISIONS

NO.	DATE	REVISION	BY
A			
A			

REFERENCE DWGS.

Dwg No	DWG. TITLE	BY

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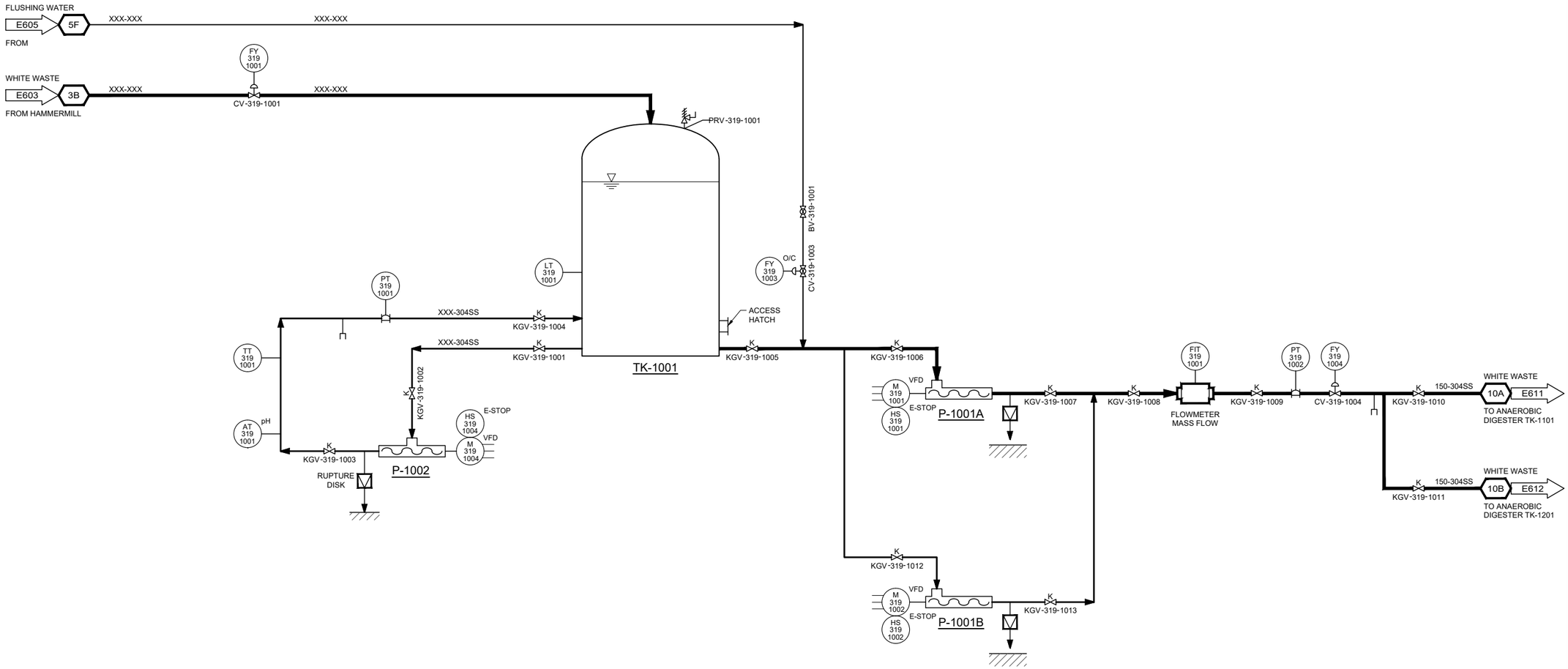
WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: P&ID
MBR PERMEATE

DWN. BY	PRV	DATE	MAY 2023
SHT. SIZE	A1	SHT. No	1 of 1
SCALE	N.T.S.		

DWG. NO. WW23032001-8500-E609 REV A



P-1002
WHITE WASTE RECIRCULATION PUMPS
ONE OPERATING
CAPACITY:
TYPE: PROGRESSIVE CAVITY
MOTOR:

TK-1001
ACIDIFICATION TANKS
SIZE:
CAPACITY:
MATERIAL:

P-1001A/B
DIGESTER FEED PUMPS
ONE OPERATING
CAPACITY:
TYPE: PROGRESSIVE CAVITY
MOTOR:

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NO.	DATE	REVISION	BY
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REFERENCE DWGS.

Dwg No	DWG. TITLE	BY

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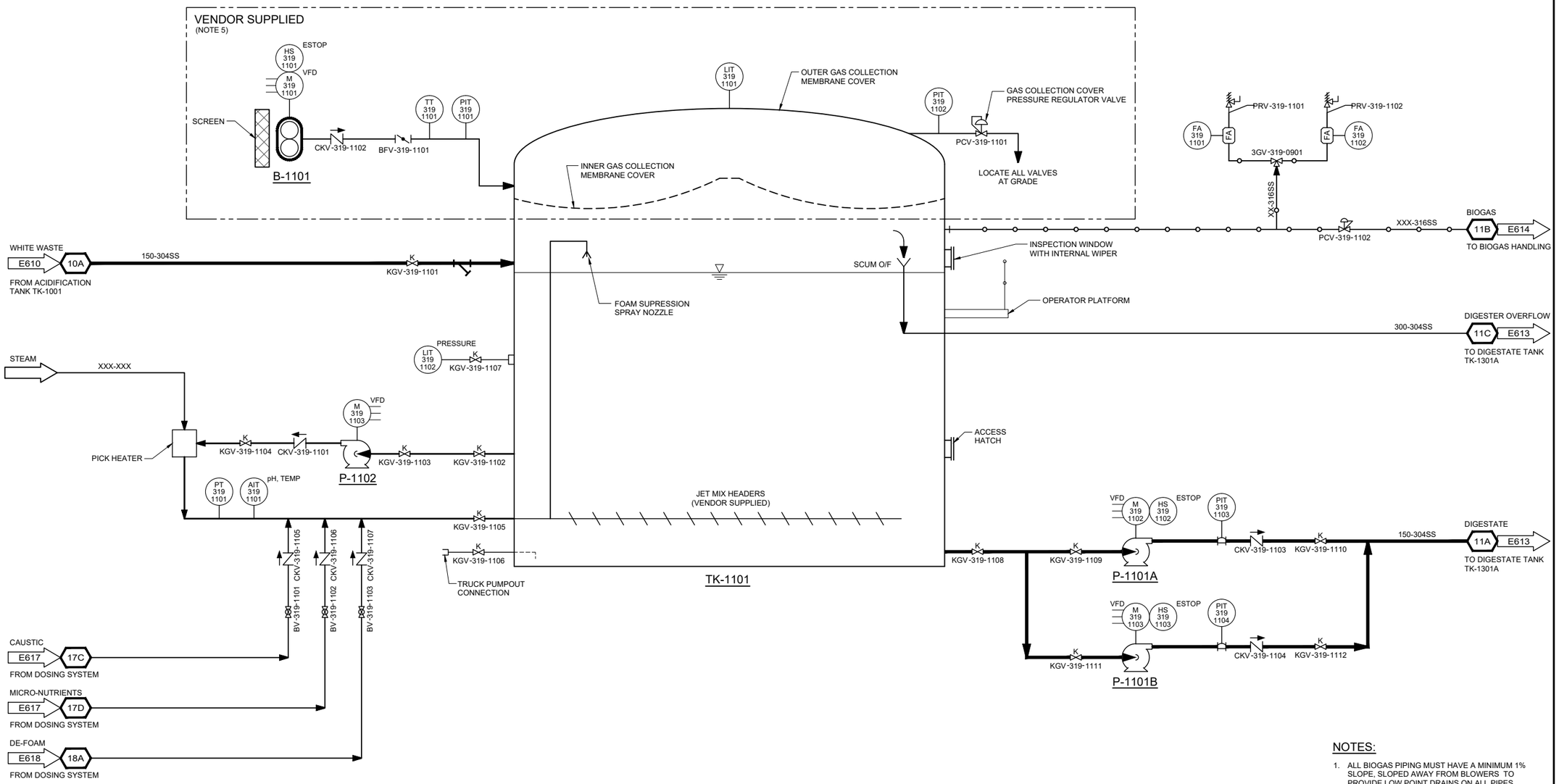
McCAIN FOODS (SA) (PTY) LTD

WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: P&ID
WHITE WASTE ACIDIFICATION TANKS

DRN. BY	PRV	DATE	MAY 2023
SHT. SIZE	A1	SHT. No	1 of 1
SCALE	N.T.S.		

DWG. NO. WW23032001-8500-E610 REV A



B-1101
GAS COLLECTION COVER BLOWER
ONE OPERATION
CAPACITY: XXXm3/hr @ XXm TDH
MOTOR: XX HP EACH

P-1102
DIGESTER RECIRCULATION PUMP
ONE OPERATING
CAPACITY:
TYPE: CENTRIFUGAL
MOTOR:

TK-1101
ANAEROBIC DIGESTER
SIZE:
CAPACITY:
MATERIAL: BOLTED STEEL
BASE: CONCRETE, SLOPE 1:40

P-1101A/B
DIGESTATE TRANSFER PUMPS
ONE OPERATING
CAPACITY:
TYPE: CENTRIFUGAL
MOTOR:

NOTES:

1. ALL BIOGAS PIPING MUST HAVE A MINIMUM 1% SLOPE, SLOPED AWAY FROM BLOWERS TO PROVIDE LOW POINT DRAINS ON ALL PIPES.
2. ALL PIPING TO BE HDPE BELOW GRADE AND SS ABOVE GRADE.
3. HIGH POINT VENTS REQUIRED ON ALL PIPING SYSTEMS.
4. ALL BIOGAS PIPING 316SS
5. BIOGAS PIPING:
   - >3" SCH 10
   - <3" SCH 40
   - ALL INSTRUMENTS TO MOUNT ABOVE GAS PIPELINE
6. ALL BIOGAS EQUIPMENT, VALVES, INSTRUMENTS, PIPING AND INSTALLATION TO MEET LOCAL CODES AND McCAIN STANDARD ANSI/CSA B149.6 REQUIREMENTS.
7. LOCATE THREE WAY VALVE, FLAME ARRESTORS AND RELIEF VALVES NEAR DIGESTER AS PER ANSI/CSA B149.6 AND MANUFACTURER'S REQUIREMENTS.
8. FLAME ARRESTOR AND THERMAL VALVE TO BE BY THE SAME MANUFACTURER.
9. EQUIPMENT SHOWN WITHIN VENDOR SCOPE IS FOR ILLUSTRATION ONLY. PROCESS DESIGN, LINE SIZING, EQUIPMENT SELECTION AND INSTRUMENTATION IS THE RESPONSIBILITY OF THE VENDOR.

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Dwg No	DWG. TITLE	BY

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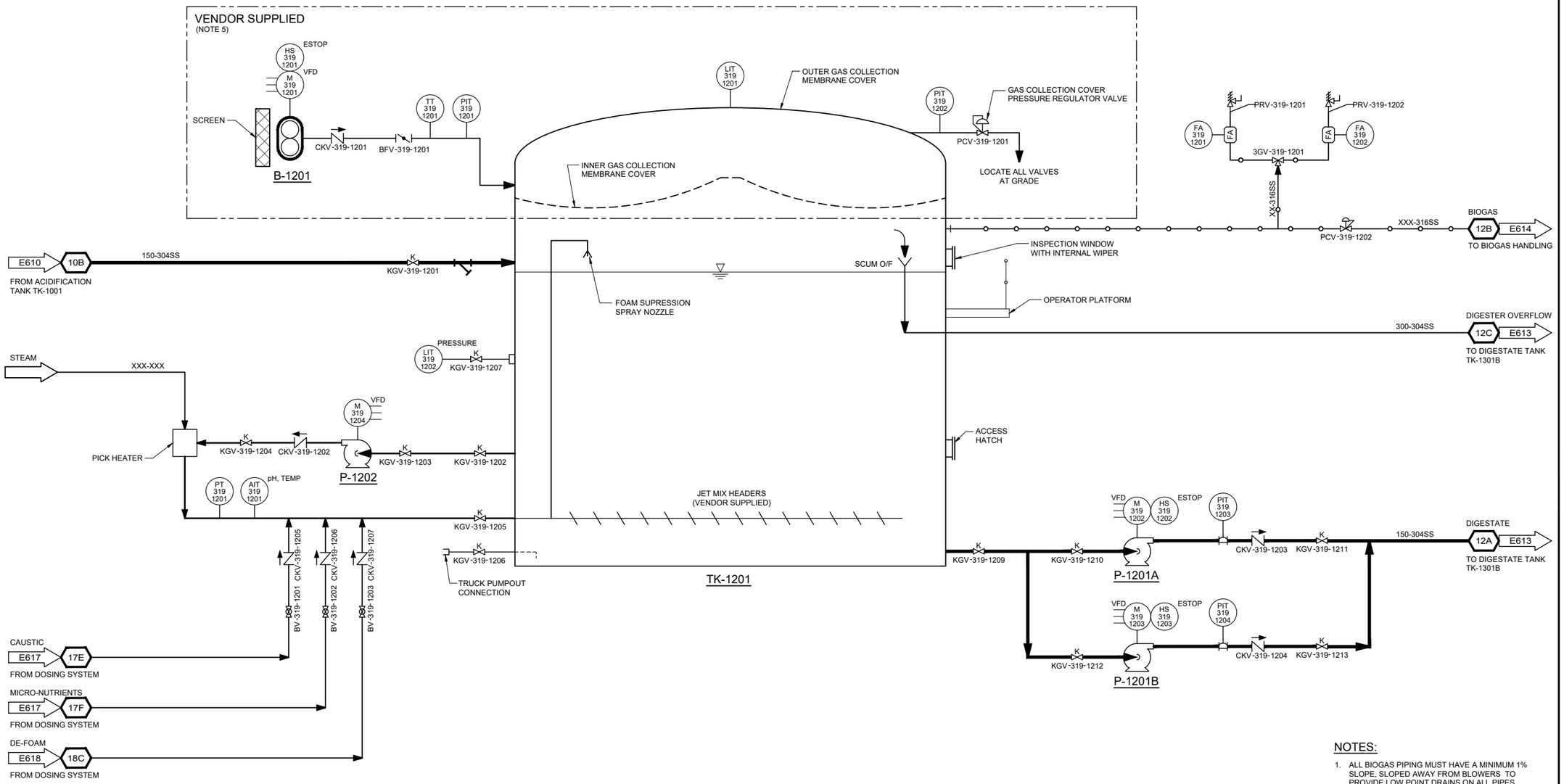
McCAIN FOODS (SA) (PTY) LTD

WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: P&ID
ANAEROBIC DIGESTER 1

DRN. BY	PRV	DATE	MAY 2023
SHT. SIZE	A1	SHT. No	1 of 1
SCALE	N.T.S.		

DWG. NO. WW23032001-8500-E611 REV A



B-1201
GAS COLLECTION COVER BLOWER
ONE OPERATION
CAPACITY: XXXm3/hr @ XXm TDH
MOTOR: XX HP EACH

P-1202
DIGESTER RECIRCULATION PUMP
ONE OPERATING
CAPACITY:
TYPE: CENTRIFUGAL
MOTOR:

TK-1201
ANAEROBIC DIGESTER
SIZE:
CAPACITY:
MATERIAL: BOLTED STEEL
BASE: CONCRETE, SLOPE 1:40

P-1201A/B
DIGESTATE TRANSFER PUMPS
ONE OPERATING
CAPACITY:
TYPE: CENTRIFUGAL
MOTOR:

NOTES:

1. ALL BIOGAS PIPING MUST HAVE A MINIMUM 1% SLOPE, SLOPED AWAY FROM BLOWERS TO PROVIDE LOW POINT DRAINS ON ALL PIPES.
2. ALL PIPING TO BE HDPE BELOW GRADE AND SS ABOVE GRADE.
3. HIGH POINT VENTS REQUIRED ON ALL PIPING SYSTEMS.
4. ALL BIOGAS PIPING 316SS
5. BIOGAS PIPING:
   - >3" SCH 10
   - <3" SCH 40
   - ALL INSTRUMENTS TO MOUNT ABOVE GAS PIPELINE
6. ALL BIOGAS EQUIPMENT, VALVES, INSTRUMENTS, PIPING AND INSTALLATION TO MEET LOCAL CODES AND McCAIN STANDARD ANSI/CSA B149.6 REQUIREMENTS.
7. LOCATE THREE WAY VALVE, FLAME ARRESTORS AND RELIEF VALVES NEAR DIGESTER AS PER ANSI/CSA B149.6 AND MANUFACTURER'S REQUIREMENTS.
8. FLAME ARRESTOR AND THERMAL VALVE TO BE BY THE SAME MANUFACTURER.
9. EQUIPMENT SHOWN WITHIN VENDOR SCOPE IS FOR ILLUSTRATION ONLY. PROCESS DESIGN, LINE SIZING, EQUIPMENT SELECTION AND INSTRUMENTATION IS THE RESPONSIBILITY OF THE VENDOR.

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NO.	DATE	REVISION	BY
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REFERENCE DWGS.

Dwg No	DWG. TITLE	BY

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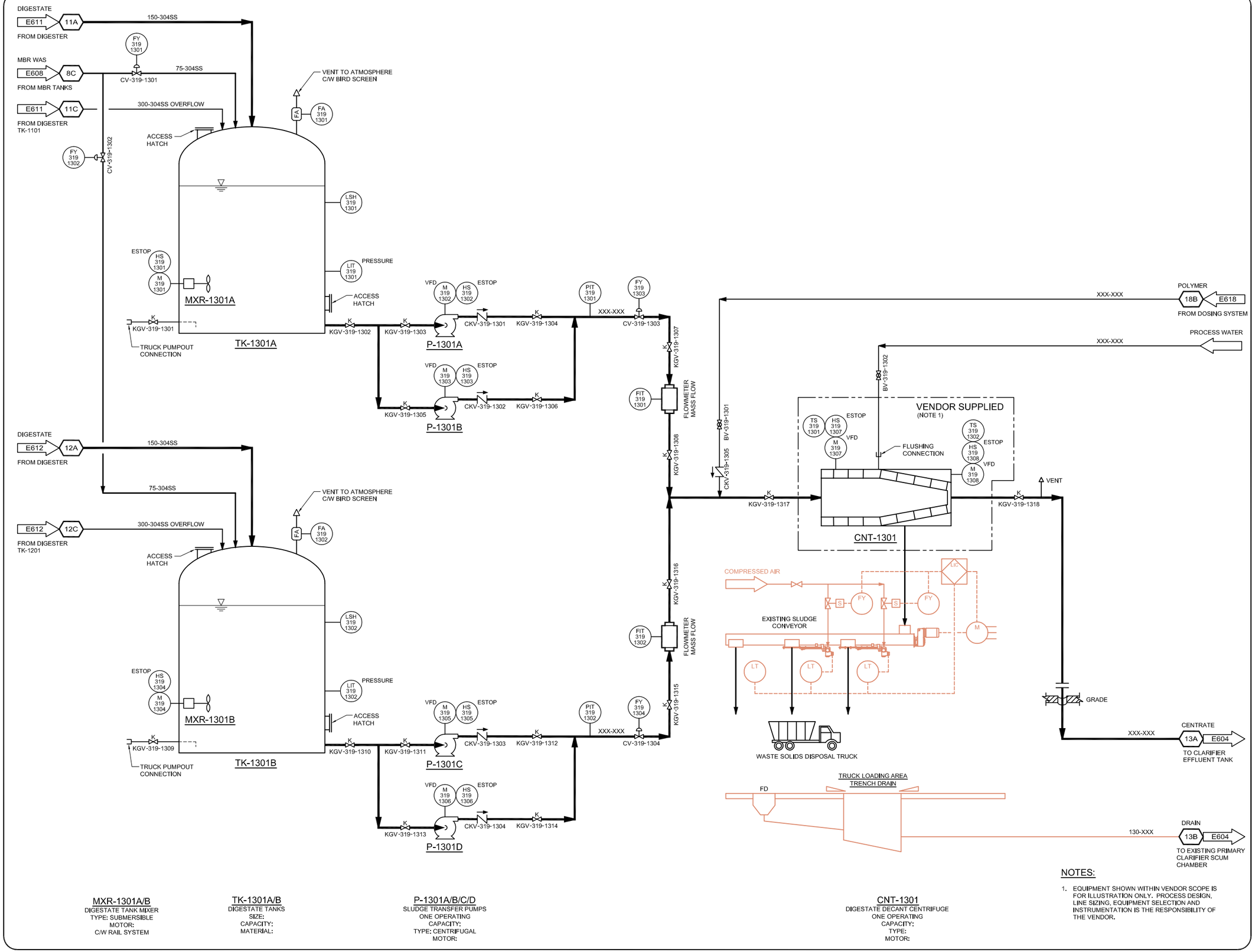
McCAIN FOODS (SA) (PTY) LTD
-
-
-
PACKED FOR .

WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: P&ID
ANAEROBIC DIGESTER 2

DWN. BY	PRV	DATE	MAY 2023
SHT. SIZE	A1	SHT. No	1 of 1
SCALE	N.T.S.		

DWG. NO. WW23032001-8500-E612 REV A



MXR-1301A/B
DIGESTATE TANK MIXER
TYPE: SUBMERSIBLE
MOTOR:
C/W RAIL SYSTEM

TK-1301A/B
DIGESTATE TANKS
SIZE:
CAPACITY:
MATERIAL:

P-1301A/B/C/D
SLUDGE TRANSFER PUMPS
ONE OPERATING
CAPACITY:
TYPE: CENTRIFUGAL
MOTOR:

CNT-1301
DIGESTATE DECANT CENTRIFUGE
ONE OPERATING
CAPACITY:
TYPE:
MOTOR:

NOTES:

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REFERENCE DWGS.		
Dwg No	DWG. TITLE	BY

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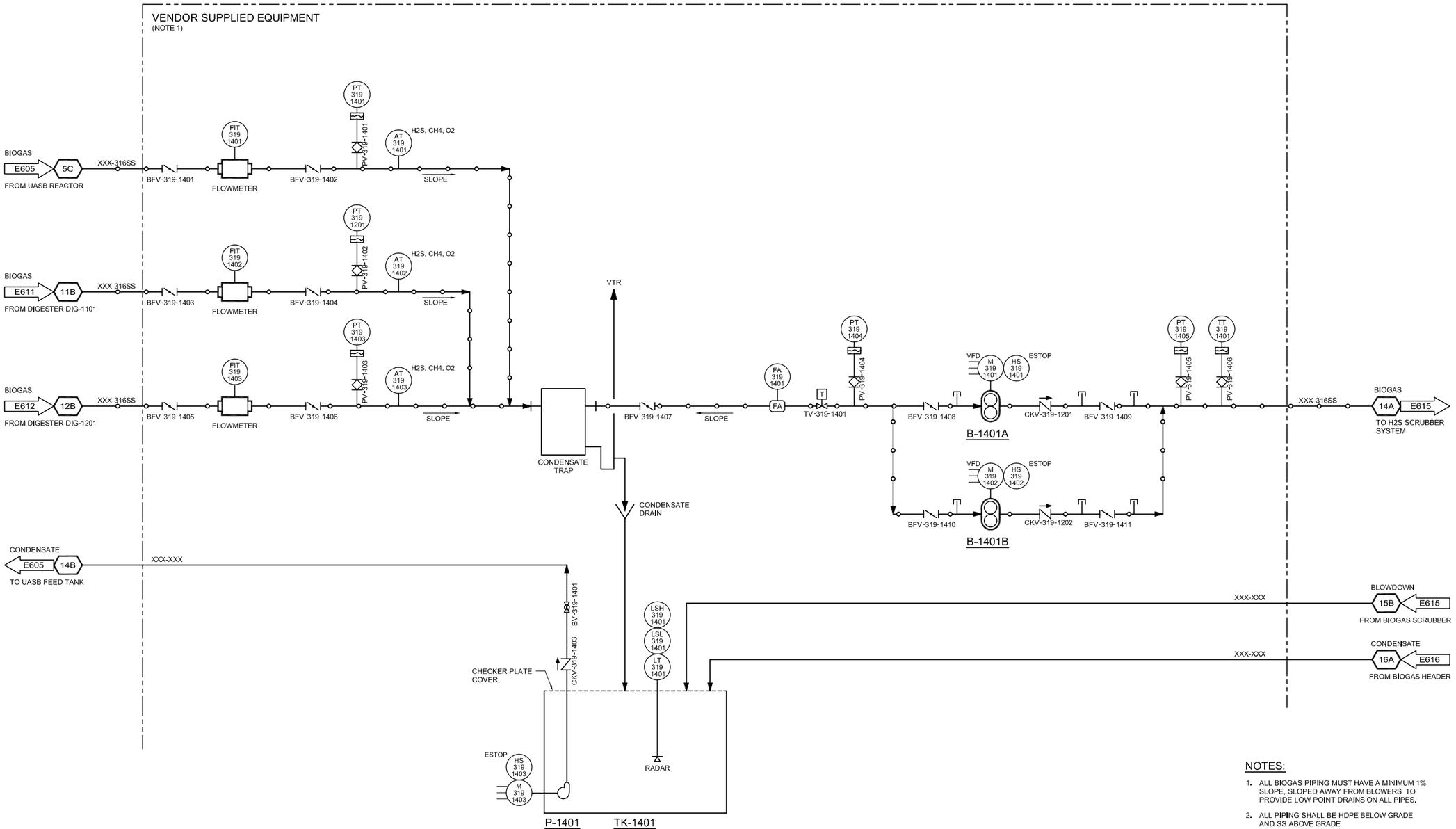
WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: P&ID SLUDGE DEWATERING

DRN. BY	DATE
PRV	MAY 2023

SHT. SIZE	SHT. No	SCALE
A1	1 of 1	N.T.S.

DWG. NO. WW23032001-8500-E613 REV A



NOTES:

1. ALL BIOGAS PIPING MUST HAVE A MINIMUM 1% SLOPE, SLOPED AWAY FROM BLOWERS TO PROVIDE LOW POINT DRAINS ON ALL PIPES.
2. ALL PIPING SHALL BE HDPE BELOW GRADE AND SS ABOVE GRADE
3. ALL BIOGAS PIPING 316SS
4. BIOGAS PIPING:
   - >3" SCH 10
   - <3" SCH 40
   - MAXIMUM PIPE LENGTH BETWEEN FLAME ARRESTOR / THERMAL VALVE AND BLOWERS IS 5m
   - ALL INSTRUMENTS TO MOUNT ABOVE GAS PIPELINE
5. ALL BIOGAS EQUIPMENT, VALVES, INSTRUMENTS, PIPING AND INSTALLATION TO MEET LOCAL CODES AND McCAIN STANDARD ANSI/CSA B149.6 REQUIREMENTS.
6. LOCATE THREE WAY VALVE, FLAME ARRESTORS AND RELIEF VALVES NEAR DIGESTER AS PER ANSI/CSA B149.6 AND MANUFACTURER'S REQUIREMENTS.
7. FLAME ARRESTOR AND THERMAL VALVE TO BE BY THE SAME MANUFACTURER.

P-1401
CONDENSATE PUMP
ONE OPERATING
CAPACITY:
TYPE: CENTRIFUGAL
MOTOR:

TK-1401
CONDENSATE SUMP
SIZE:
CAPACITY:
MATERIAL:

B-1401A/B
BIOGAS BLOWERS
ONE OPERATION, ONE STANDBY
CAPACITY: XXXm3/hr @ XXm TDH
MOTOR: XX HP EACH

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NO.	DATE	REVISION	BY
A			

REFERENCE DWGS.		
Dwg No	DWG. TITLE	BY

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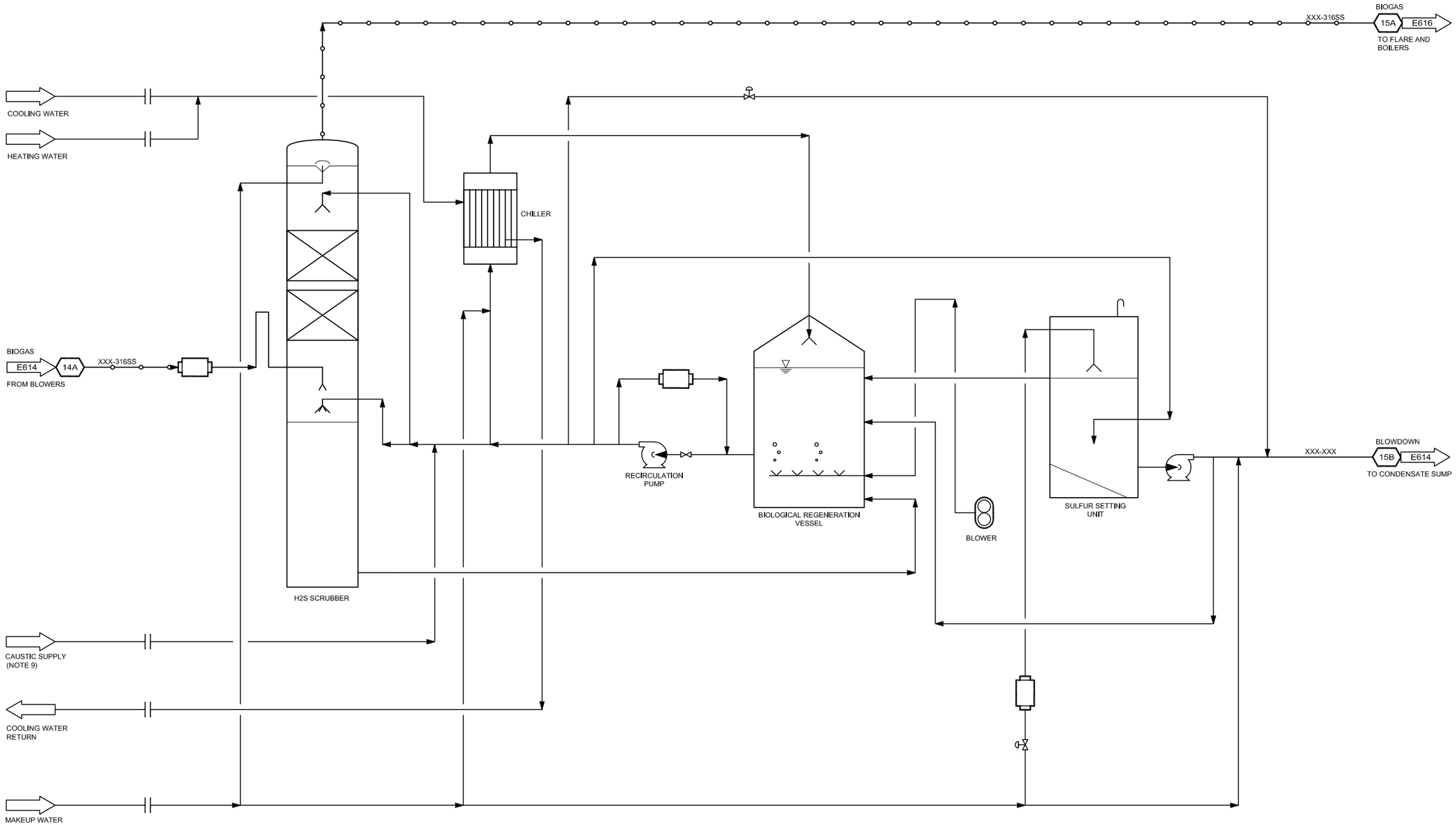
WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: P&ID
BIOGAS TREATMENT SYSTEM
1 OF 3

DWN BY	DATE	SHT. SIZE	SHT. No	SCALE
PRV	MAY 2023	A1	1 of 1	N.T.S.

DWG. NO. WW23032001-8500-E614 REV A



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2. ALL BIOGAS PIPING MUST HAVE A MINIMUM 1% SLOPE, SLOPED AWAY FROM BLOWERS TO PROVIDE LOW POINT DRAINS ON ALL PIPES.
3. ALL PIPING SHALL BE HDPE BELOW GRADE AND SS ABOVE GRADE
4. ALL BIOGAS PIPING 316SS
5. BIOGAS PIPING:
   - >3" SCH 10
   - <3" SCH 40
6. ALL BIOGAS EQUIPMENT, VALVES, INSTRUMENTS, PIPING AND INSTALLATION TO MEET LOCAL CODES AND McCAIN STANDARD ANSI/CSA B149.6 REQUIREMENTS.
7. FLAME ARRESTOR AND THERMAL VALVE TO BE BY THE SAME MANUFACTURER.
8. ALL INSTRUMENTS TO BE MOUNTED ABOVE GAS PIPELINE.
9. VENDOR IS RESPONSIBLE FOR SUPPLY OF DUPLEX DOSING PUMP SKID. TO BE MOUNTED IN CHEMICAL ROOM.

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NO.	DATE	REVISION	BY

REFERENCE DWGS.		
Dwg No	DWG. TITLE	BY

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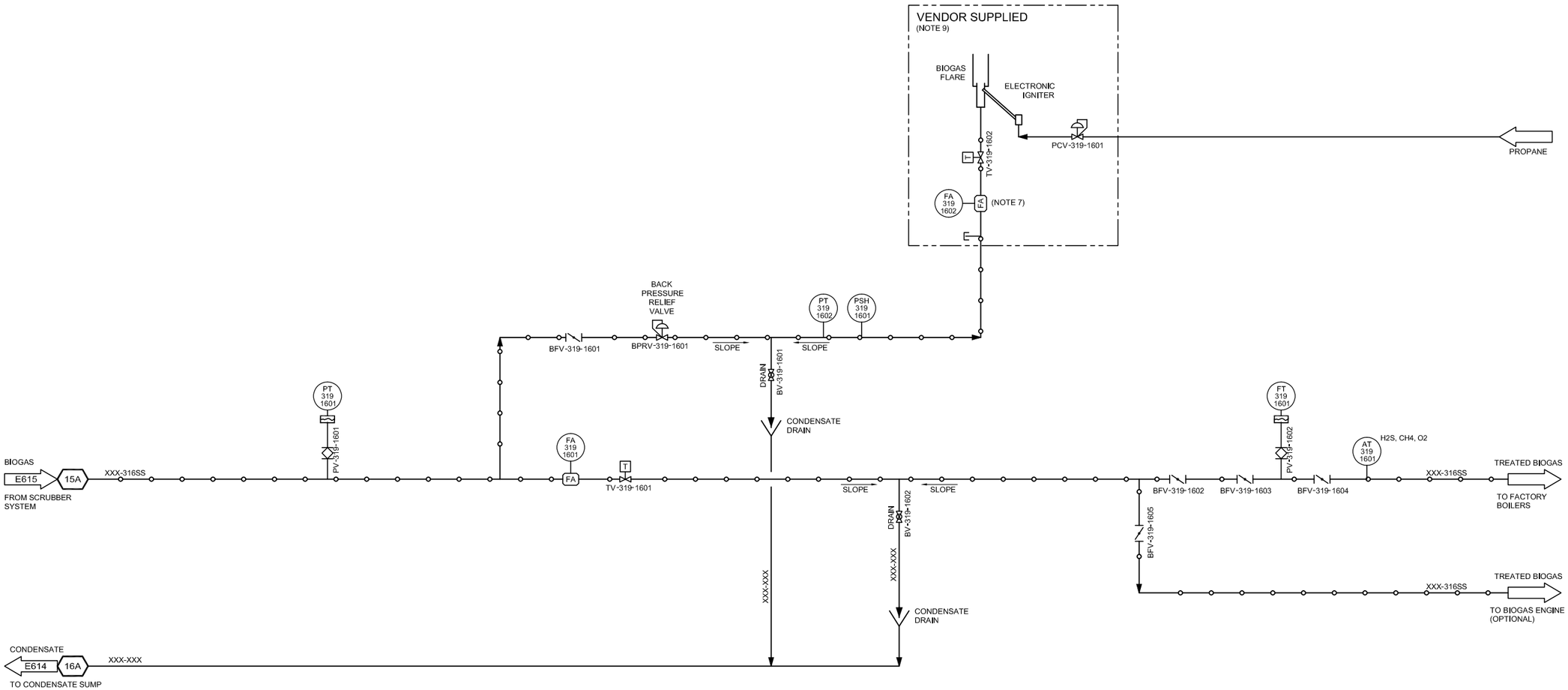
PROJECT NO

WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: **P&ID BIOGAS TREATMENT SYSTEM 2 OF 3**

DRN. BY	DATE	
PRV	MAY 2023	
SHT. SIZE: A1	SHT. No: 1 of 1	SCALE: N.T.S.

DWG. NO. WW23032001-8500-E615 REV A



NOTES:

1. ALL BIOGAS PIPING MUST HAVE A MINIMUM 1% SLOPE, SLOPED AWAY FROM BLOWERS TO PROVIDE LOW POINT DRAINS ON ALL PIPES.
2. ALL PIPING SHALL BE HDPE BELOW GRADE AND SS ABOVE GRADE
3. ALL BIOGAS PIPING 316SS
4. BIOGAS PIPING:
   - >3" SCH 10
   - <3" SCH 40
5. ALL BIOGAS EQUIPMENT, VALVES, INSTRUMENTS, PIPING AND INSTALLATION TO MEET LOCAL CODES AND McCAIN STANDARD ANSI/CSA B149.6 REQUIREMENTS.
6. FLAME ARRESTOR AND THERMAL VALVE TO BE BY THE SAME MANUFACTURER
7. LOCATE FLAME ARRESTOR AND THERMAL VALVE WITHIN 2m OF BOILER.
8. ALL INSTRUMENTS TO BE MOUNT ABOVE GAS PIPELINE.
9. EQUIPMENT SHOWN WITHIN VENDOR SCOPE IS FOR ILLUSTRATION ONLY. PROCESS DESIGN LINE SIZING, EQUIPMENT SELECTION AND INSTRUMENTATION IS THE RESPONSIBILITY OF THE VENDOR.
10. FLARE MUST BE CAPABLE OF FULL RANGE OF GAS FLOW SPECIFIED.

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NO.	DATE	REVISION	BY

REFERENCE DWGS.

Dwg No	DWG. TITLE	BY

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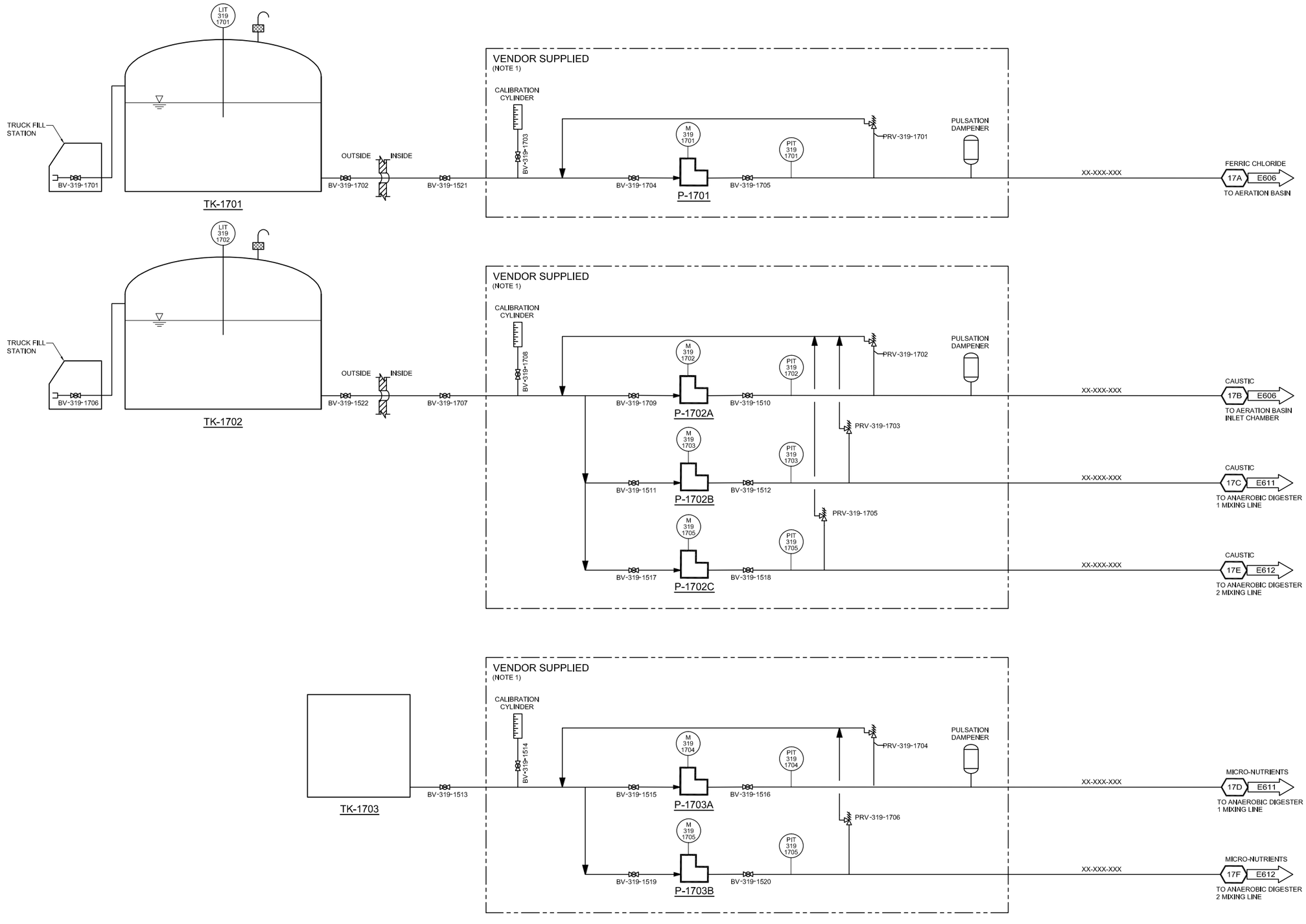
WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: P&ID
BIOGAS TREATMENT SYSTEM
3 OF 3

DWN. BY	DATE
PRV	MAY 2023

SHT. SIZE	SHT. No	SCALE
A1	1 of 1	N.T.S.

DWG. NO. WW23032001-8500-E616 REV A



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TK-1701
FERRIC CHLORIDE BULK STORAGE TANK
SIZE:
CAPACITY:
MATERIAL:

TK-1702
CAUSTIC BULK STORAGE TANK
SIZE:
CAPACITY:
MATERIAL:

TK-1703
MICRO-NUTRIENT TOTE
SIZE:
CAPACITY:
MATERIAL:

P-1701
FERRIC CHLORIDE DOSING PUMP
TWO OPERATING
CAPACITY:
TYPE: METERING
MOTOR:

P-1702A/B
CAUSTIC DOSING PUMP
ONE OPERATING
CAPACITY:
TYPE: METERING
MOTOR:

P-1703
MICRO-NUTRIENT DOSING PUMP
ONE OPERATING
CAPACITY:
TYPE: METERING
MOTOR:

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REVISIONS			
NO.	DATE	REVISION	BY
A			

REFERENCE DWGS.		
Dwg No	DWG. TITLE	BY

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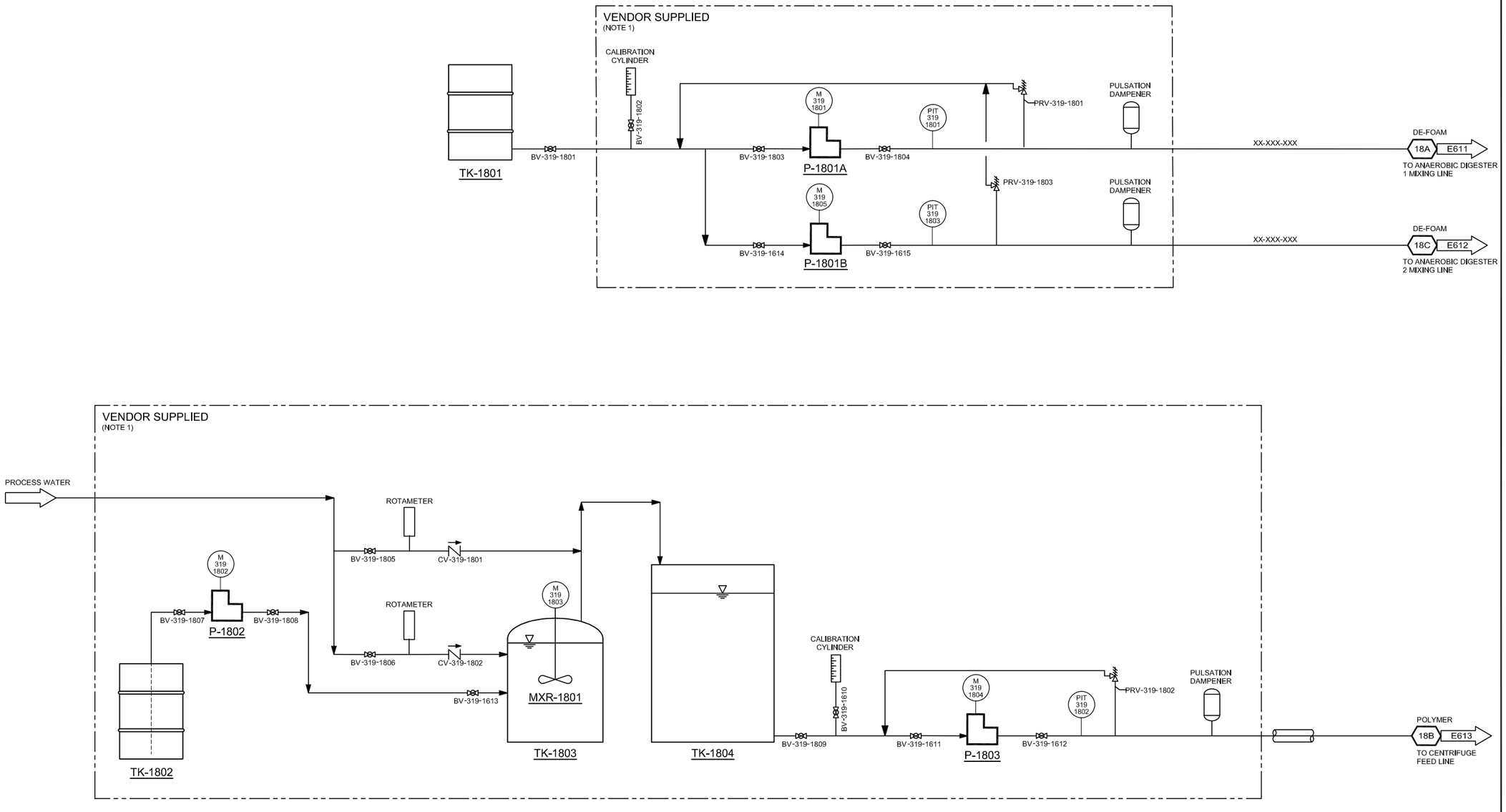
WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: P&ID CHEMICAL DOSING 1 OF 2

DRN. BY	DATE	
PRV	MAY 2023	
SHT. SIZE: A1	SHT. No: 1 of 1	SCALE: N.T.S.

DWG. NO. WW23032001-8500-E617 REV A



TK-1802
NEAT POLYMER DRUM
SIZE:
CAPACITY:
MATERIAL:

P-1802
NEAT POLYMER PUMP
ONE OPERATING
CAPACITY:
TYPE: METERING
MOTOR:

TK-1801
DE-FOAM DRUM
SIZE:
CAPACITY:
MATERIAL:

MXR-1801
POLYMER MIXER
TYPE: TANK MOUNTED
MOTOR:

TK-1803
POLYMER MIXING TANK
SIZE:
CAPACITY:
MATERIAL:

TK-1804
MAKE DOWN POLYMER TANK
SIZE:
CAPACITY:
MATERIAL:

P-1801A/B
DE-FOAM DOSING PUMP
ONE OPERATING
CAPACITY:
TYPE: METERING
MOTOR:

P-1803
POLYMER DOSING PUMP
ONE OPERATING
CAPACITY:
TYPE: METERING
MOTOR:

NOTES:

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NO.	DATE	REVISION	BY
1			

REFERENCE DWGS.

Dwg No	DWG. TITLE	BY

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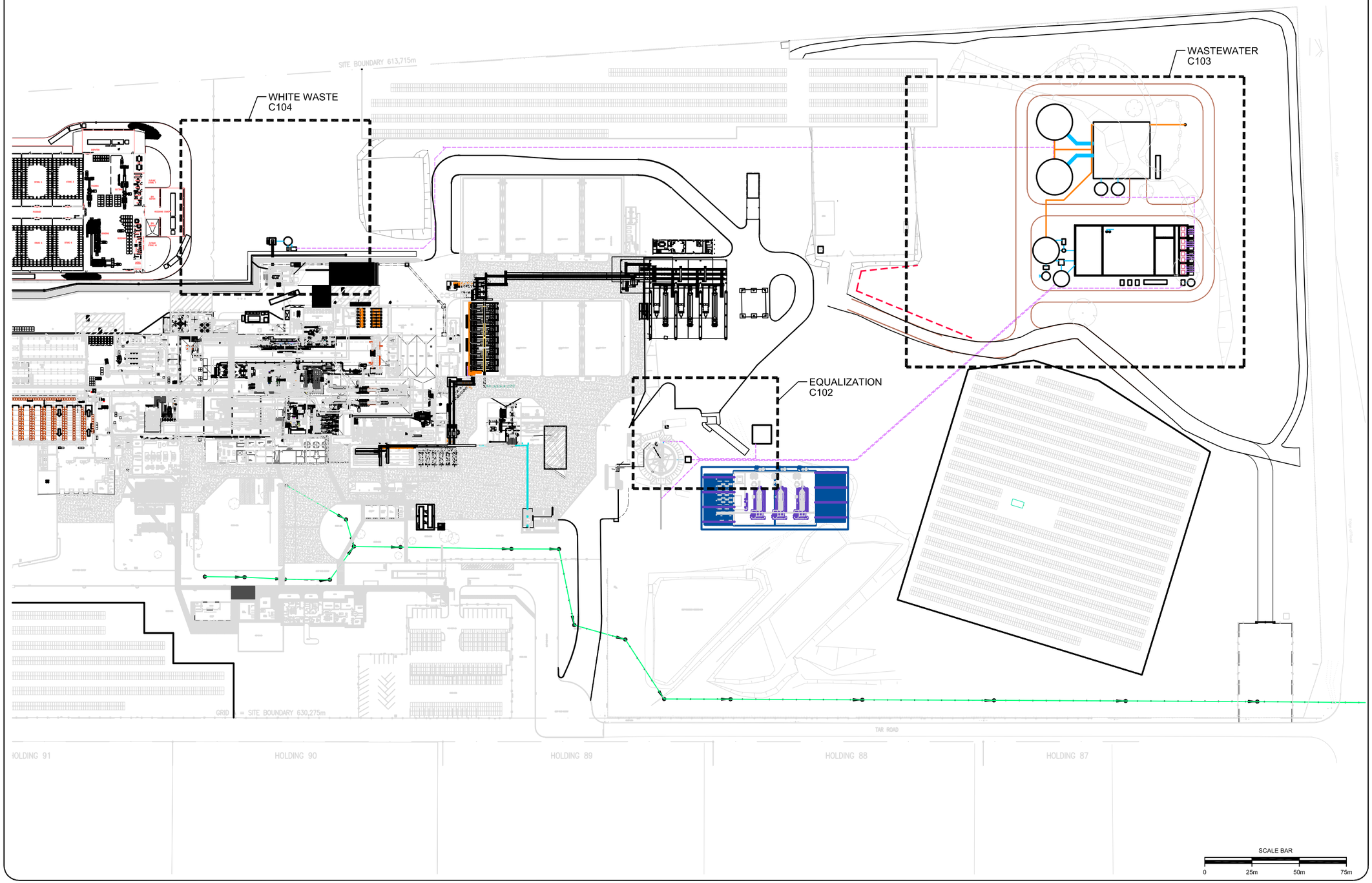
WWTP PRELIMINARY DESIGN
WASTEWATER TREATMENT PLANT (WWTP)
DELMAS, SOUTH AFRICA

DWG. TITLE: P&ID
CHEMICAL DOSING
2 OF 2

DWN BY	PRV	DATE	MAY 2023
SHT. SIZE	A1	SHT. No	1 of 1
SCALE	N.T.S.		
DWG. NO.	WW23032001-8500-E618	REV	A

Appendix C

Preliminary Layout



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NO.	DATE	REVISION	BY

REFERENCE DWGS.		
Dwg No	DWG. TITLE	BY

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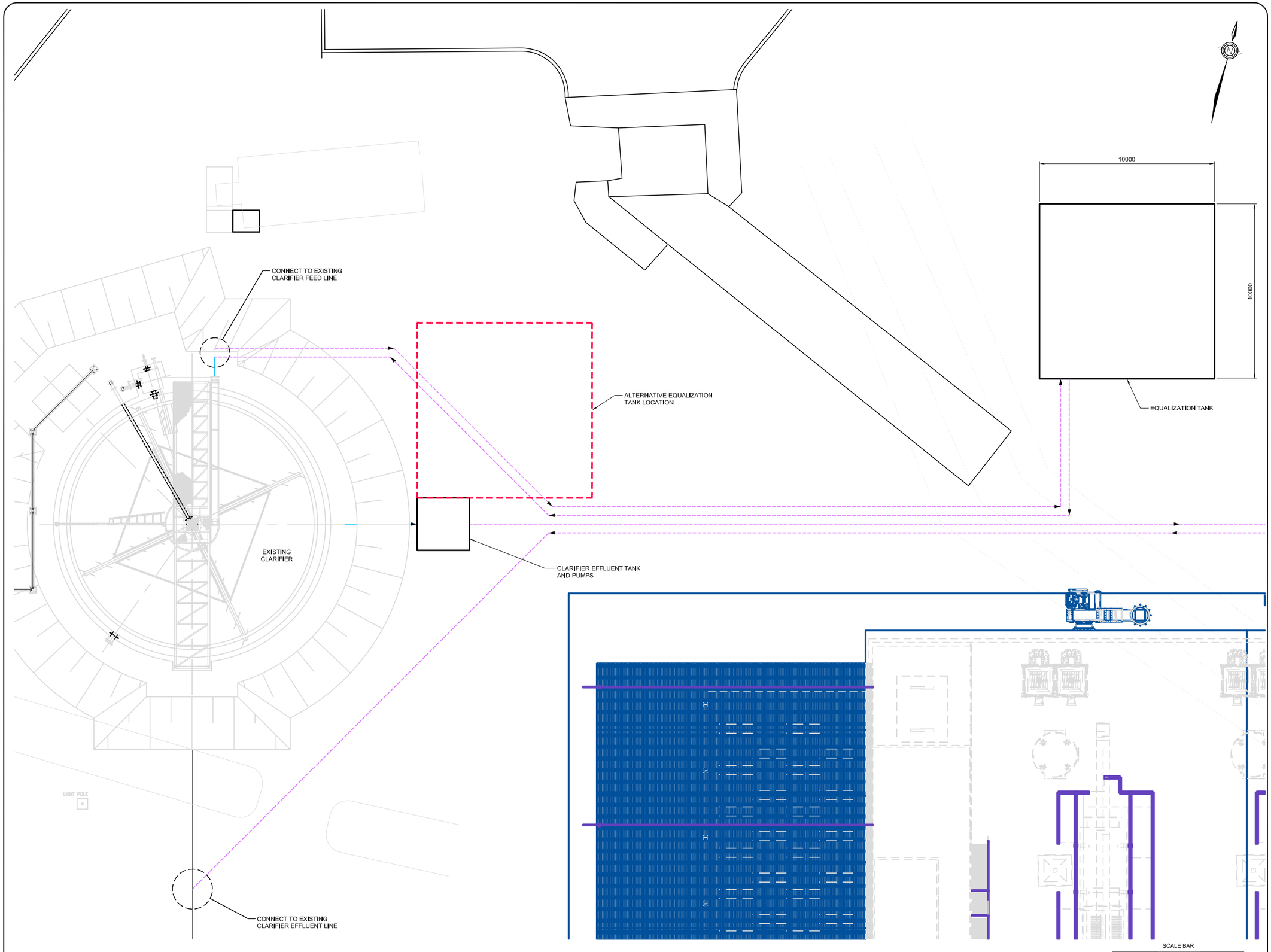
WWTP PRELIMINARY DESIGN

DELMAS, SOUTH AFRICA

DWG. TITLE: CIVIL
OVERALL SITE PLAN

DWN BY	PRV	DATE	MARCH 2023
SHT. SIZE	A1	SHEET No	1 of 1
SCALE	1 : 1000		
DWG. NO.	XXXXX-XXXXX-8500-C101	REV	A



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REVISIONS			
NO.	DATE	REVISION	BY

REFERENCE DWGS.		
Dwg No	DWG. TITLE	BY

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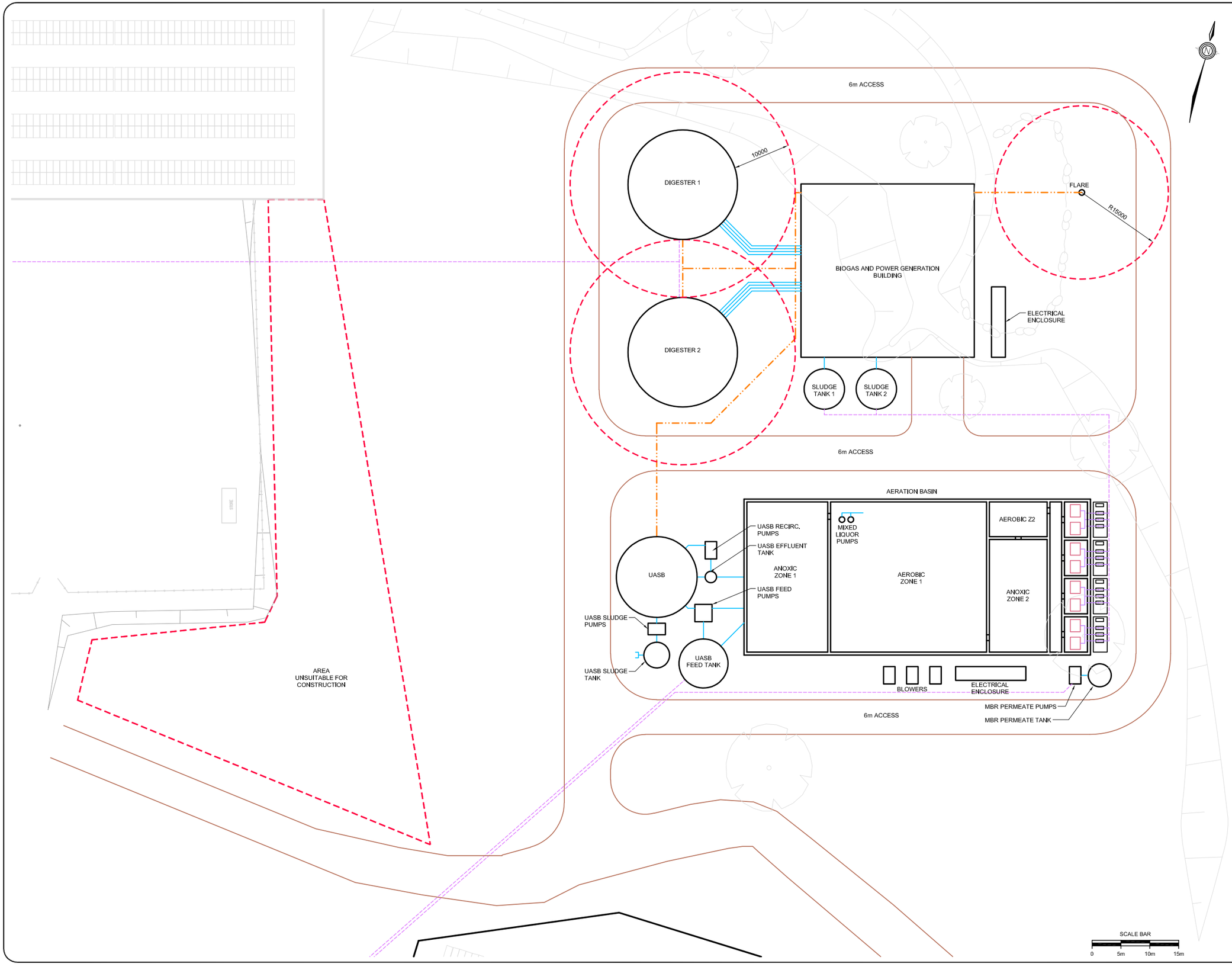
WWTP PRELIMINARY DESIGN

DELMAS, SOUTH AFRICA

DWG. TITLE: CIVIL
EQUALIZATION AREA
PARTIAL SITE PLAN

DRN. BY	PRV	DATE	MARCH 2023
SHT. SIZE	A1	SHEET No	1 of 1
SCALE	1 : 100		
DWG. NO.	XXXXX-XXXXX-8500-C102	REV	A



wsp

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REVISIONS

NO.	DATE	REVISION	BY
1			

REFERENCE DWGS.

Dwg No	DWG. TITLE	BY

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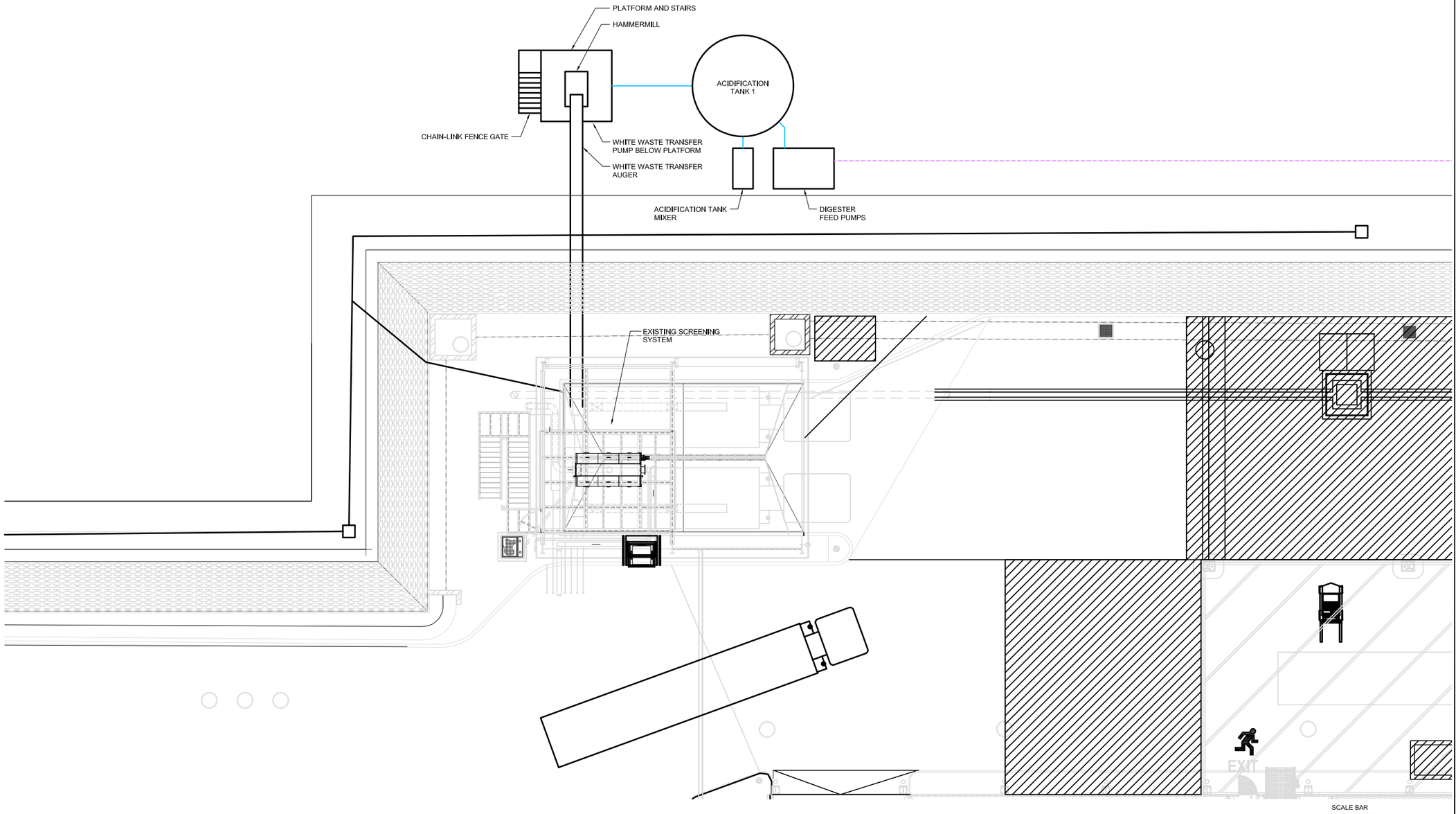
WWTP PRELIMINARY DESIGN

DELMAS, SOUTH AFRICA

DWG. TITLE: CIVIL
WASTEWATER PROCESS AREA
PARTIAL SITE PLAN

DWN BY	PRV	DATE	MARCH 2023
SHT. SIZE	A1	SHT No	1 of 1
SCALE	1 : 300		

DWG. NO. XXXXX-XXXXX-8500-C103 REV A



wsp

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REVISIONS			
NO.	DATE	REVISION	BY

REFERENCE DWGS.		
Dwg No	DWG. TITLE	BY

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McCAIN FOODS (SA) (PTY) LTD.
-
-
-
FOOD PARK

WWTP PRELIMINARY DESIGN

DELMAS, SOUTH AFRICA

DWG. TITLE	CIVIL WHITE WASTE AREA PARTIAL SITE PLAN		
DRN. BY	PRV	DATE	MARCH 2023
SHT. SIZE	A1	SHEET No	1 of 1
SCALE	1 : 100		
DWG. NO.	XXXXX-XXXXX-8500-C104	REV	A

Appendix D

Site Geotechnical Report

Rockland Geoscience since 2007
Geotechnical Consultants

Postnet Suite # 235,
Private Bag X025,
Lynnwood Ridge, 0040
info@rockland.co.za
www.rockland.co.za

Gleam Hydro (Pty) Ltd
130 Bagley Terrace
Valeriedene
Randburg
2543

20 August 2023
Our Reference: RG/022/316/Report 1
Client Reference: PO0000007

RE: MCCAIN DELMAS - WASTE WATER TREATMENT PLANT (WWTP) PHASE 1 SHALLOW SURFACE GEOTECHNICAL AND DOLOMITE STABILITY INVESTIGATIONS

Attention: Mr. Johan Kriek
Email: johan@gleam.co.za

Dear Sir,

1 Introduction

Rockland Geoscience (Pty) Ltd (Rockland) was appointed by Gleam Hydro (Pty) Ltd (Gleam) in terms of Rockland proposal letter RG/022/316/01, dated 04 June 2022, and Gleam purchase order number PO0000007 dated 05 June 2023, to undertake phase 1 shallow surface geotechnical and dolomite stability investigations for a new Waste Water Treatment Plant (WWTP) at McCain Food SA (Pty) Ltd's (McCain) Delmas plant, near the town of Delmas Mpumalanga Province, South Africa.

This letter report presents the findings of the various investigations, including the results of a desk top study, nine test pits excavated to a maximum depth of about 3m, laboratory tests and five percussion boreholes drilled to a maximum depth of 60m.

2 Site Description

The site is located at McCain's Delmas plant, near the town of Delmas Mpumalanga Province. Refer to Figure 2-1 for the location of the site and Figure 2-2 for a zoomed in image of the site and various test pits and percussion boreholes.

Figure 2-1: Location of the site

Excerpt taken from Google Earth™

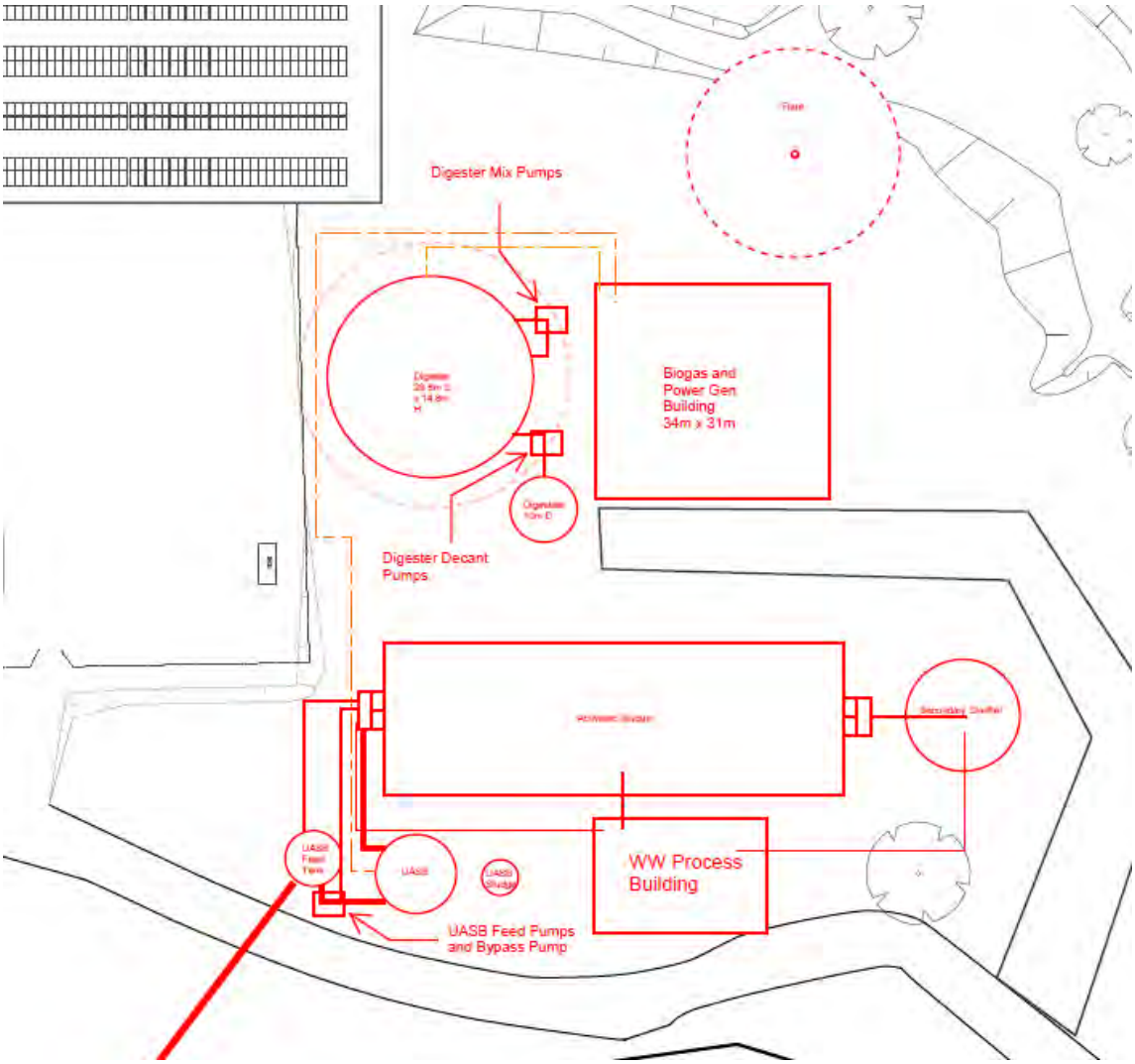
Figure 2-2: Locations of test pits and boreholes

Excerpt taken from Google Earth™

2.1 Proposed development

The proposed development, as extracted from a preliminary WSP layout plan received from Gleam and dated March 2023, is given in the figure below.

Figure 2-3: Proposed WWTP development



The proposed development includes the following elements:

- Digester (29.8m diameter x 14.8m high);
- Digestate (10m diameter);
- Biogas and power Gen building (34m long x 31m wide);
- Secondary clarifier;
- Wastewater process building;
- Activated sludge structure;
- UASB tanks (x3);
- Digester mix and feed pumps;
- UASB feed and bypass pumps.

No foundation details such as dimensions, embedment depths, loads, moments and foundation deflection tolerances were provided.

3 Results of Investigation

3.1 Desk study review

A desk top study review was undertaken of all available geotechnical and geological information pertaining to the site including published geological maps and historical geological and geotechnical reports.

3.1.1 Climate and geomorphology

According to the website https://en.climate-data.org/africa/south-africa/mpumalanga/delmas-8959/ (2023), the climate at Delmas is warm and moderate with a Köppen-Geiger classification Cwb. Summers are warm and wet while winters are dry and cold with frost common during winter months. The average annual temperature is 16.3 °C and the annual precipitation is about 787 mm.

The site has a Weinert (1978) climatic N value of between 2 and 5. A Weinert N value of 2 – 5 indicates chemical weathering (decomposition) to be dominant over mechanical (disintegration) weathering.

Figure 3-1: Climatic N-Value after Weinert (1978)

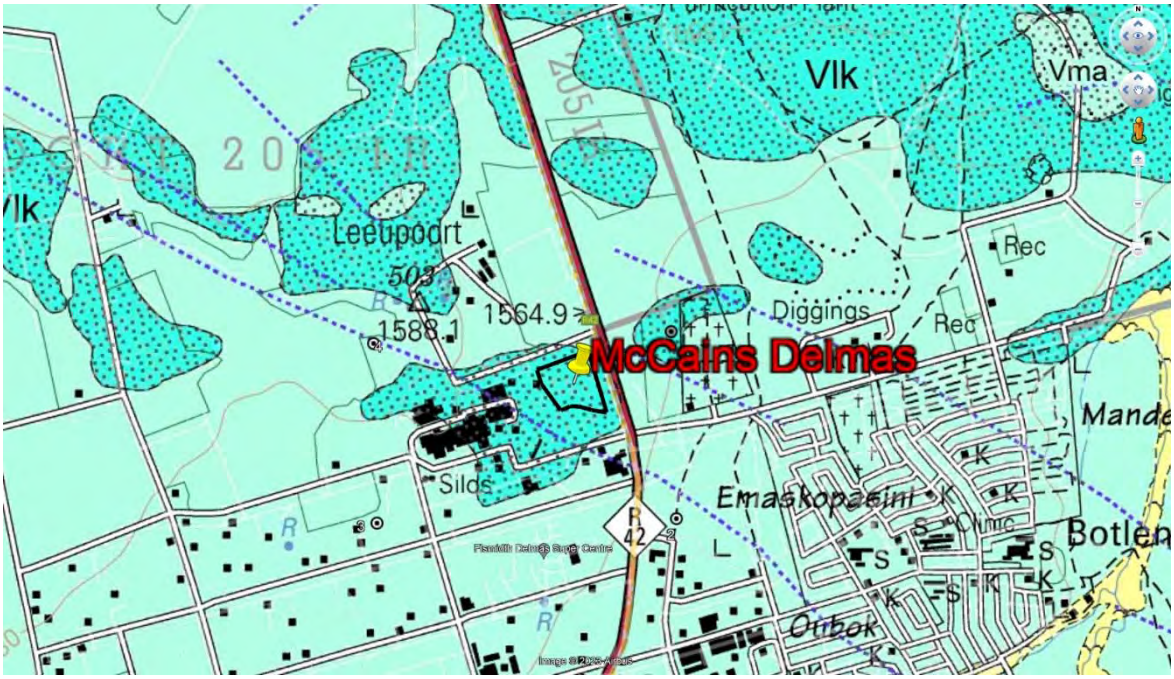
3.1.2 Geology

Regional geology

According to the 1:50 000 geological map 2628BA Delmas (2006), the site is underlain by chert breccia of the Leeuwenkloof Member (Vlk), Eccles Formation, Malmani Subgroup Chuniespoort Group of the Transvaal Supergroup. The Leeuwenkloof member overlies dolomite and chert of the Eccles Formation (Vma). The geological map shows two lineaments, marked in blue dashed lines, (possibly syenite dykes) trending north-east to south-west to the north and south of the site.

Refer to Figure 3-2 below for the 1:50 000 scale geological map 2628AB Delmas superimposed onto a Google Earth backdrop showing the location of McCain's Delmas plant.

Figure 3-2: Regional geology



1:50 000 scale geological map 2628AB Delmas overlain onto Google Earth™

Site specific geology

A search of the Council for Geoscience' (CGS) databank located two historical reports detailing drilling investigations in the vicinity of the new WWTP.

The historical reports include six percussion boreholes (BC1 to BC6), drilled in 2019, 80m to 300 m to the west of the site by JK Developments under direction of consultancy Martin van der Walt Engineering Geologist (van der Walt, 2016), for and on behalf of McCain, and four boreholes (BH1 to BH4) to the south and west of the site, drilled in 2016 by Hennie Erwee Drilling Contractors, under direction of Golder Associates (Nkosi and Marais, 2019) also for and on behalf of McCain. Please refer to Table 3-1 for a list of historical boreholes and to Figure 3-3 below for the locations of boreholes (blue and green pins) relative to the current investigation (yellow and red pins).

The historic investigations revealed a thick surface chert layer overlying dolomite bedrock at depth. Percussion boreholes, BC1 and BC6, intersected a syenite dyke (Van der Walt, 2019).

The soil and rock profiles that were encountered in the historical boreholes are summarised in Table 3-1 and discussed in Section 3.3.

Table 3-1: List of historical percussion boreholes drilled near the site.

BH No	Coordinates (WGS84 LO29)*		
	X-Coordinate	Y-Coordinate	Z-Coordinate
2016 Golder Associates Investigation			
BH1	-31753	-2890856	1565.8
BH2	-31798	-2890891	1567.8
BH3	-31821	-2890927	1568
BH4	-31942	-2890950	1570.3
2019 Martin van Der Walt Engineering Geologist Investigation			
BC1	-32104	-2890753	1577
BC2	-32027	-2890732	1578
BC3	-31973	-2890760	1576.5
BC4	-31931	-2890751	1576
BC5	-31904	-2890819	1573
BC6	-31967	-2890795	1575
BC7	-31970	-2890963	1573

*Notes: *X and Y coordinates fixed via hand-held GPS and Z-coordinates derived from Google Earth™*

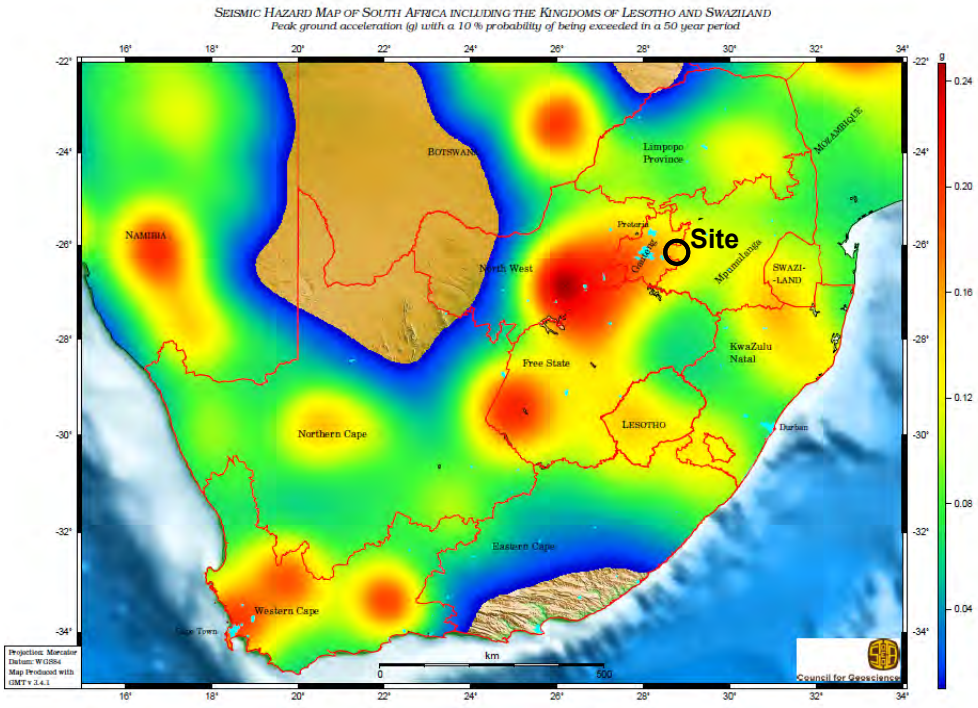
Figure 3-3: Locations of historical boreholes in the vicinity of the site

Excerpt taken from Google Earth™

3.1.3 Seismicity

According to the Council for Geoscience' (CGS) seismic hazard map of South Africa, a copy of which is reproduced in the figure below, the peak ground acceleration (PGA) at the site is about 0.13g with a 10% probability of being exceeded in a 50-year period.

Figure 3-4: Seismic Hazard Map of South Africa (After CGS)



3.2 Test pits

Nine test pits labelled TP1 – TP9, were excavated on 21 June 2023, at the locations given in Figure 3-6 below. The horizons encountered in the test pits are summarised in the table below and the soil profile logs are contained in Appendix A. Images captured of the various test pits are given in Figure 3-5 below.

Test pits were excavated by Komatsu PC200 excavator. Test pits were logged by a registered engineering geologist in accordance with the guidelines given by Brink and Bruin (1990). Representative disturbed soil samples were retrieved from the various horizons encountered in the test pits and submitted to Specialised Testing Laboratory (STL) of Pretoria for laboratory testing.

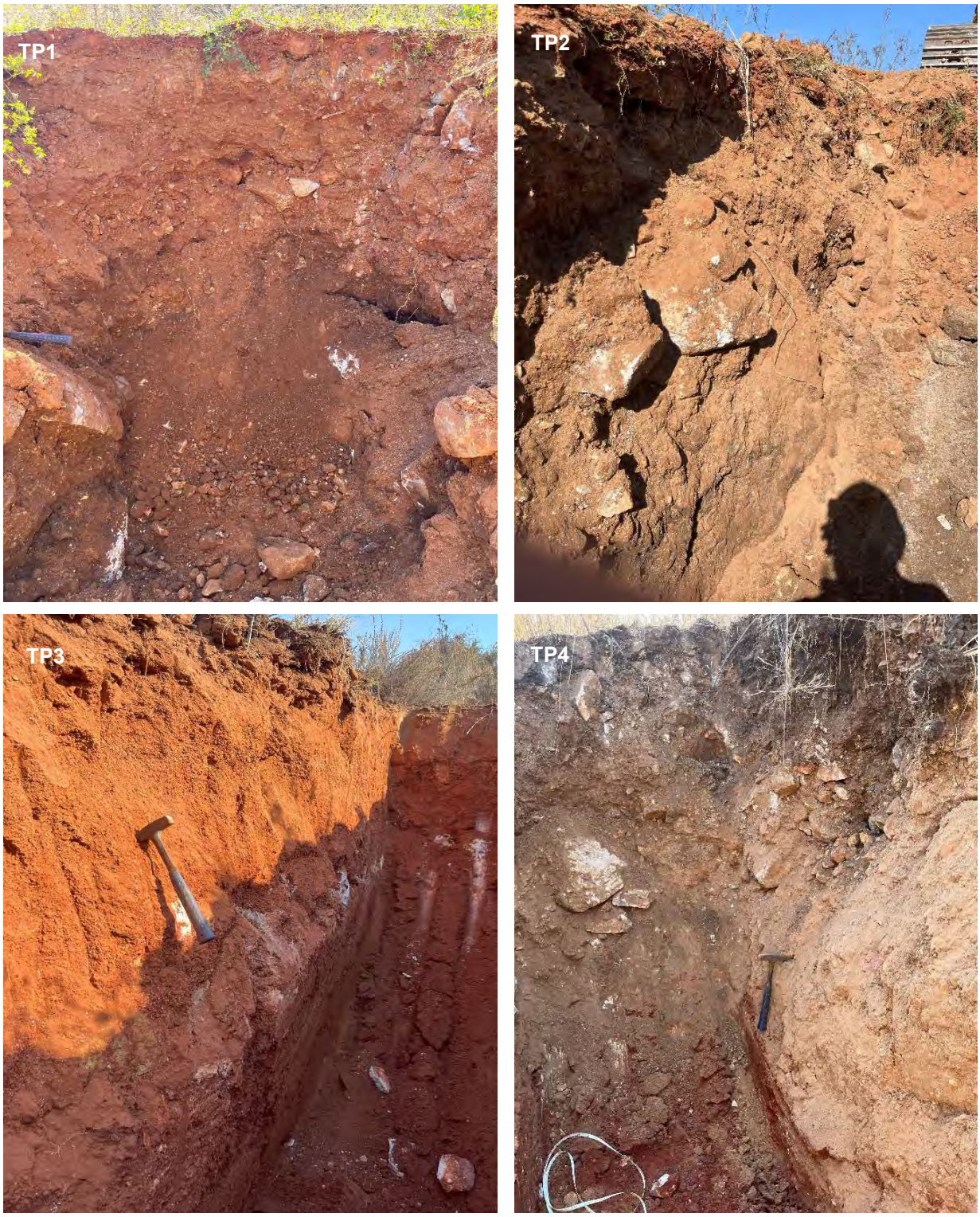
The majority of the site is overlain by fill comprising very loose to medium dense chert gravel, cobbles, boulders, building rubble and domestic waste in a matrix of silty to clayey sand. The fill is thickest in the vicinity of TP6 – TP9 (1.3m ≥3.4m). The fill was absent from test pits TP3 and TP4 while TP2 only intersected a 0.2m layer of fill.

The fill is underlain by a transported layer (hillwash and colluvium) of very loose to very dense silty to clayey sand with gravel to chert gravel, cobbles and boulders packed in a silty to clayey sand matrix. The transported materials had a slightly pinholed soil structure which is typical of collapsible soils. The transported layer had a thickness of about 1.3m to 2.3m in the test pits.

All test pits except TP7, which was terminated in fill, refused on chert residuum / chert breccia residuum at depths ranging between 1.6m and 2.3m. Chert residuum comprised medium dense to very dense chert cobbles and boulders in a matrix of silty to clayey sand with gravel and was mostly clast supported.

A pebble marker layer, consisting of dense clayey to sandy gravel, separated the overlying transported materials and underlying chert residuum in TP4 and TP5 and had a thickness of 0.3m – 1.0m.

Figure 3-5: Images of the test pits



TP5

TP7

TP8

TP9

Figure 3-6: Locations of test pits and boreholes

Excerpt taken from Google Earth™

Table 3-2: Summary of horizons encountered in the test pits.

Test Pit	Depth Interval (m)				Termination Depth (m)	Remarks
	Fill	Hillwash / Colluvium	Pebble Marker	Chert Residuum		
TP1	0.0 - 0.5	-	-	0.5 - 2.1	2.1	Refusal on chert boulders.
TP2	0.0 - 0.2	0.2 - 1.5	-	1.5	1.5	Refusal on chert boulders.
TP3	0.0 - 1.0	1.0 - 2.3	-	2.3	2.3	Refusal on chert boulders.
TP4	-	0.0 - 1.6	1.6 – 1.9	1.9	1.9	Refusal on chert boulders.
TP5	-	0.0 – 1.3	1.3 – 2.3	2.3	2.3	Refusal on chert boulders.
TP6	0.0 - 1.3	-	-	1.3 - 2.0	2.0	Refusal on chert boulders.
TP7	0.0 ≥ 3.4	-	-	-	3.4	No refusal in fill.
TP8	0.0 - 1.6	-	-	1.6	1.6	Refusal on chert boulders.
TP9	0.0 - 2.1	-	-	2.1	2.1	Refusal on chert boulders.

3.3 Percussion drilling

3.3.1 Methodology

Five percussion boreholes, labelled RG1 - RG5, were drilled across the footprint area of the proposed development by JK Development CC between 22 and 23 June 2023. All boreholes were drilled with an 18bar “Thor” rotary percussion rig, drilling 165mm diameter holes.

Chip samples were collected every meter and stored in plastic bags. During drilling, parameters such as sample return, air loss and water strikes were recorded by the drilling team.

Water rest levels were measured at least 24 hours after the completion of the boreholes where possible. Boreholes were backfilled with drill chippings to a depth of 2m below surface and with

concrete to surface followed by the installation of precast concrete plinths across the top of boreholes. Each borehole number was engraved on a metal plate affixed to the top of each concrete plinth.

The chip samples retrieved from the boreholes were logged by an engineering geologist according to the South African National Standard SANS 633:2012 “Soil profiling and rotary percussion borehole logging on dolomite land in Southern Africa for engineering purposes”.

3.3.2 Results

The results obtained from the current and historical drilling investigations are summarised in Table 3-3 below. The detailed borehole logs and the driller’s field logs are provided in Appendix C and D respectively.

Boreholes RG1, RG2 and RG3, that were drilled on the western portion of the site, intersected fill from surface to depths of between 0.8m and 8m, over hard rock chert breccia to depths of 17m to over 60m (thickness of 15m to more than 60m). Dolomite residuum, comprising weathered dolomite, wad (highly compressible clayey silt derived from decomposition of dolomite), chert and cavities underlie the chert breccia from depths of about 17m to 33m (thickness 5m – 16m).

Cavities were intersected in dolomite residuum in boreholes RG1, RG4 and RG5. RG1 intersected a cavity at 52m - 53m, RG4 at 28m - 29m and 30m - 33m and RG5 at 28m - 32m.

Three boreholes, RG3, RG4 and RG5, intersected hard rock dolomite from depths of 38m, 35m and 36m respectively. RG1 encountered weathered dolomite rock from 53m to its termination depth of 60m, while RG2 failed to intersect dolomite bedrock to its termination depth of 60m.

Based on the results of the boreholes it is postulated that the geological model for the site consists of a hard rock chert breccia cap overlying dolomite residuum comprising weathered chert, shale and clay and characterised by cavities and low-consistency materials which in turn overlies dolomite bedrock. The chert breccia cap comprises competent hard rock chert in the western portion of the site, but thins out towards the east where shallower dolomite residuum is present.

Table 3-3: Summary of horizons encountered in boreholes (current and historical investigations)

BH No	Coordinates (WGS84 LO29)*			Fill (mbgl)	Colluvium/ Hillwash (mbgl)	Residual Syenite (mbgl)	Syenite rock (mbgl)	Residual shale (mbgl)	Chert and Shale (mbgl)	Chert (mbgl)	Chert and Wad (mbgl)	Wad (mbgl)	Cavity (mbgl)	Weathered dolomite (mbgl)	Dolomite (mbgl)	Water level (mamsl)
	X	Y	Z													
Rockland 2023																
RG1	-31789	-2890669	1578	0 - 8						8 - 51			52 - 53	53 - 60		1542
RG2	-31878	-2890654	1579	0 - 2					33 - 36	2 - 33; 36 -60						
RG3	-31845	-2890764	1576	0 - 1					27 - 28	1 -27	28 - 32			32 - 38	38 - 44	
RG4	-31666	-2890773	1565		0 - 2					2 - 17	17 - 28; 29 - 30?		28 - 29; 30 - 33	33 - 35?	35 - 41?	
RG5	-31714	-2890598	1575		0 - 4				4 - 27		27 - 28?		28 - 32	32 - 36?	36 - 42?	
Golder 2016																
BH1	-31753	-2890856	1565.8		0 - 2			13 - 27		2 - 13		27 - 33			33 - 41	
BH2	-31798	-2890891	1567.8		0 - 2			23 - 40	40 - 57	3 - 12					57 - 60	1545.6
BH3	-31821	-2890927	1568		0 - 2			6 - 31 31 - 37 Carb		3 - 6						1541.6
BH4	-31942	-2890950	1570.3		0 - 1.5				21 - 29	1.5 - 21; 29 - 59						1546.4
Martin van der Walt Engineering Geologist 2019																
BC1	-32104	-2890753	1577			0 - 29	29 - 50									
BC2	-32027	-2890732	1578		0 - 1					1 -37						
BC3	-31973	-2890760	1576.5							1 - 33						
BC4	-31931	-2890751	1576		0 - 0.3					0.3 - 30						
BC5	-31904	-2890819	1573		0 - 1					1 - 27						
BC6	-31967	-2890795	1575		0 - 1	1 - 24										
BC7	-31970	-2890963	1573		0 - 1					1 - 25						

*Notes: *Coordinates taken with a hand-held GPS with a positional accuracy of about 4m. Collar elevations (z coordinates) are rough estimates obtained from Google Earth imagery; mbgl = meters below ground level; mamsl = meters above mean sea level*

3.4 Laboratory testing

The soil samples that were retrieved from the test pits were submitted to STL laboratory of Pretoria for the following tests:

- Foundation indicator (particle size analyses including hydrometer and Atterberg Limits);
- Moisture/density relationship at Modified AASHTO compaction effort;
- California Bearing Ratio (CBR);
- pH of soil paste;
- Electrical conductivity of soil paste.

The test results are summarised and discussed in the table and text below and the laboratory certificates are contained in Appendix E.

The following is evident from the table below:

- The hillwash and colluvium samples (TP2 0.2m - 0.7m and TP3 0.1m - 2.3m) contained 54% - 60% gravel, 22% - 24% sand, 22% - 16% silt and 6% - 7% clay and recorded liquid limits of 27% - 29% and plasticity indices of 8% - 9%, grading the samples as clayey sand with gravel (SC) according to the Unified Soil Classification System (USCS). The original USCS grading of GC that was assigned to sample TP3 (0.1m - 2.3m) of SM was revised to SC on the basis that more than 50% of the sample passed the 4.75mm sieve.
- The hillwash and colluvium samples had a low potential expansiveness based on Van der Merwe's (1965) method for heave prediction.
- The hillwash and colluvium samples obtained a pH of 4.9 – 5.2 and an electrical conductivity (EC) of 0.004 – 0.005 S/m or an electrical resistivity (1/EC) of 20 000 to 25 000 Ω.cm.
- COLTO (1998) sets an electrical conductivity limit of < 0.02 S/m and pH limit ≥ 6 to limit attack of cement stabilised layers while EN 12501-2:2003 grades soils with a pH of 4.5 – 5.5 and electrical resistivity of > 5000 Ω.cm as having a medium corrosiveness towards metals. In terms of these limits, the samples are expected to be slightly aggressive towards buried cementitious elements and of medium corrosiveness towards metals. Based on this evaluation buried concrete and metal elements will require appropriate protection against chemical attack.
- Hillwash/colluvium sample TP3 (0.1m - 2.3m) obtained a maximum dry density at the Modified AASHTO energy effort of 2036 kg/m^3 at an OMC of 10.7%.
- Hillwash/colluvium sample TP3 (0.1m - 2.3m) grade as a TRH14 G6 material.
- The fill samples contained 53% - 76% gravel, 17% - 32% sand, 5% - 10% silt and 2% - 4% clay and recorded a liquid limit of 22% for sample TP6 (0.2m - 0.5m) while the liquid limit of the other samples could not be determined due to their slightly plastic (SP) character. Sample TP6 (0.2m - 0.5m) obtained a plasticity index of 7%.
- The fill samples grade as silty sand with gravel (SM), silty clayey gravel with sand (GC-GM) and poorly graded gravel with silt and sand (GP-GM) according to the Unified Soil Classification System (USCS).
- The fill samples had a low potential expansiveness based on Van der Merwe's (1965) method for heave prediction.
- The fill sample obtained pH of between 4.7 and 5.7 and electrical conductivity (EC) of 0.011 - 0.028 S/m or an electrical resistivity (1/EC) of between 3571 - 9090 Ω.cm.
- COLTO (1998) sets an electrical conductivity limit of < 0.02 S/m and pH limit ≥ 6 to limit attack of cement stabilised layers while EN 12501-2:2003 grades soils with a pH of 4.5 – 5.5 and an electrical resistivity of < 4500 Ω.cm as highly corrosive towards metals and soils with a pH of 5.5 – 6.0 and an electrical resistivity of 5000 - 10000 Ω.cm as moderately ("medium") corrosiveness. In terms of these limits, the samples are expected to be moderately aggressive

Table 3-4: Summary of index, compaction, strength and chemical test results

Test Pit ID	Depth (m)	Field Description	Atterberg Limits			Grading (%)				GM	USCS	AASHTO	pH	EC (S/m)	PE	Mod AASHTO		CBR (%)						TRH14 G Class
			LL (%)	PI (%0	LS (%)	Gravel >2.00mm	Sand 2.00-0.06mm	Silt 0.06-0.002mm	Clay <0.002mm							MDD (kg/m^3)	OMC (%)	90%	93%	95%	98%	100%	Swell (%)	
TP2	0.2-0.7	Silty gravelly sand. HILLWASH.	29	8	3.5	54	24	16	6	1.91	SC	A-2-4	4.9	0.005	LOW	-	-	-	-	-	-	-	-	-
TP3	0.1-2.3	Gravelly sand with cobbles/ HILLWASH/ COLLUVIUM	27	9	4.5	60	22	11	7	2.09	SC*	A-2-4	5.2	0.004	LOW	2036	10.7	18	23	27	32	35	0	G6
TP6	0.2-0.5	Gravelly sand FILL	22	7	3.5	53	32	10	5	1.95	GC-GM	A-2-4	5.7	0.023	LOW	-	-	-	-	-	-	-	-	-
TP6	0.5-1.3	Sandy gravel with cobbles FILL	CBP	SP	0.5	50	34	12	4	1.93	SM	A-1-b	4.7	0.011	LOW	-	-	-	-	-	-	-	-	-
TP9	0-2.1	Gravelly sand with cobbles FILL	CBP	SP	0.5	76	17	5	2	2.48	GP-GM	A-1-a	5.7	0.028	LOW	2081	8.0	9	20	34	57	73	0	G6

*Notes: LL = Liquid Limit; CBP = Can not be performed; PI = Plasticity Index; LS = Linear Shrinkage; GM = Grading Modulus; USCS = Unified Soil Classification System; AASHTO = American Association of State Highway Transportation Officials; EC = Electrical conductivity ; PE = Potential Expansiveness based on Van der Merwe's (1964) method for heave prediction; MDD = Maximum Dry Density; OMC = Optimum Moisture Content; CBR = California Bearing Ratio; TRH = Technical Recommendations for Highways; *Reclassified*

towards cementitious materials and moderately to highly corrosive towards metals. Based on this evaluation, buried concrete and metal elements will require appropriate protection against chemical attack.

- Fill sample TP9 (0.0m - 2.1m) obtained a maximum dry density at the Modified AASHTO energy effort of 2081 kg/m^3 at an OMC of 8%.
- Fill sample TP9 (0.0m - 2.1m) grade as a TRH14 G6 material.

4 Evaluation

4.1 Excavatibility

The test pits were excavated with a 20 tonne Komatsu PC200 excavator. Materials which were excavated efficiently and with ease are considered soft excavation (SANS 1200 D), those in which slow excavation was experienced as intermediate excavation (SANS 1200 D) and those on which excavation plant refused or which experienced very slow, inefficient excavation, as hard rock excavation (SANS 1200 D).

The following SANS 1200 D excavation classes are estimated based on the rate of excavation and penetration attained:

- Hillwash/colluvium = Soft excavation
- Fill = Soft /intermediate/boulder excavation Class A
- Chert residuum with boulders = Hard rock excavation/boulder excavation Class A

Based on the percussion boreholes (RG1) the maximum thickness of the fill is about 8m. Although excavation through fill can generally be classified as soft excavation, the presence of large boulders assign it a boulder excavation Class A.

4.2 Stability of excavations and embankments

The predominantly loose soil profile provides for unstable conditions, which is expected to be especially poor under saturated conditions such as during and following prolonged periods of intense rains. Temporary slopes cut into in situ soils should be battered to 1V:2.5H or shallower.

Embankments constructed from sandy and gravelly fill and transported soils should be battered to 1V:1.5H or shallower.

Where steeper slopes are desired/required the installation of appropriate lateral support is advised.

The designs of permanent slopes/excavations should take account of the dimensions of structures, purpose, their design life and geotechnical material properties of foundations and construction materials.

The stability of excavations in rock, will depend on rock mass strength, the spatial orientation of discontinuities relative to the orientation of excavations and the condition of discontinuities and joint infilling, and is best evaluated on a case by case basis by an experienced geotechnical engineer or engineering geologist.

4.3 Trafficability

The very loose to loose consistency and large percentage over size particles contained within the fill may, however, hinder trafficability and require removal and stockpiling or compaction to improve trafficability during construction.

4.4 Heave/shrinkage

In situ soils have a low potential expansiveness based on Van der Merwe's method (1964) for heave prediction and ground movements due to heave and/or shrinkage are expected to be negligible.

The clayey silt (wad) that was intersected at depth in the percussion boreholes could, however, be moderately to highly expansive, based on past experienced gained by this consultant on other sites underlain by dolomite.

4.5 Aggressiveness/corrosiveness of soils

Based on the results of pH and soil conductivity tests, the fill and transported soils are expected to be moderately aggressive towards cementitious materials and moderately to highly corrosive towards buried metals, and buried concrete and metal elements will require appropriate protection against chemical attack.

4.6 Construction materials

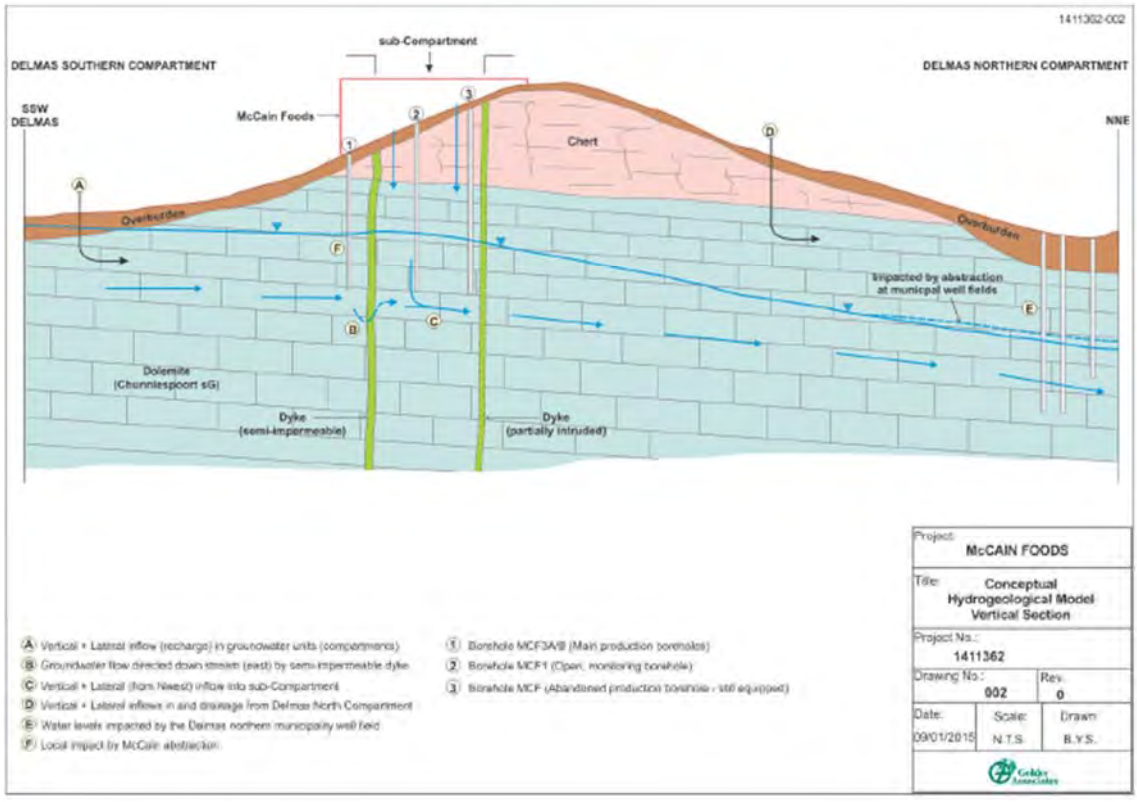
The in situ soils and the fill at the site consist of clayey sand with gravel (SC USCS materials), gravel with silt and sand (GC-GM and GP-GM USCS materials) and cobbles and boulders. Strength tests conducted on samples of hillwash/colluvium and fill, retrieved at shallow depth (>3m), grade these materials as COLTO (1998) G6 material, which are suitable for use in the lower selected layers of pavements and in engineered fills of moderate stiffness.

4.7 Hydrology

The regional hydrology of the area has been described in the 2015 Golder report (Van Wyk and Van der Linde, 2015). The greater Delmas area falls under the DWAF's Delmas Sub-area of the Eastern Dolomite Area (Golder Report: Van Wyk and Van der Linde, 2015) which is further divided into three sub-units by two parallel dykes, namely the Delmas Southern Compartment, Delmas Northern Compartment, and the McCain Food Sub-Compartment (located between the dykes). Displacements along the strikes of the dykes, however, only act as localised groundwater boundaries and the site remains part of the larger Delmas Subarea (Van Wyk and Van der Linde, 2015).

According to Van Wyk and Van der Linde (2015) the regional groundwater flow is towards the north-east and average groundwater elevations at the McCain Delmas site varies between 1540 - 1550 meters above mean sea level (mamsl). See figure 4.1 below for a conceptual hydrological model after Van Wyk and Van der Linde (Golder report, 2015)

Figure 4-1: Conceptual hydrogeological SSW-NNE profile (model) across the McCain Foods Site Area by Golder and Associates (Van Wyk and Van der Linde, 2015)



During the current investigation water strikes were recorded in two boreholes (RG1 and RG2), but water rest levels, measured a minimum of 24 hours after the completion of drilling, were recorded in only one borehole (RG1) at a depth of 36m below ground level (mbgl) or an elevation of 1542 mamsl. Water elevations of about 1541 - 1546 mamsl were recorded during the 2016 Golder dolomite stability investigation (Nkosi and Marais, 2016). Refer to Table 3-3.

The 2016 Golder investigation (Nkosi and Marais, 2016) noted no prominent dewatering at the McCain Delmas site, although dewatering was noted about 3.2km north-west of the site on the farm Leeupoort 205 IR and also at the Delmas northern municipal well field.

No shallow groundwater seepage was intersected in any of the test pits that were excavated during the investigation, but the investigation was undertaken during the dry season, and it is possible that shallow perched water tables may develop on the interface of the transported soils and underlying chert residuum during and after period of intense and sustained rains.

4.8 Dolomite stability analysis

The South African standard for geotechnical investigations on dolomitic land (SANS 1936) requires that the inherent risk of the hazard (being sinkhole and/or doline) developing and potential hazard size be determined for each borehole. This is achieved through assessing each borehole according to the following criteria:

- Nature of blanketing layer;
- Receptacle development;
- Mobilisation and mobilization agencies;
- Maximum potential development space.

These results allow a certain inherent risk characterisation and potential hazard size to be assigned to each borehole. The results of this characterisation are presented in Table 4-1 below. The characterisation was carried out in terms of both dewatering and non-dewatering (ingress) scenarios.

4.8.1 Nature of blanketing layer

The blanketing layer comprises the material overlying the dolomite bedrock. The site is covered by a thick blanketing layer comprising chert breccia with a thickness of about 28m to more than 60m. Shale partings within the chert residuum horizon were encountered in three of the five boreholes that were drilled during the current investigation. Weathered dolomite, wad and cavities were intersected above dolomite bedrock.

Boreholes RG1, RG2 and RG3 intersected fill to a depth of 8m depth, overlying hard rock chert breccia with a thickness of between 28m to more than 60m. Dolomite residuum, comprising weathered dolomite, wad and chert underlie the chert breccia.

High penetration rates, accompanied with soft, compressible material were encountered in RG4 and RG5 below 27m depth. Cavities between 1m and 4m deep were recorded. In borehole RG1 a 1m deep cavity were recorded at 52m and sample loss and air loss were recorded in RG2 between 52m and 59m.

The geological model for the area would thus be interpreted as a chert breccia cap, comprising competent hard rock chert on the western portion of the site, thinning out towards the east where shallower bedrock is present, but comprise dolomite residuum characterised by cavities and low-density material just above the dolomite bedrock.

4.8.2 Receptacle development

Cavities of between 1m and 4m deep were encountered in three boreholes (RG1, RG4 and RG5) it is therefore assumed that receptacles are present within and above the bedrock to be able to receive mobilised materials from overlying horizons.

4.8.3 Mobilisation and mobilisation agencies

In the dolomite context, mobilization is the movement of the blanketing layer by subsurface erosion, slumping, or ravelling by an external agency. Mobilizing agencies include water ingress, either from surface or from leaking underground services, or the lowering of the water table. The chert breccia encountered in the boreholes, with a minimum thickness of 28m, exhibited a low to medium mobilisation potential. The dolomite residuum encountered above dolomite bedrock, especially the wad (clayey silt derived from the decomposition of dolomite) and chert encountered in RG4 and RG5, is considered to have a medium to high mobilisation potential.

For this area the regional water level is at approximately 1545mamsl, within the dolomite residuum and a lowering of the water table is thus expected to have an adverse effect on the mobilisation of the material.

4.8.4 Maximum potential development space (MPDS)

Maximum potential development space (MPDS) is a simplified estimation of the maximum size sinkhole that can be expected to develop in a particular profile, provided that the available space is fully exploited by a mobilizing agency. The available space depends on the depth below ground surface to the throat of a receptacle or disseminated receptacle, and the angle of draw in the various blanketing materials. The thickness of the MPDS is limited by the first layer if bedrock occurs at depths of between 35 to 60m. A sinkhole developing in 35m to 60m of overburden could theoretically have a 35m to 60m diameter if an angle of draw of 45° is assumed. The presence of hard rock chert

breccia and shale would reduce the theoretical angle of draw. The maximum diameter of a sinkhole forming would thus classify as large (i.e. 5>15m diameter).

The risk characterisations show there is a medium risk for the development of small sized (<2m diameter) sinkholes, medium sized (2m<diameter<5m) sinkholes and large sinkholes (5m< diameter <15) and a low risk for doline development for the non-dewatering scenarios.

With the groundwater table within the dolomite residuum, any drawdown of the permanent water table will adversely affect the risk for sinkhole development. The low-density material encountered in RG4 and RG5 indicate a medium to high risk for up to large sinkholes (5m<diameter<15m) and a medium risk for doline development for the dewatering scenarios.

It should be noted that this assessment is based on limited point data and that given the inherent variability of dolomite bedrock the possibility of very large sinkholes developing cannot be excluded.

4.8.5 Risk class

A summary of the risk characterisation for each borehole at the site is given in the table below. An inherent risk classification of Class 4//Class 4 has been assigned to Zone A on the western portion of the site and Class 4a//Class 7 to Zone B on the eastern portion of the site, taking cognizance of the proposed industrial development.

Table 4-1: Summary of horizons encountered in boreholes

BH No	Risk of sinkhole formation				Risk of doline formation	Inherent Risk Class
	Small	Medium	Large	Very large		
	<2m	>2m<5m	>5m<15m	>15m		
RG1	M//M	M//M	M//M	L	L//M	4//4
RG2	M//M	M//M	M//M	L	L//M	4//4
RG3	M//M	M//M	M//M	L	L//M	4//4
RG4	M//H	M//H	M//H	L	L//M	4//7
RG5	M//H	M//H	M//H	L	L//M	4//7

H = High; M = Medium; L = Low; ingress water//dewatering

A dolomite designation D3 is assigned to the site, and it is imperative that stringent precautionary measures be put in place especially in terms of stormwater management and the protection of wet services.

In order to mitigate the potential damage to structures due to sinkhole formation all foundations should be designed to span a sinkhole with a minimum diameter of 5m.

4.9 Geological model

The geological model of the site to a depth of about 60m is given by the plan and sections contained in Appendix A and the stratigraphic sequence arranged from shallowest to deepest is summarised below:

- Fill depth = 0.0m - 8.0m (thickness 0.0m – 8.0m)
- Transported (Hillwash and colluvium) depth = 0.0m - 2.3m (thickness 0.0m – 2.3m)
- Chert residuum depth = 0.5m - 2.3m (thickness 0.0m - 0.7m
- Chert breccia depth = 0.5m ≥ 60m (thickness 27m ≥ 60m)
- Dolomite residuum (wad, cavities, chert) depth = 17m - 33m (thickness 5m – 16m)
- Weathered dolomite depth = 32m ≥ 60m (thickness 2m > 7m)

- Dolomite bedrock depth = 35m > 60m (thickness >3m)

4.10 Material properties

The fill and transported horizons grade as TRH14 G6 materials. The chert residuum essentially comprises cobbles and boulders in a sandy and gravelly matrix and may conservatively be considered as a rockfill with similar shear strength properties to G6.

The following shear strength parameters are proposed for TRH14 G6 materials based on the relationships proposed by Theyse et al (1996) between shear strength and G1 to G6 TRH14 materials:

TRH14 G6 compacted to 95% of Modified AASHTO maximum dry density (MDD):

φ' = 35°

c' = 25kPa but assume 0kP

γ = 20kN/m^3

E = 60MPa (estimate, assumes compaction to 95% Modified AASHTO MDD)

Chert residuum:

φ' = 35°

c' = 0kP

γ = 20kN/m^3 (estimate)

E = 80MPa (estimate)

4.10.1 Bearing capacity and settlement

Utilising the formulations as contained in Brinch Hansen (1970), and the shear strength and unit weight parameters quoted in the preceding section, drained bearing capacities were calculated for TRH14 G6 compacted to 95% Modified AASHTO and a range of footing geometries, breadths and embedment depths.

The following assumptions and simplifications were applied to the calculations:

- Foundation materials are isotropic, homogenous and exhibit linear elastic behaviour.
- Only a single layer system was considered.
- Strengths increase with depth, and the founding layer is not underlain by weaker layers within the depth of foundation influence.
- Loads are applied vertically and centrally to loaded areas. No account was taken of inclined loads and/or moments.
- Allowable bearing stresses were calculated by dividing ultimate values by a factor of safety of 1.5.
- The permissible stress method, as opposed to ultimate limit state methods, was utilised as it is felt this approach provides for more tangible results.

The results are contained in Appendix F.

Utilising the E values given in the preceding section and following a simple elastic approach, but excluding the effects of Poisson's ratio and stress reduction with depth, the following immediate (elastic) settlement is predicted beneath an 8m high G6 fill compacted to 95% Mod and subjected to an imposed contact stress of 150kPa (digester tank):

- Settlement = 150kPa/60MPa x 8m = **20mm**

Given the mostly non-cohesive nature of soils, the expectation is that the majority of foundation settlement, within the depth of the test pit investigation, of about 3 m, will be due to immediate (elastic) settlement with only minor consolidation and creep, and that the time rate of consolidation will be relatively rapid.

The above approximate analysis assumes elastic (E) stiffness increases with depth and does not take account of potentially compressible materials (wad) and cavities, such as those intersected at a depth of 17m - 41m in borehole RG4.

Large structures such as the digester tank, which has a diameter of about 30m, will stress founding materials to a depth of about 30m, including low stiffness zones such as that intersected in RG4, potentially inducing excessive settlement. In order to derive the stiffness, consolidation and swell properties of materials within the depth of foundation influence of large structures, it is proposed that a supplementary investigation, comprising rotary core drilling combined with SPTs and tube (e.g. Shelby) sampling, be undertaken, during the detailed design phase of the project.

5 Conclusions and Recommendations

This report presents the findings of phase 1 geotechnical and dolomite stability investigations undertaken at the proposed site of a new Waste Water Treatment Plant (WWTP) at McCain Food SA (Pty) Ltd's Delmas plant, Mpumalanga Province, South Africa.

The various investigations included a desk top study, nine test pits excavated to a maximum depth of about 3m, five percussion boreholes drilled to depths of 41m to 60m and laboratory testing of disturbed soil samples.

Test pits investigated shallow (<3m) founding conditions, while percussion boreholes were drilled in an attempt to confirm the presence of and depth to dolomite rock at the site, in order to obtain a qualitative indication of the degree of karst development in dolomite rock beneath the site and the potential for the mobilisation of overlying transported and residual materials into solution cavities.

The following conclusions are drawn and recommendations made:

5.1 Ground profile

(1) The majority of the site is covered by very loose to medium dense fill, comprising sand and gravel with varying amounts of chert cobbles and boulders. Building rubble and domestic waste are also present.

(2) The fill is thickest across the south-western part of the site where it attains a thickness of about 1m to 8m.

(3) The fill is underlain by a transported layer (hillwash and colluvium) consisting of very loose to very dense silty to clayey sand with gravel (hillwash) transitioning with depth to cobbles and boulders packed in a silty to clayey sand matrix (colluvium).

(4) Transported materials exhibit a slightly pinholed soil structure which is typical of collapsible soils.

(5) The transported layer has a thickness of about 1.3m to 2.3m.

(6) Weathered chert residuum comprising medium dense to very dense chert cobbles and boulders in a matrix of silty to clayey sand with gravel underlie the transported layer to a depth of 0.5m to about 2m.

(7) Hard rock chert breccia underlie the chert residuum to depths of about 20m to over 60m

(8) Dolomite residuum consisting of chert, wad (compressible clayey silt derived from the decomposition of dolomite) and cavities underlie the chert breccia to a depth of about 33m.

(9) Cavities were intersected in dolomite residuum in boreholes RG1, RG4 and RG5.
(10) RG1 intersected a cavity at 52m - 53m, RG4 at 28m - 29m and 30m - 33m and RG5 at 28m - 32m.
(11) Weathered dolomite underlie dolomite residuum and was intersected in boreholes to depths of 35m to 60m.
(12) Dolomite bedrock underlies weathered dolomite.

5.2 Seismicity

The peak ground acceleration (PGA) at the site is about 0.13g with a 10% probability of being exceeded in a 50-year period.

5.3 Excavatibility

The following SANS 1200 D excavation classes are estimated based on the rate of excavation and penetration attained:

- Hillwash/colluvium = Soft excavation
- Fill = Soft /intermediate/boulder excavation Class A
- Chert residuum with boulders = Hard rock excavation/boulder excavation Class A

Based on the percussion boreholes (RG1) the maximum thickness of the fill is about 8m. Although excavation through fill can generally be classified as soft excavation, the presence of large boulders assign it a boulder excavation Class A.

5.4 Drilling and blasting

It is recommended that the services of a blasting specialist be retained during the preparation of construction specifications, pricing schedules and contract documentation to ensure prospective contractors price drilling and blasting methods appropriate to site conditions.

5.5 The stability of cuts and embankments

(1) The predominantly loose soil profile provides for unstable conditions. Temporary slopes cut into in situ soils should be battered to 1V:2.5H or shallower.
(2) Embankments constructed from sandy and gravelly fill and transported soils should be battered to 1V:1.5H or shallower.
(3) Where steeper slopes are desired/required the installation of appropriate lateral support is advised.
(4) The designs of permanent slopes/excavations should take account of the dimensions of structures, purpose, their design life and the geotechnical material properties of foundations and construction materials.
(5) The stability of excavations in rock, will depend on rock mass strength, the spatial orientation of discontinuities relative to the orientation of excavations and the condition of discontinuities and joint infilling, and is best evaluated on a case by case basis by an experienced geotechnical engineer or engineering geologist.

5.6 Trafficability

The very loose to loose consistency and large percentage over size particles contained within the fill may impede trafficability across the site during construction and may require removal and stockpiling or compaction to improve trafficability during construction.

5.7 Heave/shrinkage

(1) Fill and transported soils have a low potential expansiveness based on Van der Merwe's method (1964) for heave prediction and ground movements due to heave and/or shrinkage are expected to be negligible for these materials.

(2) The clayey silt (wad) that was intersected at depth in the percussion boreholes could, however, be moderately to highly expansive based on past experienced gained by this consultant on other sites underlain by dolomite.

(3) It is recommended that the wad be sampled and tested for expansiveness during the detailed design phase of the project where it is present within the depth of foundation influence of structures.

5.8 Aggressiveness/corrosiveness

(1) Based on the results of pH and soil conductivity tests, the fill and transported soils are expected to be moderately aggressive towards cementitious elements and moderately to highly corrosive towards buried metals, and buried concrete and metal elements will require appropriate protection against chemical attack.

(2) Potential protection measures against chemical attach include but are not limited to increasing concrete cover to reinforcement, coating buried concrete surfaces, cathodic protection of steel pipes and addressing stormwater run-off.

5.9 Inundation

(1) In order to limit inundation at the site, a proper topographical survey of the site, utilising differential GPS and/or total station and appropriate UAV photogrammetric methods, should be conducted to enable the design of appropriate storm and ground water control measures.

(2) Permanent stormwater control measures typically include one or a combination of the following:
   a. Constructing a raised terrace;
   b. Diversion berms and channels,
   c. Installing buried storm water reticulation (pipes) and sub-soil drainage.

(3) Temporary stormwater control measures that may be undertaken during construction include:
   a. Compacting and sealing of all exposed fills and embankments;
   b. Grading temporary fills to allow free drainage away from the site;
   c. Constructing diversion berms and earth channels;
   d. Limiting both the cross sectional and longitudinal slopes of berms and drainage channels;
   e. Providing adequate provision to dewater inundated excavations as speedily and practicable as possible to limit seepage into surrounding soils, which will increase the risk of slope instability and foundation movements.
   f. Limiting the length of trenches to lengths which can efficiently accommodate excavation, pipe installation and backfill in a single day.

5.10 Construction materials

The transported (hillwash/colluvium) and fill materials, grade as a COLTO (1998) G6 material, which is suitable for use in the lower selected layers of pavements and in engineered fills of moderate stiffness.

5.11 Hydrology

(1) Water strikes were recorded in two boreholes (RG1 and RG2), but water rest levels, measured a minimum of 24 hours after the completion of drilling, were recorded in only one borehole (RG1) at a depth of 36m below ground level (mbgl) or an elevation of 1542 mamsl.

(2) Groundwater elevations of about 1541 - 1546 mamsl were recorded during the 2016 Golder dolomite stability investigation (Nkosi and Marais, 2016).

(3) No prominent dewatering has taken place at the McCain Delmas site, but the 2016 Golder investigation noted dewatering had taken place about 3.2km north-west of the site on the farm Leeupoort 205 IR and also at the Delmas northern municipal well field.

(4) No shallow groundwater seepage was intersected in any of the test pits that were excavated during the investigation, but the investigation was undertaken during the dry season, and it is possible that shallow perched water tables may develop on the interface of the transported soils and underlying chert residuum during and after period of intense and sustained rains.

5.12 Dolomite stability

(1) A dolomite stability assessment of the boreholes characterised the site as having a medium risk for the development of small sized (<2m diameter) sinkholes, medium sized (2m<diameter<5m) sinkholes and large sinkholes (5m< diameter <15) and a low risk for doline development for the **non-dewatering scenario**.

(2) The low-density material (dolomite residuum containing wad and cavities) encountered in boreholes RG4 and RG5 indicate a medium to high risk for the development of large sinkholes (5m<diameter<15m) and a medium risk for doline development for the **dewatering scenario**.

(3) An Inherent Risk Class 4//4 are assigned to Zone A and Risk Class 4//7 are assigned to Zone B and a dolomite designation of D3 are assigned to the overall site.

(4) In order to limit the risk of mobilisation of blanketing materials, stringent precautionary measures and limits should be put in place in terms of stormwater management, the protection of wet services and the dewatering of groundwater.

(5) In order to mitigate the potential damage to structures due to sinkhole formation all foundations should be designed to span a sinkhole with a minimum diameter of 5m.

(6) It should be noted that this assessment is based on limited point data and that given the inherent variability of dolomite bedrock the possibility of very large sinkholes developing cannot be excluded.

5.13 Founding recommendations

(1) Given the high percentage sand, gravel and cobbles contained in the soil profile, allowable bearing pressures are expected to be governed by settlement considerations as opposed to the shear strength (ultimate bearing capacity) of soils.

(2) The low consistency, poor grading and large percentage cobbles and boulders contained in the fill and transported horizons make these horizons vulnerable to large settlements due to settlement under self-weight and foundation loads.

(3) Moreover the fine grained sandy matrix of transported soils exhibited pinhole voids suggesting a risk of collapse settlement following an increase in soil moisture content and net loading.

(4) In order to limit foundation settlements to acceptable values, one or a combination of the following foundation solutions are proposed:

a. In situ densification of fill and transported soils via appropriate means such as dynamic compaction, impact compaction and rapid impact compaction with latter two options limited to a depth of improvement of about 1m. The presence of large boulders within the soil profile may impede compaction.

b. Remove fill and transported horizons to chert residuum and replace with TRH14 G6 fill placed in layers after compaction of 150mm.
   i. Compact each layer to 95% Modified AASHTO MDD -0% +2% of OMC.
   ii. Confirm the density of each compacted layer by conducting representative nuclear density tests on each layer using representative MDD values throughout.
   iii. Calibrate a selected number of nuclear moisture contents against moisture contents obtained from laboratory testing and applying the appropriate moisture correction throughout.
   iv. Fill and transported soils typically grade as TRH14 G6 materials and may be reused in layerworks following removal of oversize particles.
   v. If fill and transported soils are too coarse to enable conventional compaction control via nuclear density and/or sand replacement tests, construct fill in accordance with a method specification with the appropriate number of passes obtained from a trial section.
   vi. Found on conventional spread footings placed on/in completed engineered fill.
c. Support foundations on percussion (bored) piles installed to competent horizons such as the underlying chert residuum.
d. Design all foundations to span a sinkhole with a minimum diameter of 5m.

(5) Allowable bearing stresses for a range of footing breadths and embedment depths for founding on compacted TRH14 G6 are presented in Appendix F.

(6) Total settlement of about 20mm is predicted for a 8m high G6 fill compacted to 95% Modified AASHTO and subjected to a contact stress of 150kPa.

(7) Differential settlement may be taken as 75% of total settlements i.e. 15mm.

(8) Given the mostly non-cohesive nature of soils, the expectation is that the majority of foundation settlement, within the depth of test pit investigation of about 3m, will be due to immediate (elastic) settlement with only minor time related consolidation and creep, and that the time rate of consolidation will be relatively rapid.

(9) The above settlement estimate assumes elastic (E) stiffness increases with depth and does not take account of potentially compressible materials such as wad and cavities that may underlie structures beneath the depth of the test pit investigation of about 3m.

(10) Large structures such as the digester tank, which has a planned diameter of about 30m, will stress founding materials to a depth of about 30m, including low stiffness zones that may underlie its footprint potentially inducing excessive settlement.

5.14 Supplementary geotechnical investigation

The foundation assessment provided herein, only applies to the depth of the test pitting investigation of about 3m.

It is recommended that a supplementary geotechnical investigation, comprising rotary core drilling combined with Standard penetration Tests (SPTs) and tube (e.g. Shelby) sampling, be undertaken at the finalised locations of large structures, during the detailed design phase of the project. This will aid in deriving stiffness, consolidation and swell properties of materials within the depth of foundation influence of structures.

The depth to which a supplementary investigation would need to be conducted depends on the locations and dimensions (width) of planned foundations. The site investigation code of practice (2010) of the South African Institution of Civil Engineering's Geotechnical Division recommends geotechnical investigations be advanced to depths double the width of footings or to rock with a consistency of at least soft rock whichever occurs first. Other international codes (e.g. EC7), require investigation to a depth at which the net effective stress due to foundation loading reduces to 20%

of the effective overburden stress.

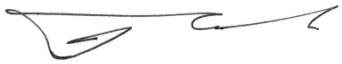
5.15 Construction monitoring

It is proposed that an experienced engineering geologist or geotechnical engineer inspect the site periodically during the construction phase of the project in order to identify any unforeseen adverse conditions and devise appropriate preventative and/or remedial actions.

5.16 Dolomite risk management

Irrespective of the design implementation, a site-specific Dolomite risk management plan should be implemented for the site as described by SANS 1936 parts 3 and 4 (2012). The main aim of this will be to eliminate any concentrated water ingress at the site that my trigger sinkhole and/or doline formation. This includes the management of stormwater runoff and installation and maintenance of all wet services.

Yours faithfully,



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Rockland Geoscience (Pty) Ltd

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