

Investigating the dewatering energy savings potential of an open pit mine

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Dissertation accepted in fulfilment of the requirements for the degree *Master of Engineering in Mechanical Engineering* at the North-West University

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Graduation: May 2020

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ACKNOWLEDGEMENTS

First and foremost I want to thank God for the blessings and opportunities He provided me with. I would also like to thank the following people:

- Prof Martin van Eldik for all his guidance and support.
- Jaco Perold for all his time and effort whenever necessary.
- Friends and family for their moral support.
- BBE Energy for the opportunity and technical support.
- All the mine personnel who assisted me.

ABSTRACT

Title: Investigating the dewatering energy savings potential of an open pit mine

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Key words: Open pit mine dewatering, pumping methodology, load shift, energy savings

The South African mining industry is heavily reliant on its electricity supply from Eskom. Due to the increasing cost of electricity, it is crucial to reduce the consumption thereof and thereby increasing the profitability of an operation. While underground mining is heavily reliant on electricity, open pit mining is, in addition to electricity, more exposed to logistical and fuel cost. Both types of operations have significant energy cost savings potential with regards to the dewatering of the mine.

The aim of this study is to develop an open pit pumping methodology, taking Eskom time-of-use periods into consideration, to decrease the electricity expenses of a case scenario mine. This will be accomplished through an in-depth investigation into load shift possibilities using the dewatering infrastructure available. With the use of validated mathematical models, different scenarios are evaluated to improve the savings.

For the case study mine the pumping methodology results indicated substantial energy savings obtainable. The operations investigated can shift 1,496,805 kWh out of the peak time of use period which translates to R2,107,609 of energy cost savings per annum. Based on this case study there are definite potential for savings at other open pit mining operations across South Africa.

SAMEVATTING

Titel: Investigating the dewatering energy savings potential of an open pit mine

Skrywer: EPJ du Plessis

Opsigter: Prof Martin van Eldik

Sleutelwoorde: Oop groef myn ontwatering, pomp metodologie, las verskuiwing, energie besparing

Die Suid-Afrikaanse myn industrie is baie afhanklik op die elektrisiteit toevoer vanaf Eskom. As gevolg van die toenemende elektrisiteitsprys is dit noodsaaklik om die verbruik daarvan te verminder en daarby die winsgewendheid van die operasie te vermeerder. Waar ondergrondse myne baie afhanklik is van elektrisiteit, is oop groef myne, buiten elektrisiteit, meer blootgestel aan logistiese en brandstof onkoste. Beide operasies het beduidende energie besparingspotensiaal met betrekking tot myn onwatering.

Die doel van hierdie studie is om 'n oop groef myn pomp metodologie te ontwikkel, wat Eskom se tyd-van-verbruik periodes in aanmerking neem, om die elektrisiteit uitgawes van 'n gevallestudie myn te verminder. Dit sal bereik word met 'n in diepte ondersoek in las verskuiwingsmoontlikhede deur die beskikbare ontwatering infrastruktuur te gebruik. Met die gebruik van gevalideerde wiskundige modelle gaan verskillende scenarios ondersoek word om die besparings te verbeter.

Vir die gevallestudie myn het die pomp metodologie beduidende energie besparing resultate aangedui. Die ondersoekte operasie kan 1,496,805 kWh skuif vanuit piek tyd van verbruik wat sal lei tot 'n energie koste besparing van R2,107,609 per jaar. Gebaseer op die gevallestudie is daar definitiewe potensiaal vir besparing by ander oop groef myne in Suid-Afrika.

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ABBREVIATIONS

EIUG:	Energy Intensive Users Group
GDP:	Gross Domestic Product
EEDSM:	Energy efficiency demand side management
DSM:	Demand side management
RWD:	Return water dam
RWD Ext:	Return water dam extension
Flownex SE:	Flownex Simulation Environment
TOU:	Time of use
PGM:	Platinum group metals
SCADA:	Supervisory control and data acquisition
OEM:	Original equipment manufacturer

NOMENCLATURE

A:	Friction factor equation specific variable [-]
Amount of intervals:	Amount of intervals during applicable period [-]
Area:	Area of the pipe [m ²]
Avg power (TOU period):	Average power recorded during TOU period [kW]
B:	Friction factor equation specific variable [-]
Buffer:	Amount of water that can be stored [MI]
C:	Currency conversion coefficient [-]
CAP:	Total dam capacity [MI]
C _{off-peak} :	Cost of energy during off-peak TOU periods [R/kWh]
cos θ :	Power factor [-]
C _{peak} :	Cost of energy during peak TOU periods [R/kWh]
C _{standard} :	Cost of energy during standard TOU periods [R/kWh]
Current level:	Current dam level [%]
D:	Inside diameter of the pipe [m]
Dam max volume:	Maximum dam capacity [MI]
DL ₀ :	Dam level before peak cost period [%]
DL ₁ :	Dam level after peak cost period [%]
E _{off-peak} :	Energy consumption during off-peak TOU periods [kW]
E _{peak} :	Energy consumption during peak TOU periods [kW]
E _{ps} :	Daily energy used to pump water [J]
E _{standard} :	Energy consumption during standard TOU periods [kW]
EW:	Excess water [MI]
F:	Pump shaft power [kW]
f:	Friction factor [-]
g:	Gravitational acceleration [m/s ²]
H:	Pressure head [Pa]
H _{dyn} :	Pressure difference between the well and ground level [Pa]

H_{LC} :	Head loss due to components [m]
H_{LP} :	Head loss due to friction [m]
H_{sta} :	Pressure in the main pipeline [Pa]
I :	Current [A]
I :	Number of pumps [-]
IPH :	Water inflow rate per hour [l/s]
k :	Hydraulic losses for each specific component [-]
L :	Length of the pipeline [m]
L_1 :	Dam level at which the first pump will start [%]
L_{cr} :	Specified dam control range [%]
L_i :	Dam level at which pump i will start [%]
L_{max} :	Maximum dam level [%]
L_{min} :	Minimum dam level [%]
$L_{start,next}$:	Difference in dam level that will activate subsequent pumps [%]
$L_{stop,next}$:	Difference in dam level that will stop subsequent dam level [%]
L_x :	Dam level at the start of the first interval [%]
L_{x+1} :	Dam level at subsequent intervals [%]
M :	Total mass of daily pumped water [kg]
Max :	Maximum dam level [%]
Min :	Minimum dam level [%]
NP :	Number of pumps [-]
P :	Power consumption [kW]
p :	Pressure [Pa]
PF :	Power factor [-]
p_i :	Pump power conversion coefficient [-]
PO :	Percentage overshoot [%]
Power TOU:	Recorded power at each time interval [kW]
Previous level:	Previous dam level [%]
Q :	Mass flow rate [l/s]

Re:	Reynolds number [-]
RF:	Rated flow of pumps [l/s]
R _t :	Cost per unit of electricity [R/kWh]
T:	Number of time intervals [-]
Δt_n :	Time between intervals [min]
v:	Velocity of the fluid [m/s]
V:	Voltage [V]
w ₁ :	Next step pump operating status [-]
WIR _i :	Water inflow rate for hour i [l/s]
W _{lb} :	Lower boundary condition for sump water capacity [MI]
W _{max} :	Maximum water capacity of sump [MI]
W _{min} :	Minimum water capacity of sump [MI]
W _{tot} :	Total water capacity of sump [MI]
W _{ub} :	Upper boundary condition for sump water capacity [MI]
X:	Total duration pump is active during specific interval [min]
Z:	Energy cost [R]
Z _{cost after} :	Projected cost of proposed pumping methodology [R]
Z _{cost before} :	Projected cost of existing pumping methodology [R]
Z _{cost saving} :	Projected cost saving after implementation of proposed pumping methodology [R]
Z _{cost} :	Projected cost of method used regardless of methodology [R]
Z _{daily} :	Total daily energy cost [R]
Z _{elevation} :	Elevation change [m]
ε:	Pipe material roughness [m]
η _{pump} :	Efficiency of the pump [%]
μ:	Absolute viscosity [kg/m·s]
ρ:	Density [kg/m ³]
γ:	Specific weight of water [N/m ³]

CHAPTER 1: INTRODUCTION

1.1. Background

1.1.1. Overview

Nearly half of South Africa's electricity is consumed by a small number of industrial concerns of which most are members of The Energy Intensive Users Group (EIUG). In 2015 it was documented (De Vos, 2015) that these members collectively consume 44% of the total amount of electricity and they are also responsible for more than 20% of South Africa's gross domestic product (GDP) contributing R741 billion. When looking more specifically into mining and quarrying, it was documented in 2010 that the mining sector contributes 6% to the annual GDP (Deloitte, 2012). Figure 1 illustrates the GDP contribution per sector with nearly half of the members of the EIUG being in the mining sector and a third in manufacturing. Collectively among the EIUG members, nearly 20% of their annual expenses is electricity which clearly indicates their heavy reliance thereon and their exposure to any price increase (De Vos, 2015).

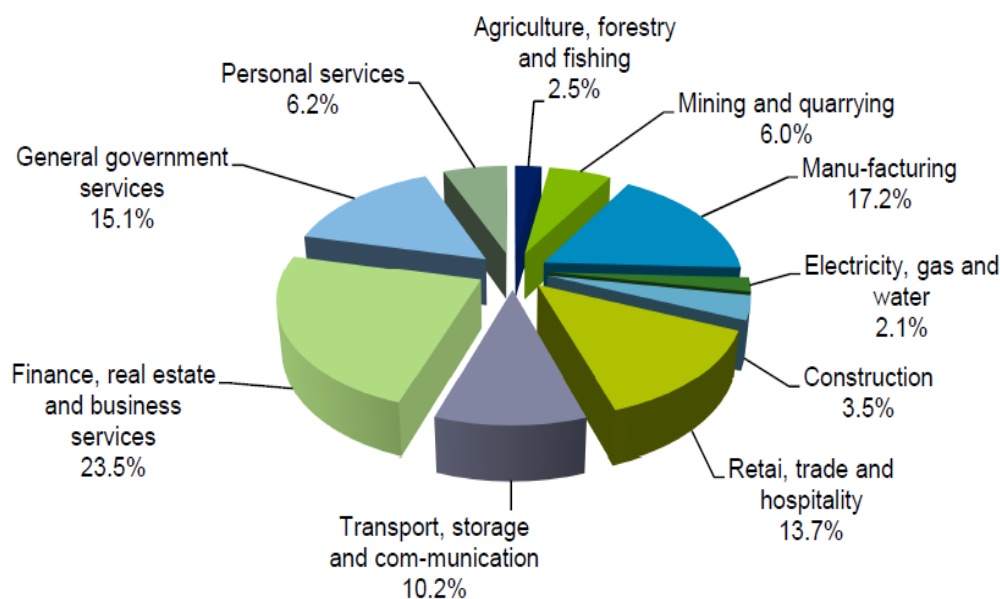


Figure 1: GDP by sectors (Deloitte, 2012)

After the 2008 electricity crisis in South Africa, there has been a sharp increase in the tariffs. Between 2003 and 2017 there has been an increase of 525% (Eskom, 2017). In comparison, the inflation during that period increased by 110% as illustrated in Figure 2 below (STATS SA, 2017).

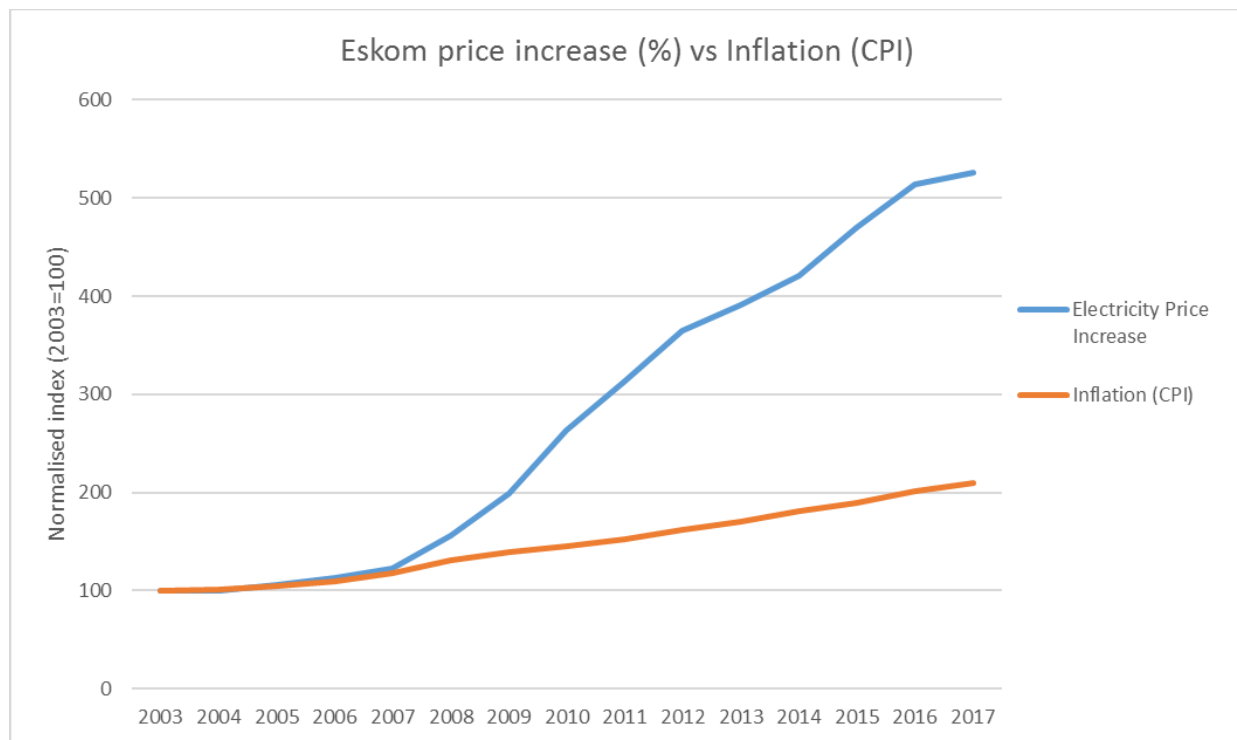


Figure 2: Eskom Price increase (%) vs. Inflation (STATS SA, 2017)

In the mining sector underground mining is more electricity dependent than open pit mining, due to the ventilation, lighting and hoisting requirements. On the other hand open pit mining is much more exposed to logistical and fuel costs (*RMB|Morgan Stanley, 2011*). For South Africa, the largest consumer of electricity is the gold mining sector using 47% of the total mining industries electricity, followed by platinum mining consuming 33%, while all the other various mines consume the remaining 20% (*Eskom, 2010*).

In the gold mining industry, electricity cost as a percentage of total cost ranges from 6% to 14%, and for platinum mining it ranges between 3% and 7%. For the other diversified mining groups' electricity cost as a percentage of total cost ranges from 3% to 21% (*Deutsche Securities, 2010*) as illustrated in Figure 3. With the sharp increase in electricity prices over the past few years the percentage of total cost that electricity represents, will increase and therefore have a negative financial impact on the mining sector (*Deloitte, 2012*).

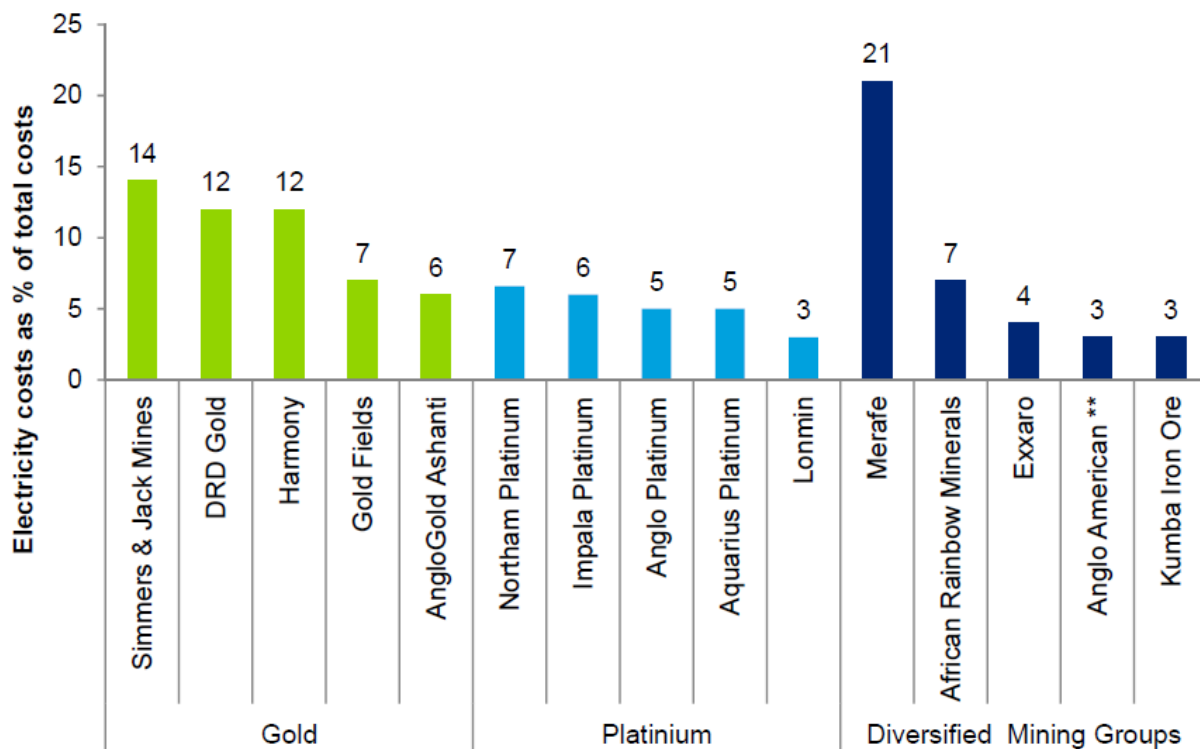


**Figure excludes electricity costs related to Kumba and Angloplat

Figure 3: Electricity cost as % of total costs for various mines (Deloitte, 2012)

Energy efficiency demand side management (EEDSM) is a highly encouraged method of reducing the total electricity expenses of a mining operation. EEDSM is considered to be a win-win solution because of the energy saved and also the tariff-based financial incentive (Department of Energy-South Africa, 2010). Demand side management (DSM) refers to using the equipment outside the peak times in order to lessen the stress placed on the electricity network and to ultimately reduce the cost of using the equipment.

In the mining sector, there are many ways in which savings can be achieved as illustrated in Figure 4 (Eskom, 2010). One specific area of energy saving opportunities lies within the pumping and dewatering process. These savings can be realized by implementing more energy efficient solutions or by applying DSM solutions. Examples of energy efficient solutions include the replacement of older inefficient equipment with new energy efficient versions as well as appropriate pump and motor sizing for the specific task to be completed. This can be supplemented by a DSM solution which can enhance the energy cost savings potential by allowing operation outside of peak periods (Smith, 2014).

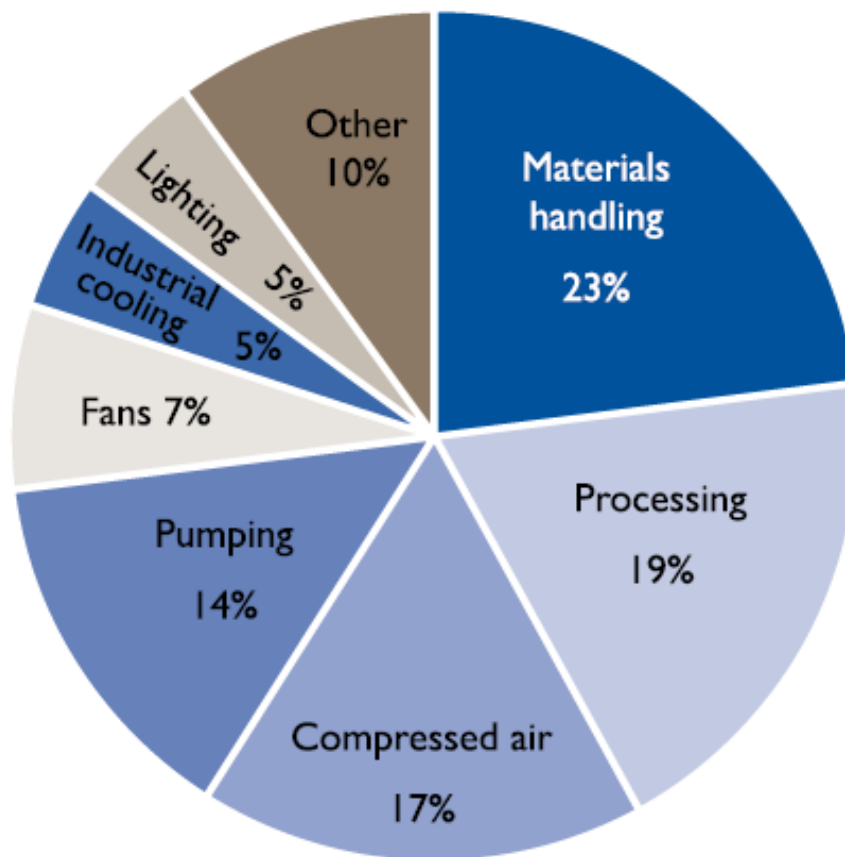


Figure 4: Possible saving in different mining areas (Eskom, 2010)

Figure 4 shows energy usage distribution of which a portion may lend itself to savings opportunities. For underground mining these opportunities are in the compressed air, fans and industrial cooling areas. Conversely, open pit mining contains opportunities in different areas. Pumping, as shown in Figure 4, is an area where potential energy savings can be achieved in open pit mining.

1.1.2. Investigated open pit mine

This particular study will focus on Anglo Platinum's Mogalakwena mine located near the town of Mokopane as shown in Figure 5 (AngloAmerican, 2017). Due to the size of the operations at Mogalakwena, it is a suitable candidate for the evaluation and implementation of energy efficiency projects.



Figure 5: Google Earth image of Anglo Platinum's Mogalakwena Mine (Google Earth, 2017)

The Mogalakwena mine complex consists of five pits, but only four of them are currently being mined. Mogalakwena has two concentrators (referred to as North- and South Concentrator) and each pit has a dewatering operation to remove all ground- and/or rain water that has accumulated in the pit. The dewatering operation consists of either diesel pumps used to pump water from a sump to a designated dam or electric powered mobile trailer pumps. The importance of the dewatering process is to enable the drilling, blasting, load and hauling operations to continue with as few delays as possible. Without the dewatering process, the water in the sump can cause the drilling operation to be less effective, and this will delay the blasting operation which will further cause the entire mining operation to slow down. Further consequences of water accumulation are the damages sustained by the trucks hauling the mined substance as well as the difficulty operators experience in wet circumstances. All of the mentioned consequences impact production negatively.

The annually recorded rainfall per month for the years 2012 to 2016 are shown in Figure 6. The figure clearly indicates that there is regular rainfall in the months of October to April with very little during the rest. It is therefore expected that the dewatering requirement during the rainfall season

be much higher than the rest of the year. The difference between the wet and dry seasons highlights the requirement for a flexible dewatering methodology capable of fulfilling both the requirements of ground water removal in the dry season as well as the additive effect of fluctuating rain water during the wet season.

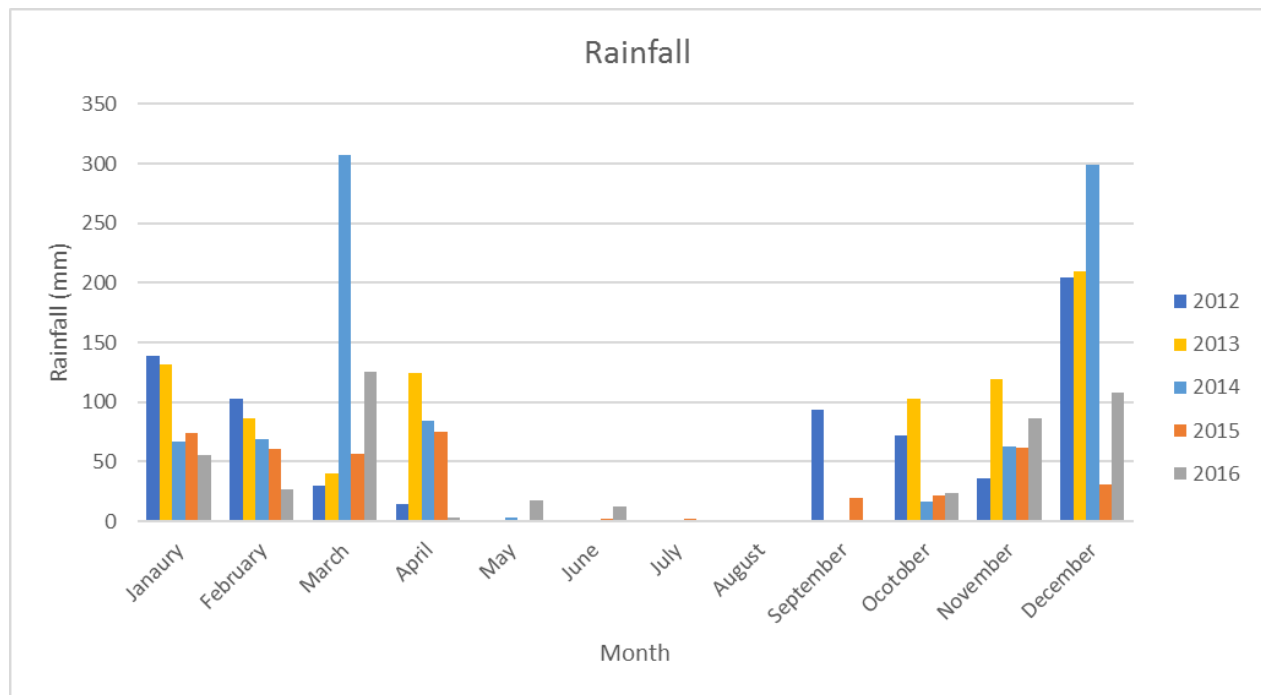


Figure 6: Monthly rainfall for 2012-2016

1.1.3. Current dewatering process

Currently there are three submersible type pumps (Figure 7) that can be connected to the mobile trailer pump, with the number of pumps connected depending on the dewatering requirement (Figure 8). These submersible pumps are placed in the areas where water accumulates in the pit. The decision in terms of how many submersible pumps will be used along with the secondary pump on the mobile trailer, is made solely by an operator mostly based on his experience. At certain pits it is necessary to attach the secondary pump on the mobile trailer to a booster pump positioned outside the pit in order to acquire the necessary head to pump the water effectively.



Figure 7: Submersible Pump



Figure 8: Mobile Trailer Pump

The water from the pit is pumped to various possible locations as shown in Figure 9. These locations are: i) the return water dam (RWD), ii) the return water dam extension (RWD Ext), iii) the Rockfill dam (dam 1160), and also iv) Sandsloot pit. Mining in the Sandsloot pit was ceased years ago and it is now primarily used for water storage. The decision to which dam the water will be pumped is made beforehand based on the requirements of the concentrators and the current pit dewatering requirement.



Figure 9: Location of Rockfill dam (dam 1160), return water dam (RWD), return water dam extension (RWD Ext) and Sandsloot

Currently, when the operator arrives at the pit in the morning he decides how many submersible pumps need to run by visually inspecting the sump from a distance. After either turning on more submersible pumps, turning off certain submersible pumps or leaving the current operation as is, he leaves to take care of other responsibilities. After a few hours he returns and the same routine check will take place.

From the approach described above, it is evident that there is currently very little control in place and as such it is believed that the entire system can be improved considerably. It is critical for the mine to operate more efficiently due to the cost of electricity and it therefore needs to investigate improvements to the current method of operations. Areas of improvement to consider include shifting the pumping to lower tariff electricity periods and varying the pumping operation according to the amount of water to be pumped.

1.2. Problem Statement

Mogalakwena is the largest open pit platinum mine in the world where the total operational cost directly impacts the profitability. One of the operations that may seem insignificant at first but impacts all other operations, and therefore the profitability, is the pit dewatering. The dewatering is currently manually operated and is considered to be a suitable candidate for the implementation of a carefully developed load shift schedule.

1.3. Aims and objectives

The aim of this study is to develop an open pit pumping methodology to decrease the operational cost of a mine.

To reach this aim, the following objectives needs to be reached:

- Detailed numerical modelling of the dewatering network of a case study mine as basis for the pumping methodology.
- Detailed simulation modelling of the dewatering network of a case study mine as verification for the pumping methodology.
- Acquire in-field measurements during normal operation of the dewatering operation of a case study mine as validation for the pumping methodology.
- Simulate five high likelihood dewatering scenarios for the case study mine to ascertain the possible energy cost savings that can be achieved with an improved pumping methodology.

1.4. Methodology

To reach the aim and objectives stated above this methodology will be followed:

- Do a detailed literature review on what has been done in the field of dewatering but more specifically the scheduling thereof for mining applications.
- Obtain detailed information for the specific case study mine including the pipe network layout, pipe diameters, restrictions, wall thicknesses, pump curves, dam sizes and levels.
- Do in field measurements of the current manual control methodology including flow measurements, power consumption and obtain monthly pumping reports.
- Model the investigated section of the dewatering network in Microsoft Excel to analyse the current dewatering operation.
- Model the investigated section of the dewatering network in Flownex Simulation Environment (M-Tech industrial, 2017) to verify the results obtained from the numerical model.
- Simulate potential dewatering scenarios applicable at the case study mine to investigate the proposed pumping methodology.
- Make conclusions and recommendations from the results obtained in terms of the operational cost savings potential of the developed methodology.

1.5. Motivation for this study

Many dewatering DSM solutions have been researched in underground mining, ranging from time specific pumping to pumping from one shaft to the next. This study is unique in a South African context as very few energy saving projects have been done at open pit mines.

1.6. Contribution to knowledge

Similar projects have been implemented for underground mining operations but not on open pit mines, which make this study unique. This study will propose an open pit pumping methodology and indicate whether energy cost savings are achievable. Knowledge gathered from this study is expected to be applicable at all open pit mines where electricity cost is dependent on time of use (TOU) periods.

CHAPTER 2: LITERATURE STUDY

2.1. Overview of mining in South Africa

In 1867 the first diamond was discovered on the banks of the Orange River. This led to the initial surge to mining in South Africa. After the discovery of the world's largest gold deposits in the Witwatersrand, mining in South Africa had a large requirement for industrial support which later shaped South Africa into a mining country (Projects IQ, 2015).

In 1970 South Africa was responsible for 68% of global gold production. By 2001, 51% of the global produced platinum group metals (PGM) was mined in South Africa (Projects IQ, 2015). During the 1970's, the contribution mining had on the total economic production increased and peaked at 21% in 1980. The relatively high gold price of 1980 was one of the contributing factors to the upward surge. Employment directly linked to the mining sector peaked in 1987 at more than 760,000 individuals (STATS SA, 2017). In Figure 10 below the peaks of both production and employment are illustrated:

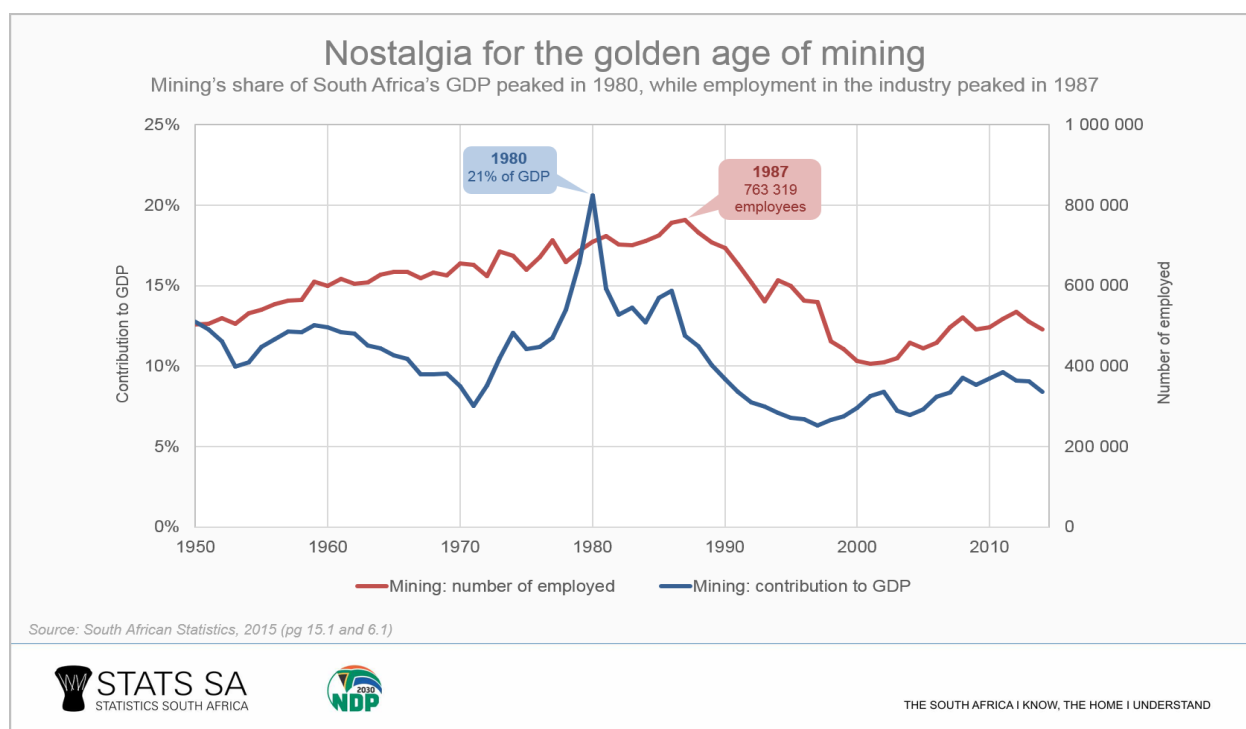


Figure 10: Mining Peak production and employment (STATS SA, 2017)

In 1980 mining was the second largest industry, contributing 21% to the GDP with manufacturing being the largest contributor of 22%. In 2016 the mining industry's contribution to the GDP dropped to 8% and the total employment directly linked to mining was estimated in 2015 to be 490,146 (STATS SA, 2017). The total reserves in South Africa remain some of the most valuable worldwide with an estimated value of R20.3 trillion. The largest reserves of manganese and PGMs and among the largest reserves of gold, diamonds, chromite ore and vanadium are found in South Africa (Kearney, 2012).

During the last decade there has been significant resource advancements. South Africa has unfortunately missed its opportunity to take advantage of the resource advancement for many reasons. Some of these reasons are: possible nationalisation, cost and availability of electricity, difficult regulatory environment, quality and availability of water as well as labour related issues such as cost and union related problems. The increase in prices have been beneficial but there has been a decline in the production of precious metals over the last decade (Chester, 2013). Even though there has been recent labour force reductions in the gold and platinum sectors, the mining sector is still a strong part of the economy (Teke, 2017). In Figure 11 below the physical volumes of mining production is illustrated (Lehohla, 2015).

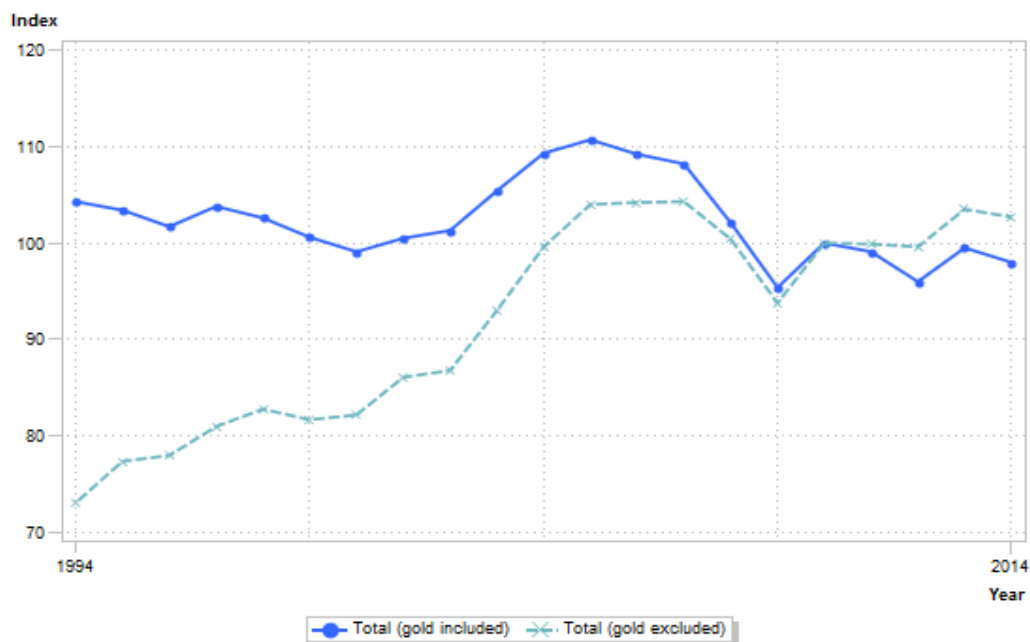


Figure 11: Physical volumes of mining production (Lehohla, 2015)

Deep level mines are highly labour and electricity intensive, the desire for this type of mine has been steadily declining. The new mines that are being developed are mostly open cast mines that can facilitate greater mechanisation. The implementation of open cast mines will negatively impact the employment availability in the mining sector but it will increase the amount of research and development to mechanise a mine (Chester, 2013). One area with significant potential to automate is the dewatering section.

2.2. Mine dewatering

Development of a mine often means penetrating the local or regional water table which causes inflows of ground water that can be a nuisance at best but a hazard at worst (Morton & Van Mekerck, 1993). Before a pumping system can be designed, all relevant information must be known and taken into consideration. These considerations include but are not limited to rainfall and groundwater inflow. The resultant dewatering system must be designed to be capable of exceeding the maximum

requirements. It is important for the dewatering system to be capable of adapting because the circumstances can vary greatly during its operating life (Weir Minerals, 2017).

In order to design a dewatering system that fulfils in all the requirements, it needs to be part of the mine's initial planning process. A groundwater study can provide valuable information such as the amount of water, the quality of the groundwater, what treatment the water will require and whether or not any additional water may be required (Hubert & Canahai, 2012). It is preferable to work in dry conditions because it reduces the wear on machinery and earth moving costs, as well as improving slope stability and therefore safety. Wet working conditions are avoided for the following reasons: it is considered unsafe, increased difficulty in ore handling, increased cost of explosives, higher likelihood of slope instability, decrease in machinery operating life and it is in general a nuisance (Morton & Van Mekerck, 1993).

2.2.1. Underground mine dewatering

South African underground mines experience extreme difficulties with the high temperatures they encounter. These temperatures increase as the mine depth increases. Virgin rock temperatures can reach up to 60°C when a depth of 4,000m is reached. In underground mining, a wet-bulb temperature of below 27.5°C is required to ensure acceptable working conditions. It is also important to ensure that the equipment operates within an acceptable temperature range (Vosloo, et al., 2011). The water requirements for each mine is unique, depending on the required water for the various underground operations. The mining processes in underground operations that require water include: cooling, drilling, cleaning and energy recovery (Stols, 2016). In Figure 12 below, the water requiring processes included in underground mining are illustrated in a typical underground deep mine water reticulation layout (Vosloo, et al., 2011).

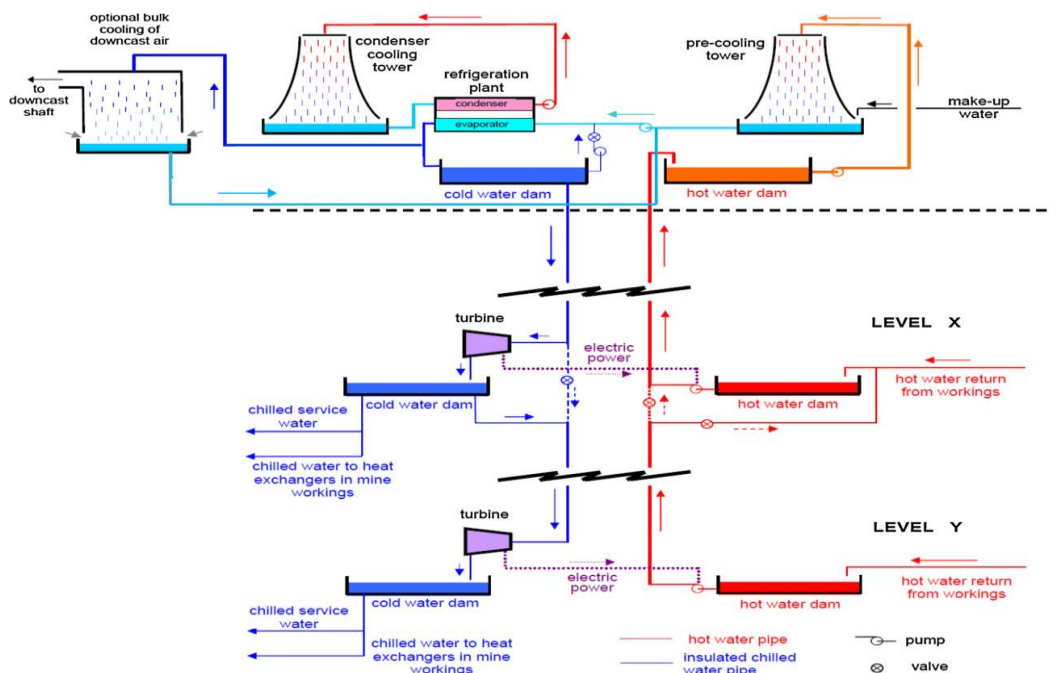


Figure 12: Water reticulation layout of a typical deep mine (Vosloo, et al., 2011)

After the water has been utilised underground, it is returned to the surface with large dewatering systems (Deysel, 2014). Dewatering systems consist of dewatering pump stations, hot water storage dams and settlers. Water is channelled to the settlers where mud and other debris are separated from the water (van Niekerk, 2014). The function of the dewatering system is to remove water from the mine to ensure safe operating conditions are maintained. There are several sources for the water encountered underground, including meteorological precipitation, ground water seepage, and used service water (Romero, et al., 2015). In order to reach the surface refrigeration plant, the water needs to travel a large vertical distance. To achieve this, multistage high pressure pumps are used in pump stations (de la Vergne, 2008).

2.2.2. Open pit mine dewatering

Open pit mining has two major sources of water inflows, surface water and ground water. The runoff water of the mine catchment area and the water available in lakes, rivers, ponds and any other body of water around the mining area is referred to as surface water. Ground water is generated by rain or snow that descends into the mining area to form a standing body of water (Sahoo, et al., 2014). The most significant problems experienced due to uncontrolled groundwater inflow is slope failure (Figure 13) and flooding of pit floors (Figure 14). Due to these problems, it is important to install an effective dewatering system (Chironga, 2013).



Figure 13: Pit wall collapse at Ruashi Mine (Chironga, 2013)



Figure 14: Flooded Pit Mogalakwena Mine

The main dewatering objective is the removal of significant quantities of water that would hinder the mining capability. Wall stability and reducing groundwater inflow are the main concerns for a dewatering system (Rowland, et al., 2017). There are various methods to achieve these objectives (Straskraba, 1979):

- Digging drainage ditches at the mine surface.
- Digging drainage ditches at the bottom of the mine.
- Horizontal drains.
- Drilling vertical wells from the surface.
- Drilling vertical wells from the pit bottom or benches.
- Various combinations of methods listed above.

The selection of the correct dewatering method depends on several factors and is crucial for successful dewatering of the mine. The factors that influence the correct dewatering method are:

- Geology and hydrogeology of the mine site: the dewatering design of every mining site must have a hydrogeological investigation as a basis. Included in the hydrogeological investigation is knowledge of aquifer characteristics, general flow direction, thickness and hydraulic conductivity (Straskraba, 1979).
- The scope of dewatering: improvement of the slope stability, improvement of the mining conditions, groundwater quality protection (Straskraba, 1979).
- Mining method: mining methods traditionally fall into two broad categories based on locale. These methods are surface mining and underground mining (Harraz, 2010).
- Cost study: cost of designing and implementing a dewatering strategy is an important part as an inefficient system will lead to slope failure and substandard mining conditions (Straskraba, 1979).

2.3. Influencing factors on a mine's dewatering requirement

The leading sources of water inflow into a mine is ground water and surface water that accumulates and require pumping to enable ore excavation. Total annual precipitation refers to surface water, ground water and evaporative losses to the atmosphere (Sahoo, et al., 2014).

In order to create a dewatering system that will fulfil in the dewatering needs it is very important to have an accurate estimation of the quantity of water inflow into the mine working area. The quantity of water that enters the mine working area is a function of surface geology, size and shape of water source, recharge area and hydraulic characteristics of the intervening strata between the source of water and the mine workings (Senadhira, 2014).

2.4. Different approaches to reduce mine electrical cost

Load management refers to the scheduling of loads to ultimately reduce the electrical cost. The daily consumption profile is changed either by direct intervention or by increasing the efficiency of the system (Ashok & Banerjee, 2000). Due to the importance of energy management, there are various benefits to the successful management of loads. The management of loads in electric power systems benefit the power utilities, customers and the environment from unnecessary pollution (Paracha & Doulai, 1998). Some methods to reduce the electrical cost at mines will be discussed in the sections below.

2.4.1. Load shifting

Load shifting is a load management method that does not influence the total production but reschedules the processes in order to reduce peak demand and improve the load factor (Ashok & Banerjee, 2000). Load shifting methodology allows for constant availability of electric power to the equipment but the usage thereof is dependent on the TOU. Application of the load shifting procedure requires a type of load that will not be affected by short interruptions (Vosloo, et al., 2011). Figure 15 illustrates a load profile where load shifting is applied. Processes where load shifting can be applied exhibit the following characteristics (IST, 2015):

- Processes that do not run continuously.
- If the process has an internal storage such as silos, dams, tanks, etc.
- There is spare capacity available that will enable the process to run less hours at a higher capacity.

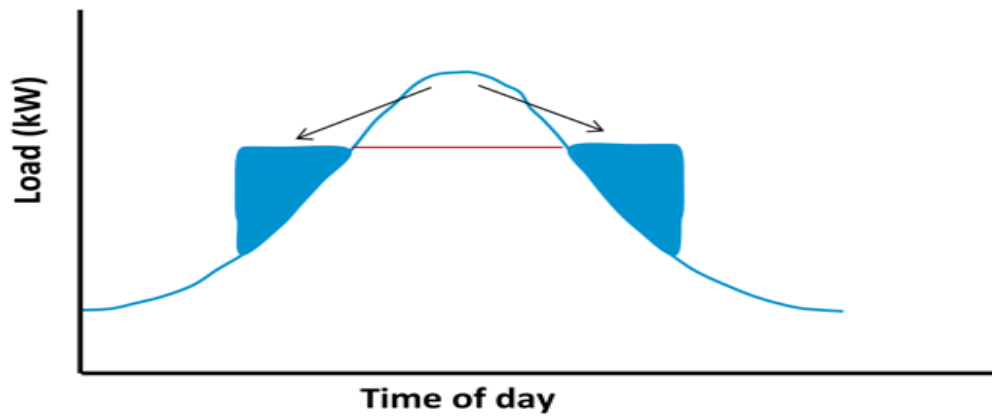


Figure 15: Load shifting (Energy EXchange, 2011)

2.4.2. Peak clipping

Peak clipping is a method of load management that reduces the maximum demand of consumers during peak TOU periods. Peak clipping can be applied to reduce capacity requirements, operating costs and dependence on critical fuel (Paracha & Doulai, 1998). It is normally applied through direct load control of equipment by consumer action, automated controls or communication (Gellings, 2016). The outcome is a reduction in the peak demand as well as the total demand (Powerwise Bureau, 2011) Figure 16 illustrates a load profile where peak clipping is applied.

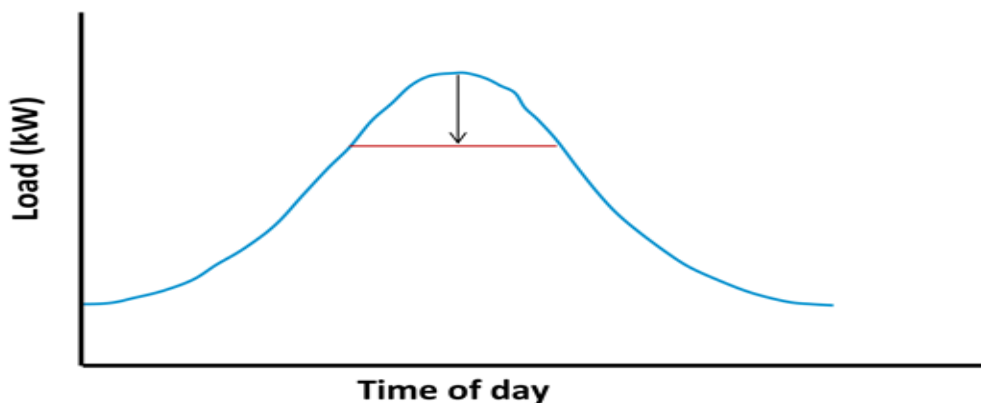


Figure 16: Peak Clipping (Energy EXchange, 2011)

2.4.3. Energy efficiency

A permanent reduction in energy usage can be achieved by implementing energy efficient solutions. This not only results in a reduction in energy usage but also lowering the total demand and consumption charges (Energy EXchange, 2011). Improving the end-use electricity efficiency is also considered a less expensive alternative to achieve the desired electricity service (Gyamfi, et al., 2017). Figure 17 illustrates the reduction in energy consumption if the overall efficiency is improved.

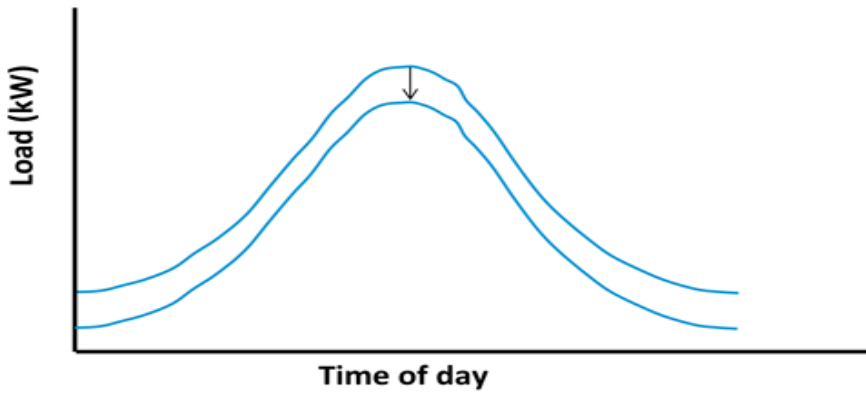


Figure 17: Improving operation energy efficiency (Energy EXchange, 2011)

The following energy efficient improvement is specific to the dewatering system of a mine (Senadhira, 2014):

- Eliminate inefficiencies in a piping network: repairing pipeline leakages, removing unwanted/incorrect components in the piping network and installing the correct component where necessary, installing the shortest possible pipe network and removing any unnecessary branches.
- Improving pump efficiency: installing a pump specifically designed for the task at hand, using variable speed drive (VSD) pumps and using the correct pumping orientation (single or parallel operating pumps).

2.5. Case studies of pump scheduling in mine dewatering

Pump scheduling methodologies are formulated based on two possible scenarios. The first scenario is based on the amount of pumps operating during specific times of the day (Luo, et al., 2012). The objective for the first scenario is to determine the energy consumption of all applicable pumps throughout the modification period. The mathematical expression is as follows (Vladimir, et al., 2010):

$$Z_{daily} = \sum_{i=1}^I \sum_{t=1}^T P_{it}(Q_{it}, H_{it}) \times C \quad (1)$$

Where Z_{daily} is the total daily energy cost, C is the currency conversion coefficient, P is the power consumption, Q is the flow rate, H is the pressure head, I the number of pump stations and T the number of time intervals per day.

With the main restriction being the flow rate and the pressure head:

$$Q_{min}^T \leq \sum_{i=1}^I Q_i \leq Q_{max}^T$$

$$Q = Q(H)$$

$$H = H_{dyn} + H_{sta} \quad (2)$$

Where H_{dyn} represents the frictional head losses and H_{sta} height between surface and well water level.

The second scenario is concerned with the real-time requirement of available pumps while the operating methodology is dependent on the fluctuating demand (Luo, et al., 2012). The objective of this particular scenario is the shaft power of the pump (Zhang, et al., 2004):

$$F = \sum_{i=1}^I w_i P_i(Q_i, H_i) \quad (3)$$

With F the shaft power to be minimized, w_i is the operating status of the pump for the next step, P_i is the shaft power of the pump, Q_i the flow rate of pump and H_i the pressure head of pump.

The power of the pump under the required condition is expressed as follows, with p_i being the conversion coefficient:

$$P(Q, H) = p_0 H^3 + p_1 H^2 Q + p_2 H Q^2 + p_3 Q^3 \quad (4)$$

Thus, there are various factors that influence the energy consumption cost of a pumping system (Ormsbee, et al., 2009):

- Flow rate.
- Pressure head.
- Required period of pumping.
- Cost per unit of electricity.
- Efficiency of pumping combinations.

The mathematical expression of the objective function is (Ormsbee, et al., 2009):

$$Z = \gamma \sum_{t=1}^T R_t \sum_{i=1}^I \left(\frac{Q_{t,i} H_{t,i} X_{t,i}}{e_{t,i}} \right) \quad (5)$$

Where Z is the energy cost, $Q_{t,i}$ is the flow rate, $H_{t,i}$ is the pressure head, $X_{t,i}$ is the total duration pump i is active during interval t , R_t is the cost per unit of electricity, γ is the specific weight of water, I the number of pumps and T the number of time intervals.

Various pump scheduling projects have been implemented at underground mining operation but not yet on an open pit mining operation. The pump scheduling in underground mines have been done to achieve different objectives that include: reduction in energy requirement, reduce the required maintenance and finally to achieve an optimal system operating life. In the sub-sections below a few case studies of implemented pump scheduling will be discussed.

2.5.1. Applying load shift opportunities on water reticulation systems of marginal deep level mines (van Niekerk, 2014):

During the first case study, marginal deep level mines were investigated for possible load shift opportunities relating to the water reticulation system. The affected systems were the dewatering and refrigeration systems. The details specific to the refrigeration system will not be discussed due

to its relevance. Figure 18 displays a simplified layout of the specific mine's pumps (van Niekerk, 2014).

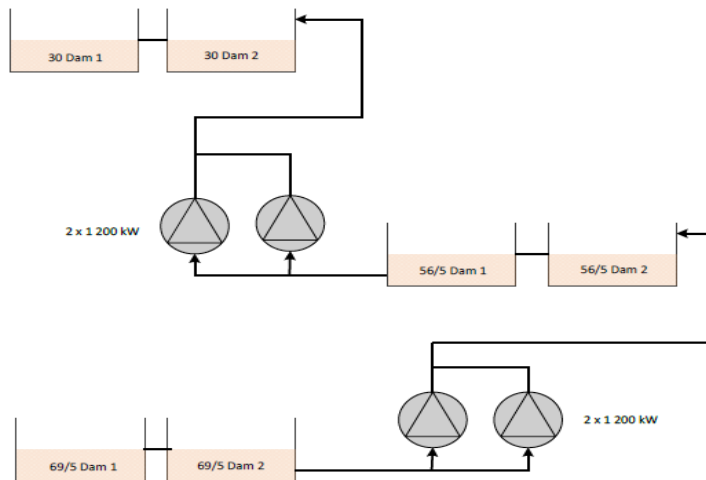


Figure 18: Case study 1, simplified layout of dewatering pumps (van Niekerk, 2014)

For dewatering purposes, multistage pumps are normally used and placed at approximately 600m vertical intervals. If the pressure head is equal to the difference in elevation, the power of the fluid can be calculated as (van Niekerk, 2014):

$$P = \rho g Q H \quad (6)$$

Where P is the Power (kW), ρ is the density (kg/m^3), Q is the mass flow rate (l/s), g is the gravitational acceleration in (m/s^2) and H is the pressure head (m).

Normal underground operations use multiple pumps operating together. These pumps are regularly operated in parallel due to fluctuating requirements for dewatering. The advantage of parallel operated pumps is an increase in the delivered flow rate (van Niekerk, 2014) while the pressure head remains the same, this is displayed in Figure 19. Multiple pumps that work in series, deliver an increased pressure head while the delivered flow rate remains the same.

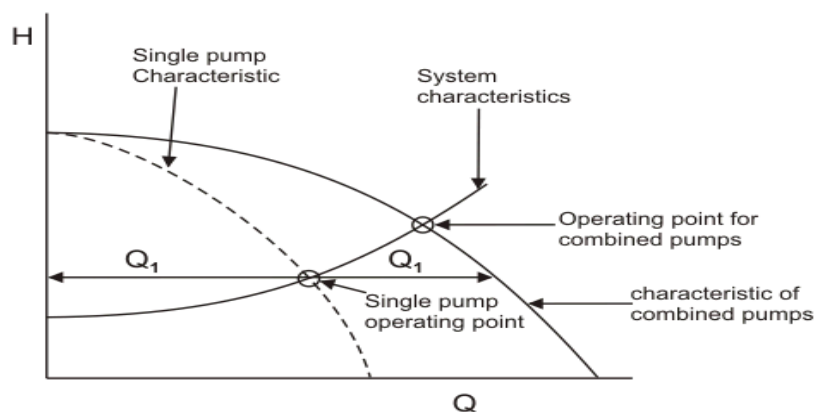


Figure 19: Case study 1, flow rate of pumps in parallel (NPTEL, 2007)

If the power consumption of a particular pump is not readily available, a portable data logger can be installed. The loggers will record the voltage and current of the respective motor in predetermined intervals. With that information available, the following equation can be used to calculate the power consumption of a three phase motor (van Niekerk, 2014):

$$P = \sqrt{3} \times V_L \times I_L \times \cos\theta \quad (7)$$

With P the Power (W), V the Line voltage (V_L), I the Line current (I_L) and $\cos\theta$ the power factor.

For the mine investigated by Van Niekerk (2014), the buffer capacity of the pumping system must be assessed. In order to accomplish that, the amount of water that can be stored underground in hot water dams is calculated (van Niekerk, 2014):

$$Buffer = (Max - Min) \times CAP \quad (8)$$

Where *Buffer* is the amount of water that can be stored, *Max* refers to the maximum dam level (%), *Min* to the minimum dam level (%) and *CAP* to the total dam capacity (MI).

In order to calculate a water inflow profile, pump log sheets are required from each pumping station. The log sheets contain the information on when a pump is switched on and the dam level on an hourly basis. The inflow profile is calculated by quantifying the corresponding volume of water according to the log sheets and subtracting the amount of water pumped according to the pumps' rated flow. To obtain an accurate hourly inflow profile, this must be done using historic data for an extended period of time (van Niekerk, 2014).

$$IPH = \frac{[(DL_1 - DL_0) \times CAP \times 1,000,000] - (I \times RF \times t \times 3,600)}{3,600} \quad (9)$$

Where *IPH* is the water inflow per hour (l/s), DL_0 is the dam level at beginning of the hour (%), DL_1 is the dam level at the end of the hour (%), *CAP* is the dam capacity (MI), *I* is the number of pumps, *RF* refers to the rated flow of pumps (l/s) and *t* is the period that the pumps were in operation (hours).

Due to varying demand the daily inflow profile will be different every day but it is used for preliminary investigations. By assuming that the dam is at minimum level before the peak cost period and applying the inflow profile it can be calculated whether the dam will exceed the maximum dam level or not. This will be used to determine if peak load shift is possible or not (van Niekerk, 2014):

$$DL_1 = \frac{(DL_0 + CAP) + \left(\frac{WIR_7 + WIR_8 + WIR_9}{10000} \right) \times 36}{CAP} \times 100 \quad (10)$$

Where DL_1 is the dam level after the peak cost period, DL_0 is the dam level before the peak cost period, *CAP* is the total dam capacity (MI), WIR_7 refers to the water inflow rate for 06:00 - 07:00 (hour 7), WIR_8 refers to the water inflow rate for 07:00 - 08:00 (hour 8) and WIR_9 refers to the water inflow rate for hour 08:00 - 09:00 (hour 9).

The main constraints were: the size of the hot and cold water dams and the amount of water required by the mine. An average estimated load shift of 870 kW was calculated for the dewatering system. A 24-hour average profile was created in order to compare the baseline with the calculated savings that were achieved as illustrated in Figure 20 where green represents off-peak TOU, yellow standard TOU and red peak TOU (van Niekerk, 2014).

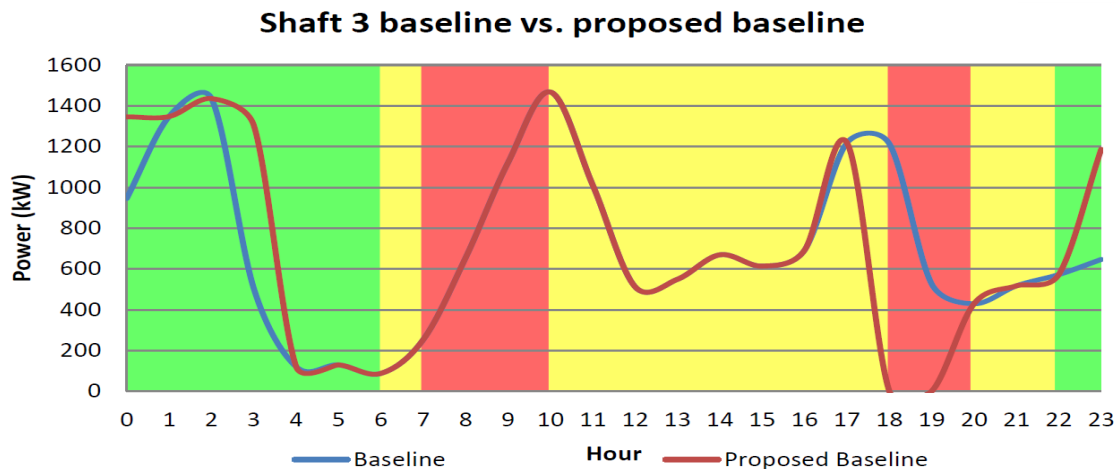


Figure 20: Case study 1, baseline vs savings achieved (van Niekerk, 2014)

An assessment period of three months was used to monitor the implemented interventions. After conclusion of the assessment period, it became clear that the calculated average load shift was not obtained. Reasons offered by the author for actual performance deviating from expectations included the following (van Niekerk, 2014):

- Electrical breakdowns.
- Fridge plant breakdown and gas leaks.
- Maintenance on refrigeration system.
- Errors by control room operators.
- Communication failures.

It is highly beneficial to implement load shift projects. Higher accuracy is achievable if more historic data is collected. Measurement and verification processes can be implemented to ensure the historic data is always up to date (van Niekerk, 2014).

2.5.2. Improvement of a hydropower gold mines' dewatering system through pump scheduling (Van Niekerk, 2017):

The second case study will focus on load shifting at a hydropower mine. A hydropower mine uses pressurized water to operate the equipment underground. For this particular case study, the affected system was the dewatering system of the mine. In Figure 21 the water reticulation system of the hydropower mine is illustrated (Van Niekerk, 2017).

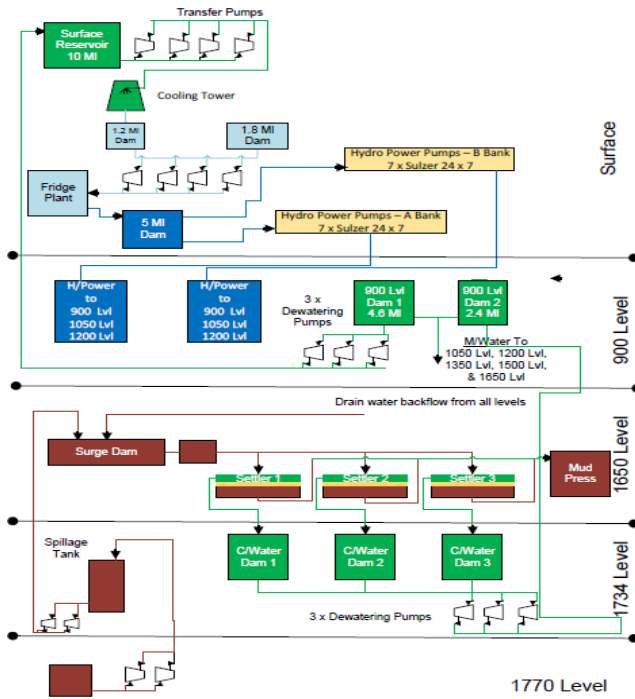


Figure 21: Case study 2, hydropower mine water reticulation system (Van Niekerk, 2017)

It is important to know the power consumption of a system before any load shifting can be applied because it provides a baseline that can be used when the energy savings are calculated. The average power consumption during any specific period can be calculated with the following method (Van Niekerk, 2017):

$$\text{Avg Power (TOU period)} = \frac{\sum \text{Power TOU}}{\text{Amount of intervals}} \quad (11)$$

Where *Avg power (TOU period)* refers to the average power during the recorded TOU period, *Power TOU* is the recorded power at each time interval and *Amount of intervals* refers to the amount of intervals during the applicable period.

Furthermore, the average power consumption for the entire day can be calculated with the following method (Van Niekerk, 2017):

$$\text{Avg Power (daily)} = \frac{\sum \text{Total power per day}}{\text{Amount of intervals}} \quad (12)$$

Where *Avg Power (daily)* refers to the average power consumption per day and *Total power per day* is the sum of all the power consumed throughout the day.

In order to implement load shifting, it is first required to know whether load shifting during the specific period is possible. It is therefore necessary to calculate a peak ratio (indication whether load shifting is possible during certain periods):

$$\text{Peak ratio} = \frac{\text{Avg Power (TOU period)}}{\text{Avg power (daily)}} \quad (13)$$

If the peak ratio is more than 1 there is currently no load shifting being applied during this period and there is still an opportunity. After it has been determined whether load shifting is possible during peak TOU periods, it is necessary to calculate the dam level at any moment (Van Niekerk, 2017):

$$\text{Current level (\%)} = \frac{\left(\frac{\text{Previous level (\%)}}{100} \times \text{Max dam volume} + \text{Inflow} - \text{Outflow}\right) \times 100}{\text{Max dam volume}} \quad (14)$$

Where *Current level (%)* refers to the current dam level (%), *Previous level (%)* is the previous dam level (%), *Max dam volume* is the maximum amount of water the dam can contain (l), *Inflow* is the water flowing into dam (l/s) and *Outflow* is the water flowing out of the dam (l/s).

For this particular mine, the maximum allowable dam level was 100% and the minimum dam level 20%. The reason for the choice of minimum dam level is to protect the pump by preventing mud from getting sucked into the pump. The maximum dam level is commonly chosen to ensure enough capacity remains if the pumps are unable to run. Figure 22 displays an example of the applied load shifting methodology (Van Niekerk, 2017).

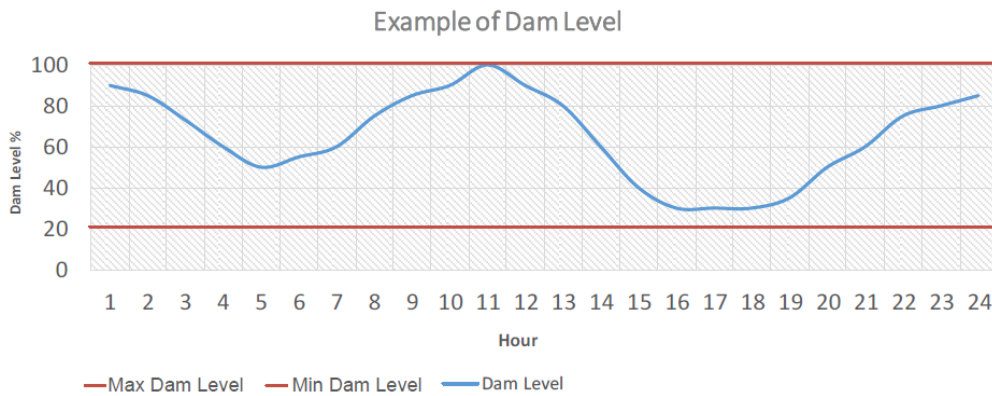


Figure 22: Case study 2, dam levels with applied load shifting (Van Niekerk, 2017)

2.5.3. Energy cost of dewatering pumps with quantification of their system constraints and the effects thereof (Stols, 2016):

The third case study will focus on an underground gold mine. The dewatering system of this particular gold mine, is shown in Figure 23. It consists of five different levels and has an installed pumping capacity of 33 MW (Stols, 2016).

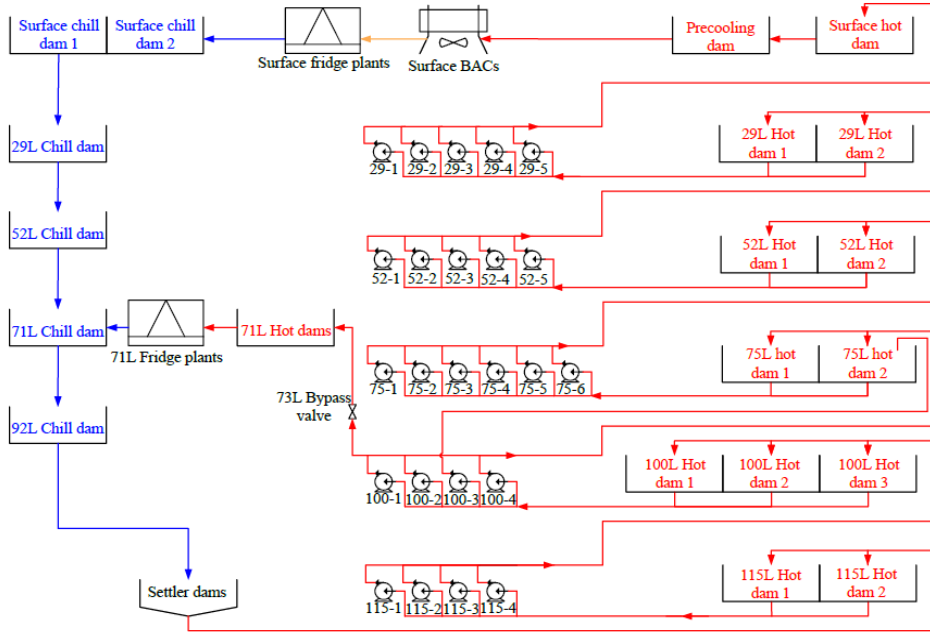


Figure 23: Case study 3, mine water reticulation system (Stols, 2016)

During the simulations, certain assumptions had to be made (Stols, 2016):

- Assumed system flow rates and efficiencies are equal or similar to the actual values experienced.
- The flow rates and efficiencies will remain constant.
- Continuous mining operations with no unexpected technical problems (such as breakdowns).
- The dam capacity at each pumping station is the same.

Simulations were run on certain levels, as not all levels were viable for load shifting opportunities. The pumps on 115 level are rated at 2000 kW. For simulation purposes of the 115 level dewatering system, the minimum and maximum levels are 50% and 85% respectively. During the simulations the minimum and maximum dam levels were chosen for a variety of reasons (Stols, 2016):

- To prevent the pumping of mud.
- Provide enough time to solve any technical problems before start-up if necessary.
- Fridge plant water requirements.
- Shape and mud build-up in dams.

The pumps will start outside the peak TOU period according to the following (Stols, 2016):

$$L_1 = L_{min} + L_{cr} \quad (15)$$

$$L_i = (L_{min} + L_{cr}) + ((i - 1) \times L_{start,next}) \quad (16)$$

Where L_1 is the dam level at which the first pump will start, L_{min} is the minimum dam level, L_{cr} is the specified control range, L_i is the dam level where pump i will start, i is the applicable pump number

and $L_{start,next}$ is the difference in dam level that will activate the subsequent pumps (pump two and upwards).

For the pumps to start during the peak TOU period, the calculations below will be used (Stols, 2016):

$$L_1 = L_{max} + L_{cr} \quad (17)$$

$$L_i = (L_{max} + L_{cr}) + ((i - 1) \times L_{start,next}) \quad (18)$$

With L_{max} as the maximum dam level.

Stopping the pumps outside (22) and during (23) peak TOU period is calculated through the following method (Stols, 2016):

$$L_i = L_{min} - ((i - 1) \times L_{stop,next}) \quad (19)$$

$$L_i = L_{min} - (i \times L_{stop,next}) \quad (20)$$

Where $L_{stop,next}$ is the difference in dam level that will stop the subsequent pumps.

The flow into the dams was calculated using the change in water level during two successive intervals (Stols, 2016):

$$Q_{net} = \frac{(L_x - L_{x+1})}{100} \times \frac{(V_{vol} \times 1000)}{\Delta t_n \times T} \quad (21)$$

Where Q_{net} is the flow rate into the dam during specified intervals (l/s), L_x is the dam level at start of first interval (%), L_{x+1} is the dam level at subsequent intervals (%), V_{vol} is the dam volume (m^3), Δt_n is the time between intervals (s) and T is the amount of intervals.

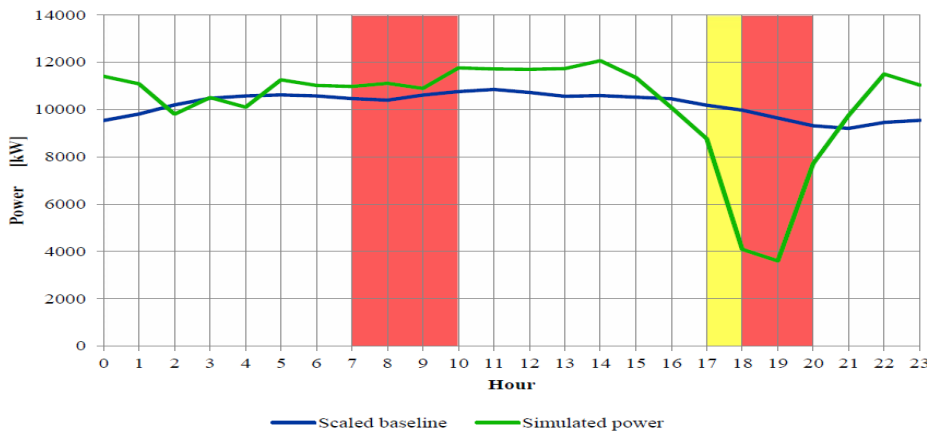


Figure 24: Case study 3, daily baseline before and after load shift application

2.6. Summary

There are several load management techniques that can be implemented. These load management techniques reduce the electrical cost and improve the load factor. This is especially applicable to industries reliant on a TOU tariff structure since the peak of the load curve will be reduced (Ashok & Banerjee, 2000). Examples of automated underground dewatering systems have been discussed but there are no previous examples of automating the dewatering system of an open pit mine.

CHAPTER 3: METHODOLOGY

Chapter 2 highlighted that there are numerous prospective approaches with regards to load shifting pumping methodologies. Each individual pumping methodology requires substantial research to enable the researcher to construct mathematical models capable of customization according to the present requirements. In this chapter the methodology of creating the appropriate models and acquiring the necessary in-field measurements are discussed. After completion of the numerical investigation with the use of Microsoft Excel, verification thereof will be done with simulation models in Flownex SE (M-Tech industrial, 2017) and validation using the in-field measurements recorded during normal operation. The models will initially be compared with the in-field measurements, while taking the different operating conditions into account. When the accuracy of the models are established, it will be used to simulate five potential dewatering scenarios at the case study mine while taking the proposed pumping methodology into account.

3.1. Development of mathematical models

3.1.1. Numerical investigation

The first element of the methodology is constructing a numerical model, based on the research done in the previous chapter while taking site specific considerations into account. This will be done with the use of Microsoft Excel. The objective of this model is to theoretically investigate the current pumping network and propose a different pumping methodology. Furthermore, the accuracy of numerical model will be validated by comparing it to the results obtained from the in-field measurements. In a pumping system numerous variables are taken into consideration:

- Static head.
- Pipe material, length and diameter.
- Components (valves, elbows, reducers, expanders, etc.).
- Fluid composition.
- Type of pump (fixed speed and VSD).
- Flow rate requirement.
- Available storage capacity.

Development of the numerical model will be based on the conservation of momentum. When the net force acting upon a system is equal to zero, the momentum of the system remains constant and hence the momentum is conserved. For this application it can be simplified as Bernoulli's equation which illustrates a unique relation between the pressure and velocity of the incompressible fluid in a system. It states that the sum of the kinetic, potential and flow energies remain constant if steady flow and negligible viscous forces are assumed in a hydraulic system (Cengel & Cimbala, 2006):

$$Z_{elevation,1} + \frac{p_1}{\gamma} + \frac{v_1^2}{2g} = Z_{elevation,2} + \frac{p_2}{\gamma} + \frac{v_2^2}{2g} \quad (22)$$

Where $Z_{elevation}$ is the elevation change, p the pressure, γ refers to the specific weight of the fluid, v is the velocity and g refers to the acceleration of gravity.

The velocity of the fluid is calculated with the following:

$$Q = v \times Area \times 3600 \quad (23)$$

Where Q is the flow rate of the fluid (m^3/h), v is the velocity of the fluid (m/s) and $Area$ is the cross-sectional area of the pipe (m^2).

The Reynolds number (Re) is used to distinguish between turbulent and laminar flow of the fluid. It can be calculated by means of the following (Greeff & Skinner, 2000):

$$Re = \frac{\rho v D}{\mu} \quad (24)$$

Where Re is the Reynolds number, ρ is the density (kg/m^3), v the velocity (m/s), D the inside diameter of the pipe (m) and μ the absolute viscosity ($kg/m \cdot s$).

Determining the head loss (and ultimately the total pressure loss) due to friction requires calculation of the friction factor. The method chosen to calculate the friction factor of each pipe section was introduced by Churchill in 1977. The Churchill friction factor equation is (Greeff & Skinner, 2000):

$$f' = 8 \left[\left(\frac{8}{Re} \right)^{12} + \frac{1}{(A+B)^{1.5}} \right]^{\frac{1}{12}}$$

$$A = \left(-2.457 \ln \left[\left(\frac{7}{Re} \right)^{0.9} + 0.27 \left(\frac{\epsilon}{D} \right) \right] \right)^{16}$$

$$B = \left(\frac{37530}{Re} \right)^{16} \quad (25)$$

With f' as the friction factor, ϵ the pipe material roughness (m) and A as well as B equation specific variables.

The Darcy-Weisbach method is used to calculate pressure loss due to pipe friction, also known as the primary loss, and the pressure loss due to components, also known as the secondary loss, in the pipeline is illustrated below (Greeff & Skinner, 2000):

$$H_{LP} = \frac{f' L v^2}{2 D g} \quad (26)$$

$$H_{LC} = \frac{k v^2}{2 g} \quad (27)$$

Where H_{LP} refers to the head loss due to pipe friction (m), H_{LC} is the head loss due to components (m), L is the length of the pipeline and k the hydraulic losses for each specific component.

After all applicable losses have been calculated the system's operating point can be graphically illustrated by plotting the pump curve, which illustrates the delivered flow rate at a particular pressure

head, along with the system curve, which illustrates the system experienced pressure head at a particular flow rate. The point of intersection illustrates the system operating point and indicates the pressure head as well as the flow rate (discharge) that will be achieved as illustrated in Figure 25:

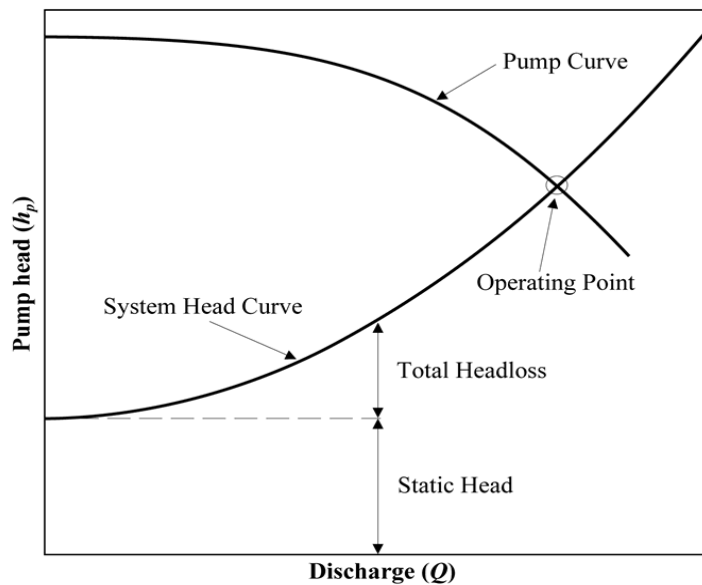


Figure 25: Pump curve and system curve (Dickinson, 2017)

Construction of the numerical model was based on an iterative approach with the experienced flow rate as the main variable. This entailed using a specific flow rate value and calculating the pressure head that will collectively be produced by all the pumps. Figure 26 illustrates the pumping system.

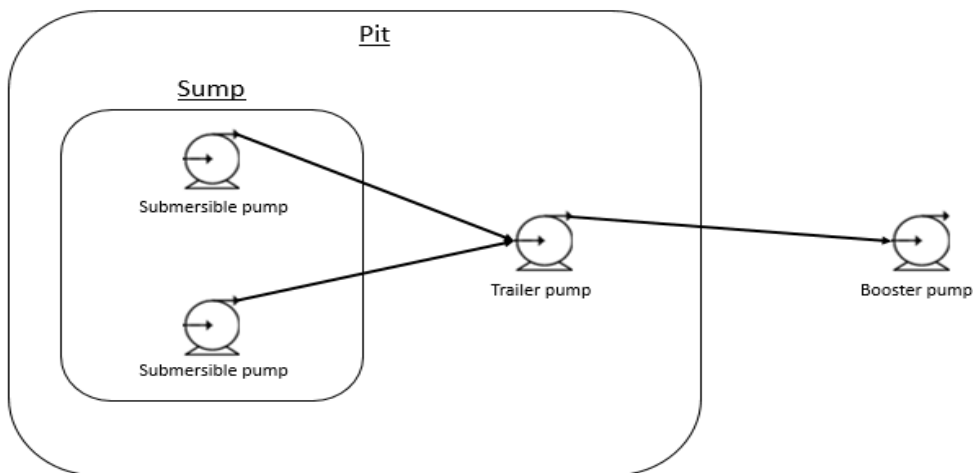


Figure 26: Pumps used to pump water to storage dams

The numerical model will also be used to determine the system head that will be experienced under those conditions. The calculations will be repeated with a marginally increased flow rate as illustrated in Figure 27. This process will continue until an operating point is acquired. The proposed pumping methodology was based on the numerical model that was developed using the methods and equations mentioned above to create a final pump and system curve for the dewatering network (Appendix C: Numerical model - System graph).

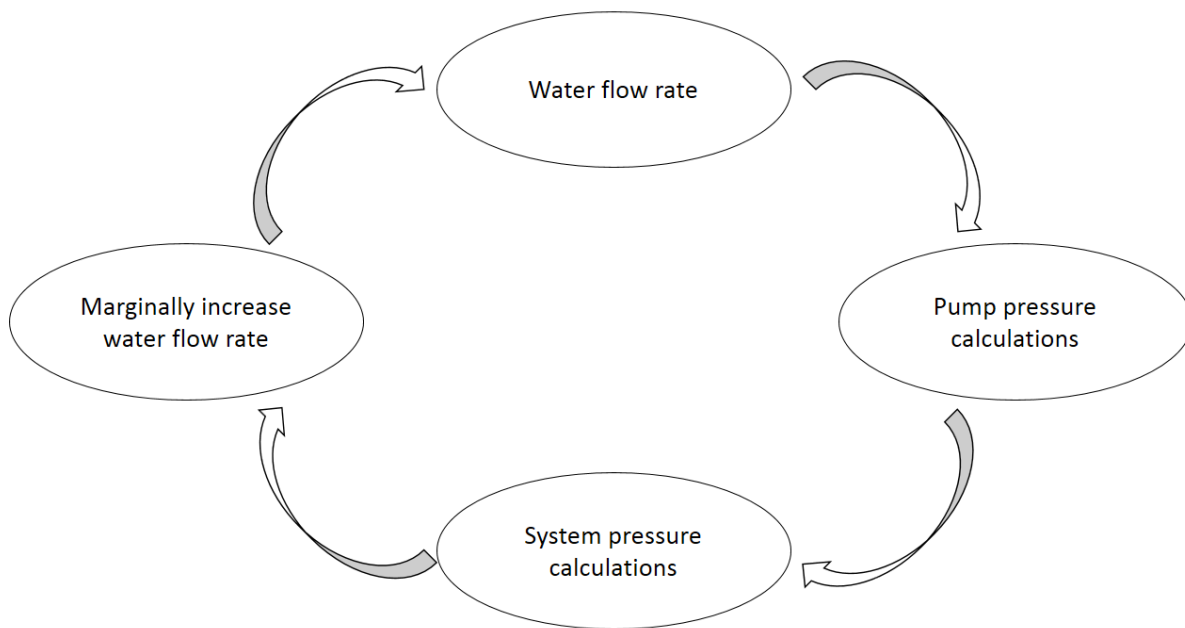


Figure 27: Iterative approach in numerical model

After conclusion of pressure head and flow rate calculations, the power consumption can be determined. The energy consumption of a pump is dependent on the power consumption and the amount of time it was active. Power and energy consumption of the pump is calculated as follows:

$$P = \frac{\rho g Q H}{\eta_{\text{pump}}} \quad (28)$$

$$E = P \times t \quad (29)$$

Where P is the power (W), Q is the flow rate (l/s), H is the pressure head (m), η_{pump} is the pump efficiency, E the energy (kWh) and t is the time (h).

3.1.2. Development of simulation models

The second element of the methodology will represent the construction of the simulation model that will serve as verification of the results obtained from the numerical model. Simulation modelling is used to provide an accurate answer in a fast and safe manner. It is used in the engineering industry to assist the user in different areas. These areas include design, problem solving, system optimisation, etc. The most critical element in a simulation model is the inputs. The inputs should therefore be considered carefully along with the final results to make an informed decision.

The simulation program selected for this study is Flownex Simulation Environment. The objective of this model is to investigate the current pumping network (Appendix G: Pipe network) and verify the results obtained in the numerical model. The results obtained will be validated by the in-field measurements. The reason for using Flownex SE is because it allows the user to examine a system and how it will behave during real world conditions. It provides accurate and detailed analysis of the designated system while delivering comprehensive warnings and errors, wherever applicable, to

assist in solving the specific system. Flownex SE also illustrates the general effect of altering a property on any component within the examined system to facilitate extensive analysis thereof. For these reasons Flownex SE will be used to further investigate the proposed pumping methodology through five potential dewatering scenarios. Figure 28 displays a simplified version of the simulation model with kindred inputs and limitations to the numerical model. Certain details are not divulged here due to the sensitive nature thereof:

- Pit capacity (Appendix E: Pit capacities).
- Submersible pump curve (Appendix F: Pump curves).
- Pipeline material, length, diameter, etc.
- Trailer pump curve and booster pump curves. In this case they are similar pumps (Appendix F: Pump curves).
- Trailer pump and booster pump stations' physical locations.
- Valve types and locations.
- Storage dams' capacities and boundary conditions.
- Concentrator requirement (Appendix A: Concentrator requirement).

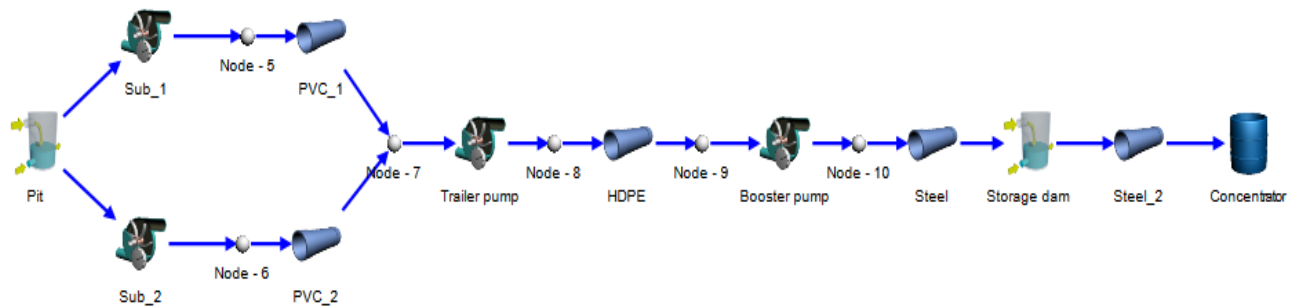


Figure 28: Basic Flownex SE layout

Pit capacities and all applicable pump curves were obtained from the responsible engineer and the simulation was updated accordingly. The dewatering pipeline for Mogalakwena mine is displayed in Figure 29 with the new pipeline illustrated in blue and the old pipeline in red. The new pipeline consists of two parallel lines each with a diameter of 450 mm while the old pipeline consists of a single line with a diameter of 450 mm. The project to install the new pipeline commenced in 2014 and was recently completed. The main supporting reasons for initiating the pipeline project were the increased volume flow and the increased flexibility with regards to transferring water. Detail drawings of the new pipeline, obtained from the mine, included the sectional lengths, diameters and material of the pipeline as well as the locations of all the valves, processing plants, storage dams and required static head. The storage capacities of all water storage facilities were acquired from the appointed water officer.

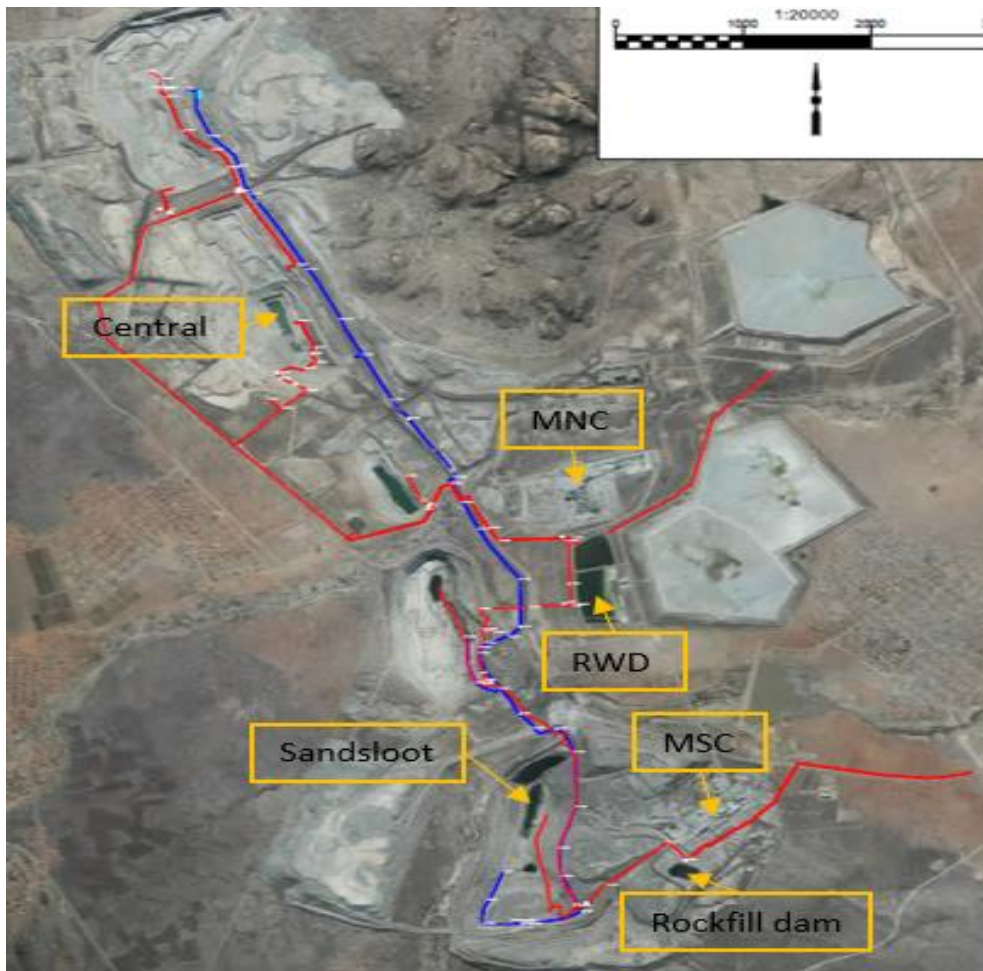


Figure 29: Mogalakwena New (blue) and Old (red) Dewatering Pipeline

Inclusion of all the required data led to the formulation of the final simulation layout displayed in Figure 30. The new pipeline is connected to the old pipeline at various location. When the water is pumped from Sandsloot pit towards either Rockfill dam or RWD, it initially goes through the new pipeline until it is connected with the old pipeline whereupon it goes to the designated storage dam. As mentioned before, the new pipeline consists of two identical lines, which enable Sandsloot pit to both receive and deliver water while the old pipeline consists of only one line limiting water delivery from Sandsloot pit to only one of the storage dams.

Simulation based automated control entails the implementation of the proposed pumping methodology within the simulation model created in Flownex SE. It was implemented by taking the applicable valves and dam levels into consideration along with the TOU period and process water requirement. Both a script (Appendix B: Simulation model - Flownex script) and Excel components were used in Flownex SE to ensure the simulation would run according to the proposed pumping methodology. The script in Flownex SE implemented the proposed pumping methodology while the Excel components ensured that average rainfall (Appendix D: Rainfall) for a particular time interval was implemented. Excel components were also used to ensure that the concentrator process water requirement was taken into consideration (Appendix A: Concentrator requirement).

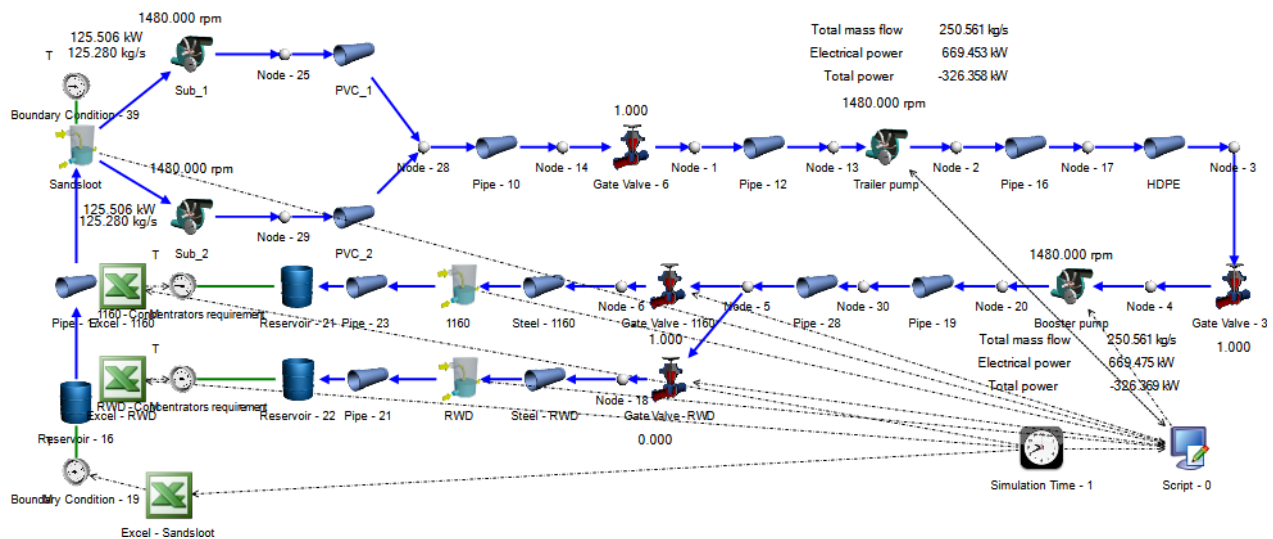


Figure 30: Final simulation layout

A description of the components used in the simulation is provided in Appendix I: Simulation component description. A description of the boundary conditions present in the simulation is provided in Appendix J: Flownex SE Boundary conditions. Two solution methods will be used in Flownex SE:

- Steady state: this will be used to indicate the initial accuracy of the simulation when compared with the numerical investigation as well as the in-field measurements.
- Transient variable analysis: this will be used after the steady state analysis to simulate the current – and proposed pumping methodology over a period of time. The time increment used in the transient variable analysis was as short as possible to get the most accurate results (fifteen minute increments).

3.2. Proposed pumping methodology

The equipment used in an open pit mining operation is exposed to numerous risks in the presence of excessive amounts of water. It is therefore critical for an open pit mining operation to have as little water as possible present during any form of mining activity. Currently there are large quantities of water stored in two of the five pits at Mogalakwena Mine, namely Central pit and Sandsloot pit. In Sandsloot pit there is no mining activity while Central pit is expanding rapidly resulting in a need to remove all the water therein. Water from these pits are used as one of several sources for the concentrators' required process water. It is pumped from the designated pit towards one of the storage dams (Return Water Dam or Rockfill dam) and then utilized by the concentrators as required (flow diagram illustrated in Figure 31). Each concentrator constantly require water from both storage dams for different sections of the operation. For this reason the water flow towards the concentrators from the storage dams will not form part of the proposed pumping methodology.

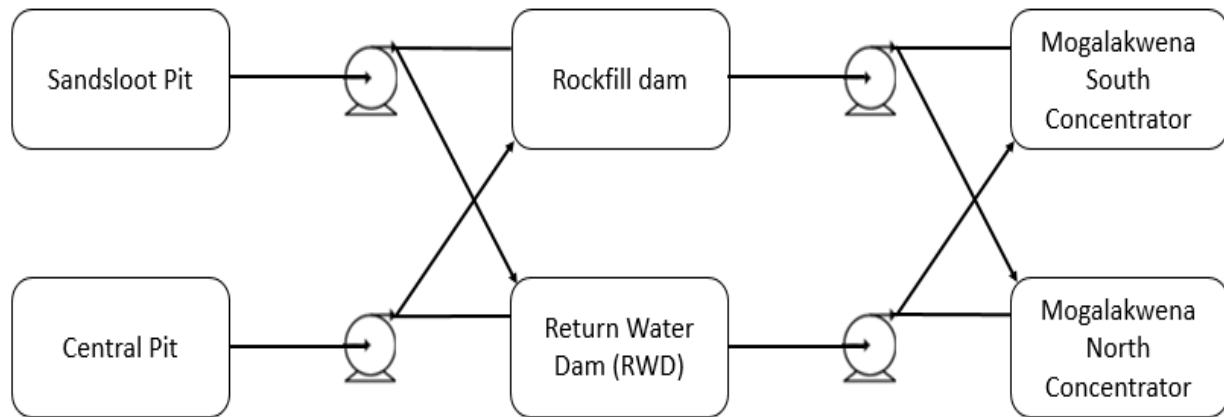


Figure 31: Water flow diagram from pit to concentrator

Future objectives for Mogalakwena mine is to join three of its five pits (North, Central and South pit) and pump all excess water towards Sandsloot Pit with its vast water storage capacity (Figure 32). For this reason the main focus will be placed on scheduling and improving the pumping process from Sandsloot pit towards the storage dams feeding the concentrators. The pump orientation used during this particular phase was previously illustrated in Figure 26.



Figure 32: Sandsloot pit

The minimum and maximum capacities for all the storage facilities involved is of vital importance. The minimum allowable water capacity of 40% was specified by the concentrator engineers while taking into account the necessity of continuous supply of process water along with the possibility of a pit dewatering pump failure. Furthermore the minimum level also prevents pumping mud, ensure water availability to flush the pipes and maintain sufficient water to run through the plant after a shutdown before start up. The dewatering operation is only allowed to pump water towards the storage dams until it reaches a maximum of 85%. The reason for this is to provide a buffer during raining season to protect the surrounding area against flooding. The boundary condition prevents

frequent starting and stopping of the motors to avoid potential breakdowns (if the pump starts when the destination level is below 40% it will continue to run until it reaches a minimum of 45% and if the pump stops when the destination level reaches 85% it is not allowed to start up again until the level is at least 80%):

$$W_{min} = W_{tot} \times 40\% \quad (30)$$

$$W_{lower\ boundary} = W_{tot} \times 45\% \quad (31)$$

$$W_{upper\ boundary} = W_{tot} \times 80\% \quad (32)$$

$$W_{max} = W_{tot} \times 85\% \quad (33)$$

Where W_{tot} is the total water capacity (l), W_{min} is the minimum water capacity (l), $W_{lower\ boundary}$ is the lower boundary capacity (l), $W_{upper\ boundary}$ is the upper boundary capacity (l) and W_{max} is the maximum water capacity (l).

The processing plants at Mogalakwena Complex receive water from various sources. These sources are water from the pits, waste water from the local municipality, rain water and water returning from the tailings dams. Water entering the processing plants are recorded on the supervisory control and data acquisition (SCADA) software for each individual concentrator. From here it was possible to calculate the average water requirement from the storage facilities (RWD and Rockfill dam). The water required by the concentrators from RWD and Rockfill dam was acquired for a period of six months and the average daily requirement is displayed in Figure 33. The concentrators are continuously running and constantly require water. The demand remains approximately the same throughout the year only changing when the plants are shut down for scheduled maintenance. All rainfall events at Mogalakwena Mine was recorded (Appendix D: Rainfall) and the average rainfall per event for each month for the years of 2007 to 2017 is illustrated in Table 1.

Table 1: Average rainfall per event for 2007 to 2017

Rainfall (mm)	
January	104.59
February	69.73
March	73.82
April	63.73
May	15.00
June	2.91
July	1.09
August	0.36
September	14.64
October	51.64
November	100.91
December	140.59

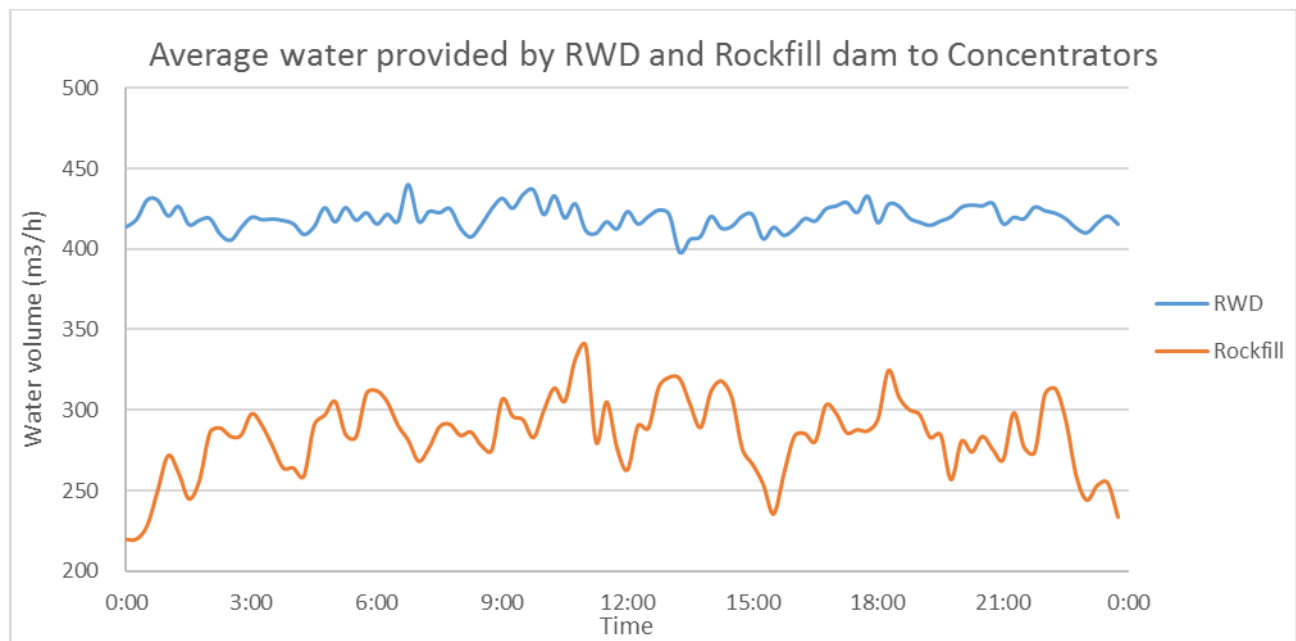


Figure 33: Average water provided by RWD and Rockfill dam to concentrators

The current manual control methodology is to pump water towards one of the storage dams for several days and then switch to a different storage dam or to switch the pumps off until water is required again. The aim of the proposed methodology from this study is to reduce power consumption, primarily during the peak TOU periods (Figure 34). Low demand season represents the period between September and May the following year while high demand season represents the period between June and August. The cost of electricity during high demand season is higher than low demand season. There are three TOU periods: off-peak, standard and peak. Comparing the electricity demand to the different TOU periods, the demand is the highest during peak TOU and the lowest during off-peak TOU. The cost of electricity follows the same course being the most expensive during peak TOU and the least expensive during off-peak TOU.

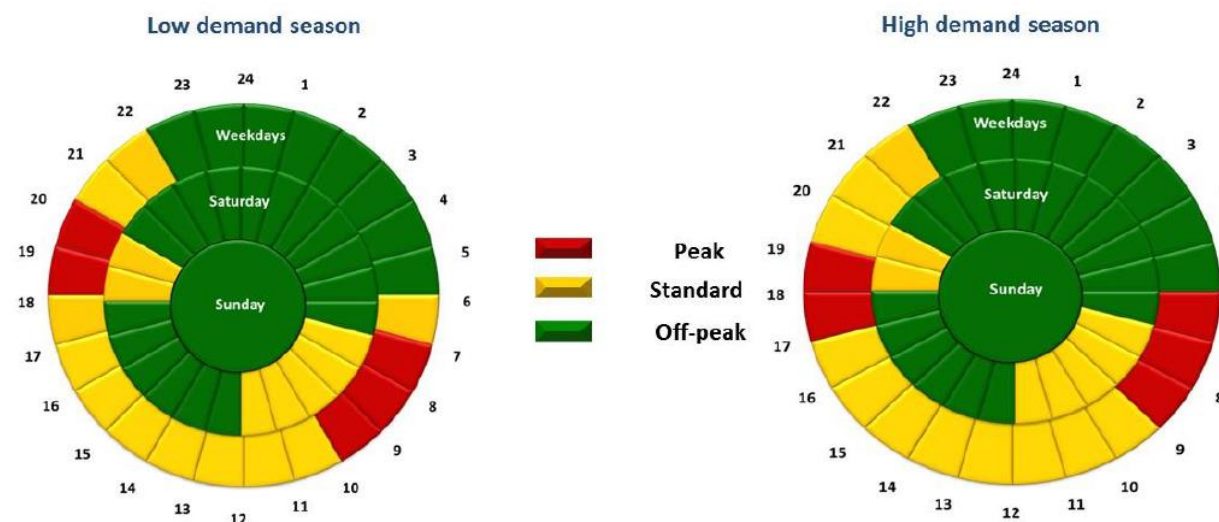


Figure 34: Megaflex low and high demand TOU periods (Eskom, 2018)

Figure 35 below illustrates the proposed pumping methodology. The pumping conditions (yellow blocks) for each individual pump orientation (blue blocks) can be awarded a condition value (green and red blocks) of either true or false. Pumping towards a specific water storage facility depends on the results of the pump orientation and pump status (orange blocks). If all the pumping conditions obtain true condition values for a specific pump orientation, the pump status will result in the pumps either turning on or staying on and pump water towards the predetermined destination. Alternatively, if any of the pumping conditions obtains a false condition, value of a specific pump orientation, water will not be pumped according to the specified pump orientation. When both pump orientations obtain false condition values, it will result in the final pump status to turn the pumps off or remain off until required differently. The proposed pumping methodology was implemented in the simulation model using the Script component in Flownex SE.

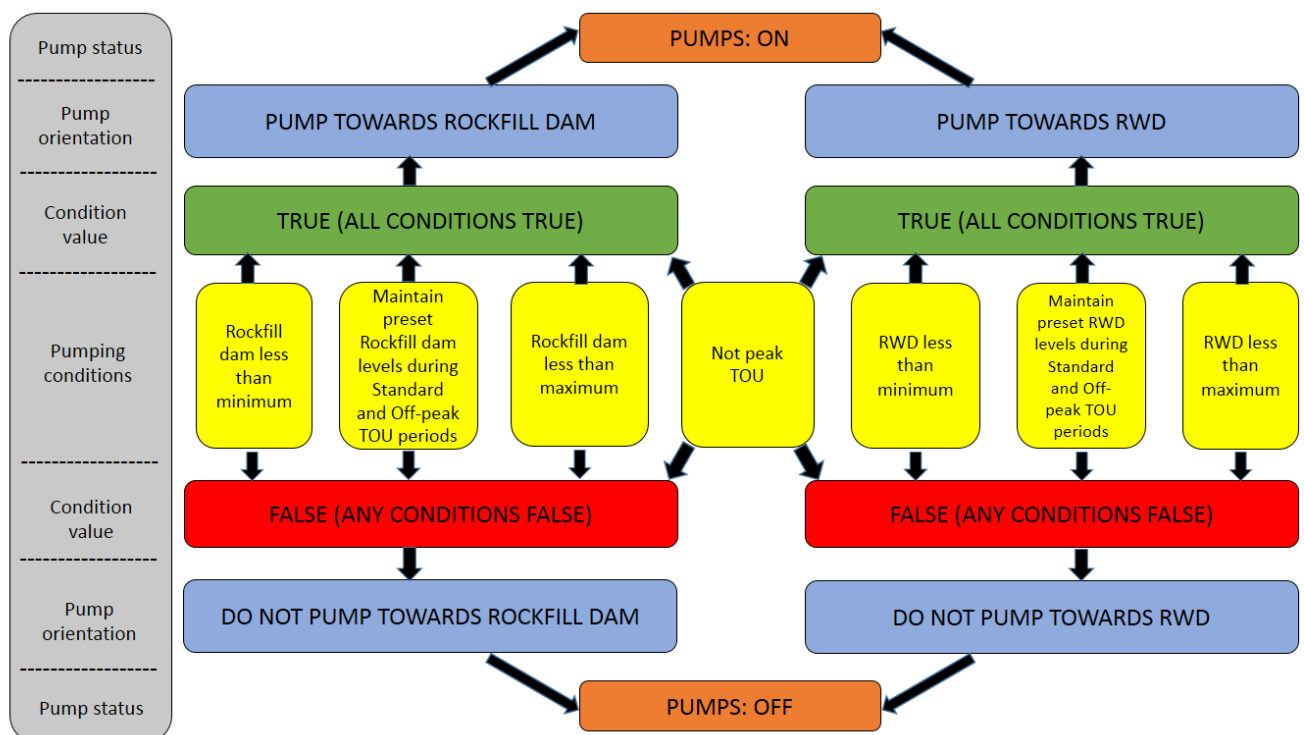


Figure 35: Proposed new pumping methodology

The objective of the proposed pumping methodology is as follow:

- Prevent both water storage dams (Rockfill dam and RWD) from reaching a capacity below minimum.
- Maintain adequate water capacities in the water storage dams.
- Prevent the capacities exceeding the maximum level.
- Prevent, as far as possible, pumping during peak TOU periods.

After implementation of the proposed pumping methodology, a cost saving analysis must be done using the equations below. This is done by calculating the total energy consumption before (Z_{cost}

before) and after ($Z_{cost\ after}$) implementation of the proposed pumping methodology and comparing the energy related cost (Cilliers, 2014):

$$Z_{cost\ saving} = Z_{cost\ before} - Z_{cost\ after} \quad (34)$$

$$Z_{cost} = (\sum_{n=1}^i E_{off-peak} \times C_{off-peak}) + (\sum_{n=1}^j E_{standard} \times C_{standard}) + (\sum_{n=1}^k E_{peak} \times C_{peak}) \quad (35)$$

Where $Z_{cost\ saving}$ is the projected energy cost saved after implementation of the new proposed pumping methodology (R), $Z_{cost\ before}$ is the energy cost of the existing pumping methodology (R), $Z_{cost\ after}$ is the energy cost of the proposed pumping methodology (R). Z_{cost} is the result of the method used to calculate the energy cost regardless of the pumping methodology (R), i is the number of applicable off-peak TOU hours (h), $E_{off-peak}$ is the energy consumption during off-peak TOU periods (kW), $C_{off-peak}$ is the energy cost during off-peak TOU period according to the Megaflex tariff (R/kWh), j is the number of applicable standard TOU hours, $E_{standard}$ is the energy consumption during standard TOU periods (kW), $C_{standard}$ is the energy cost during standard TOU period according to the Megaflex tariff (R/kWh), k is the number of applicable peak TOU hours, E_{peak} is the energy consumption during peak TOU periods (kW) and C_{peak} is the energy cost during peak TOU period according to the Megaflex tariff (R/kWh).

3.3. Practical Measurements

The final element of the methodology will represent the in-field measurements that will serve as validation of the results obtained from the mathematical models. Due to the criticality of this element in the study, special focus was given to make certain the measurements were accurate. In-field measurements of the water flow rate and power consumption of Sandsloot pit booster pump station will be recorded whilst pumping water towards the storage dams. Water flow measurements were taken with a SiteLab SL1188 ultrasonic meter (Figure 36) and the power consumption was recorded with a Dent recording poly phase power meter (Figure 37). The instrumentation was calibrated and installed by trained professionals (further installation details are provided in Appendix K: Instrumentation installation). These measurements were taken at Sandsloot pit booster pump station (Figure 38).

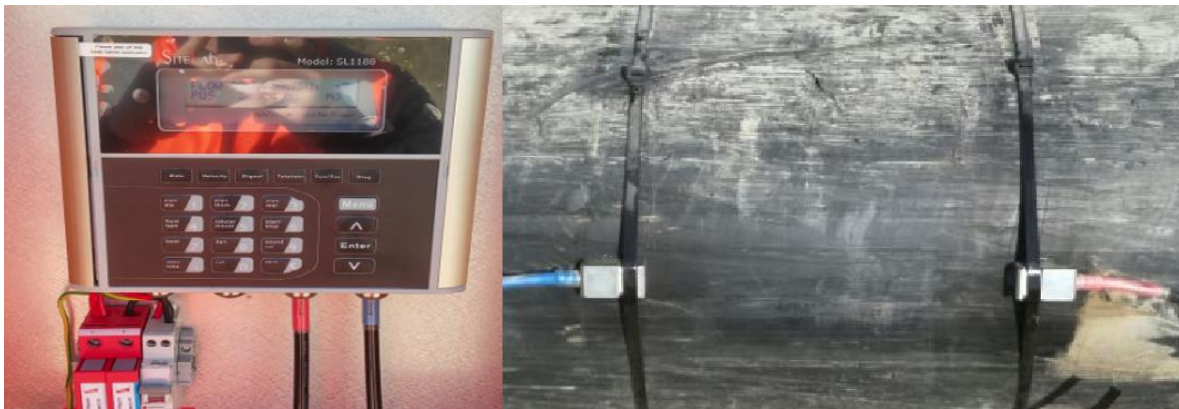


Figure 36: SiteLab SL1188 ultrasonic meter data storage unit and attached sensors used at Sandsloot Pit



Figure 37: Installation of Dent ElitePro Recording Poly Phase Power Meter



Figure 38: Sandsloot booster pump station

Power consumption and water flow rate were recorded for a total of twelve weeks. The Dent power meter was used to record the phase voltage as well as the phase current at Sandsloot pit booster pump station. An energy information and reporting service that provides Mogalakwena Complex with online information on energy usage, eiEnterprise, was used to obtain the average power factor based on an entire year of previous power factor values (a calculated power factor value of 75% was used). Together, the data was used to calculate the power consumption of the pump using equation (39).

The Dent power meter has a typical accuracy of less than 1% while the attached current transformers have an accuracy of approximately 0.5% - 1% (DENT Instruments, 2018) and the SiteLab SL1188 ultrasonic meter has an accuracy of approximately 1% (SiteLab, 2016). The possibility of site measurement inaccuracies still exists but every step in the process was carefully considered and the appropriate steps were taken to ensure the most accurate measurements possible were

obtained. After collection and analysis of the recorded data, the validity of both the mathematical models are determined.

$$P = 3 \times V_{ph} \times I_{ph} \times PF \quad (36)$$

Where P is the power (W), V_{ph} is the phase voltage, I_{ph} is the phase current, PF is the power factor.

3.4. Summary

In this chapter the methodology followed in creating the numerical model, simulation model as well as accumulating the necessary information to validate both models are stated explicitly. Included in the methodology are the equations used as well as the proposed new pumping methodology that will result in successfully shifting the electrical load away from peak TOU periods while maintaining adequate storage dam capacities.

CHAPTER 4: RESULTS

The previous chapter discussed the methods used to achieve the desired results. Included in this chapter is both the verification and validation of the mathematical models. Furthermore, the proposed pumping methodology will be investigated for five potential dewatering scenarios to demonstrate the possible energy cost savings that can be achieved by improving the dewatering pumping methodology.

4.1. Verification and validation of mathematical models

In-field measurements were taken during normal operations to validate the accuracy of the mathematical models. The in-field measurements were taken at Sandsloot pit booster pump station and included the power consumption of only the booster pump, not the entire investigated dewatering network, as well as the water flow rate. The investigated dewatering network consists of a trailer pump, booster pump and two submersible pumps as displayed previously in Figure 26. Power consumption measurements were taken only at the booster pump station because to take measurements at the submersible pumps are nearly impossible, due to space constraints in the supply cabinet, and the power consumption of the trailer pump and booster pump are assumed equal due to the pumping orientation (Figure 26). The in-field measurements along with the systems' operating condition, while the measurements were taken, were compared with the mathematical models in order to verify and validate the models.

During the twelve weeks that in-field measurements were taken, different operating scenarios were observed for varying time periods. This included i) a period where the pumps were operating with the valves fully open for two weeks, ii) a period of five weeks where the pumps were operational with valves partially open (approximately 25%) and the remainder of the measured data shows that the pumps were off and was therefore discarded (system curves for both operating scenarios included in Appendix C: Numerical model - System graph). During both the operating scenarios, the pumps were predominantly operational with no consideration of the TOU periods (one month of in-field measurement data included in Appendix M: In-field measurements). The pumping destination changed regularly from Rockfill dam to RWD. The decision was made manually with no information recorded with regards to the time the orientation changed back and forth between the two possible pumping destinations. The total volume of water pumped to Rockfill dam and RWD were recorded for each day and taken into consideration for further evaluation (Appendix H: Volume of pumped water).

4.1.1. Comparison – First operating scenario

During the first operating scenario, the pumps were predominantly on and the valves fully open. The results for the first operating scenario will be illustrated with the following:

- The average power consumption and water flow rate (using the actual in-field measurements and the different simulated values) for the entire applicable period (Table 2).
- A daily average graph to demonstrate the lack of TOU consideration and to highlight repeating actions or a lack thereof. It presents the average values for the power consumption and water flow rate at Sandsloot pit booster pump station measured in fifteen minute intervals for the entire applicable period (Figure 39).
- The total energy consumption, volume of water transferred and energy related cost of the recorded pump (Table 3).

Table 2: Initial comparison of the first operating condition

	Power (kW)	Flow rate (l/s)
Numerical Model	674.91	249.24
Simulation Model	668.93	249.20
In-Field Measurements	678.94	248.18

In Table 2 the numerical model had a 0.59% deviation in average power consumption and a 0.43% deviation in average water flow rate from the in-field measurements. The simulation model had a 1.47% deviation in average power consumption and a 0.41% deviation in average water flow rate from the in-field measurements. Potential reasons for the deviations are:

- Theoretically ideal circumstances that differ from the actual circumstances during normal operation.
- Measurement practices not adhering strictly to OEM (original equipment manufacturer) guidelines and requirements.
- Administrative habits from mine personnel leading to inaccurate assumptions, calculations and deviations in actual and assumed site specific circumstances.

The power consumption measurements have an accuracy of 2%, as mentioned previously, while the flow rate measurements have an accuracy of 1%. Both mathematical models produced results within the uncertainty bounds.

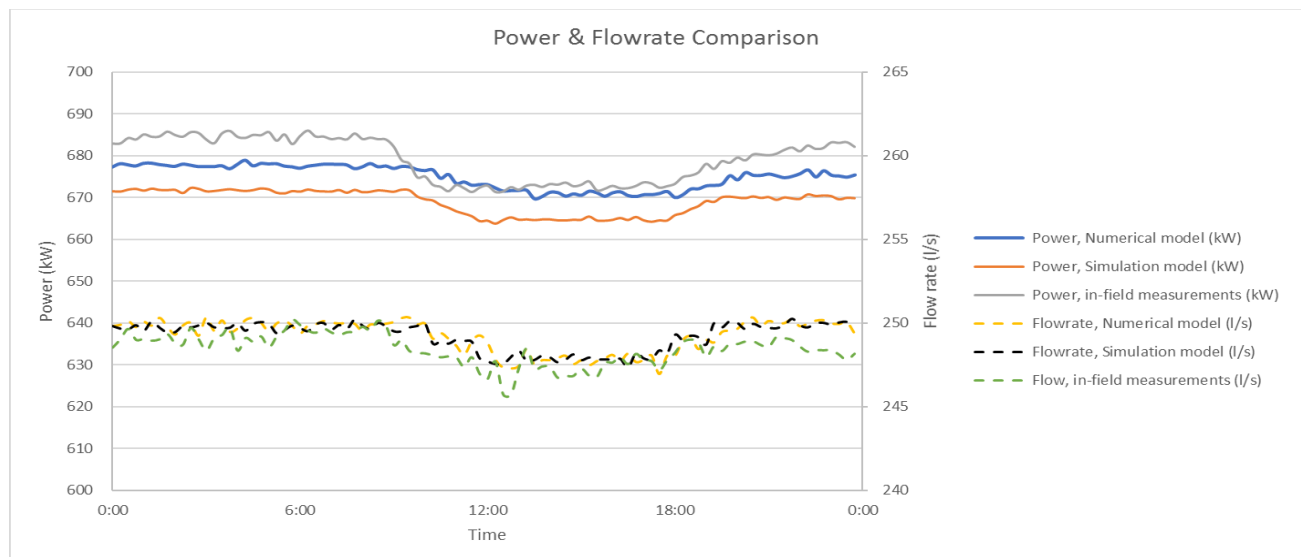


Figure 39: Daily average graph of the first operating scenario

Figure 39 represents the daily average graph comparing both the power (kW) and water flow rate (l/s) obtained from both models and in-field measurements. Minimal deviation can be observed in both the power and flow rate graphs. A straight line is not present because all the calculated values took the different changes in circumstances into consideration. These change are: change in submersible pump elevation, change in surrounding temperature, change in direction, etc. During the hours of 12:00 and 18:00 there were several interruptions in the dewatering operation leading to the slight dip noticed above. Possible reasons therefore are: required maintenance of dewatering equipment, breakdown of dewatering equipment, etc.

Table 3: Comprehensive comparison of the first operating scenario

	Consumed Energy (kWh)	Pumped water volume (kl)	Energy Cost (R)
Numerical Model	206,015.92	273,891.89	166,872.90
Simulation Model	204,246.66	273,696.64	165,439.79
In-Field Measurements	207,247.51	272,729.30	167,870.48

In Table 3 the numerical model had a 0.59% deviation in total energy consumption and a 0.43% deviation in total volume of pumped water from the in-field measurements. The simulation model had a 1.45% deviation in total energy consumption and a 0.35% deviation in total volume pumped water from the in-field measurements. The illustrated energy cost was calculated according to 2018/2019 Eskom Megaflex tariff. As shown in Table 3 the mathematical models consumed less energy while pumping more water. The deviation in total energy consumption and volume of water transferred can also be attributed to the small deviation regarding average power consumption and water flow rate over an extended period of time. Possible reasons therefore are deviations in the actual and assumed pump and electrical efficiency.

4.1.2. Comparison – Second operating scenario

During the second operating scenario, the pumps were predominantly on and the valves were only partially open. The results for the second operating scenario will be illustrated with the following:

- The average power consumption and water flow rate (using the actual in-field measurements and the different simulated values) for the entire applicable period (Table 4).
- A daily average graph to demonstrate the lack of TOU consideration and to highlight repeating actions or a lack thereof. It presents the average values for the power consumption and water flow rate at Sandsloot pit booster pump station measured in fifteen minute intervals for the entire applicable period (Figure 40).
- The total energy consumption, volume of water transferred and energy related cost of the recorded pump (Table 5).

Table 4: Initial comparison of the second operating condition

	Power (kW)	Flow rate (l/s)
Numerical Model	656.57	233.02
Simulation Model	657.37	233.80
In-Field Measurements	666.99	231.03

In Table 4 the numerical model had a 1.57% deviation in average power consumption and a 0.86% deviation in average water flow rate from the in-field measurements. The simulation model had a 1.44% deviation in average power consumption and a 1.20% deviation in average water flow rate from the in-field measurements. Potential reasons for the deviations are:

- Theoretically ideal circumstances that differ from the actual circumstances during normal operation.
- Measurement practices not adhering strictly to OEM (original equipment manufacturer) guidelines and requirements.
- Administrative habits from mine personnel leading to inaccurate assumptions, calculations and deviations in actual and assumed site specific circumstances.

The power consumption measurements have an accuracy of 2%, as mentioned previously, while the flow rate measurements have an accuracy of 1%. Both mathematical models produced results within the uncertainty bounds.

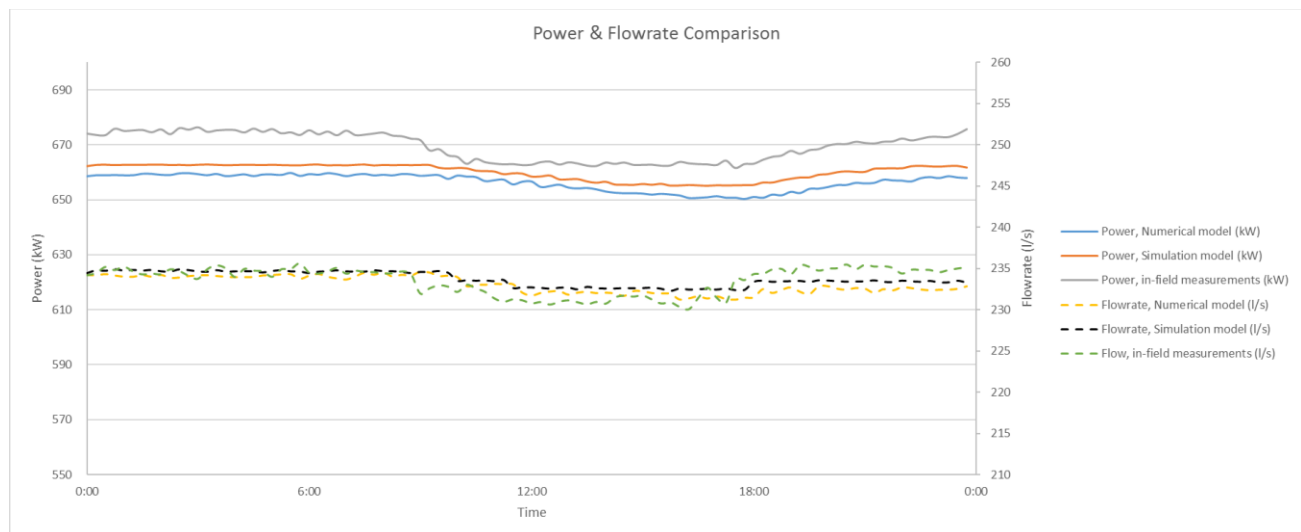


Figure 40: Daily average graph of the second operating condition

Figure 40 represents the daily average graph comparing both the power (kW) and water flow rate (l/s) obtained from both models and the in-field measurements. Minimal deviation can be observed in both the power and the flow rate graphs. A straight line is not present because all the values took the different changes in circumstances into consideration. These change are: change in submersible pump elevation, change in surrounding temperature, change in direction, etc. During the hours of 12:00 and 18:00, there were several interruptions in the dewatering operation leading to the slight dip noticed above. Possible reasons therefore are: required maintenance of dewatering equipment, breakdown of dewatering equipment, etc.

Table 5: Comprehensive comparison of the second operating condition

	Consumed Energy (kWh)	Pumped water volume (kl)	Energy Cost (R)
Numerical Model	500,633.65	639,621.93	405,513.26
Simulation Model	495,492.79	634,400.06	401,349.16
In-Field Measurements	514,414.03	633,129.13	416,675.37

In Table 5 the numerical model had a 2.68% deviation in total energy consumption and a 1.03% deviation in total volume of pumped water from the in-field measurements. The simulation model had a 3.68% deviation in total energy consumption and a 0.20% deviation in total volume pumped water from the in-field measurements. The illustrated energy cost was calculated according to 2018/2019 Eskom Megaflex tariff. As shown in Table 5, the mathematical models consumed less energy while pumping more water. Possible reasons therefore are deviations in the actual and assumed pump and electrical efficiency.

4.2. Investigated improvement scenarios

In the previous section of this chapter, the mathematical models were validated with the use of in-field measurements, enabling further investigation regarding improvement of the current pit

dewatering methodology. Investigation continued by investigating five potential dewatering scenarios for Mogalakwena Complex. These scenarios will be investigated further using the previously validated simulation model. This will be done to determine the energy cost savings that can be achieved by implementing a load shifting pumping methodology to maintain sufficient water levels in RWD and Rockfill dam, while simultaneously avoiding Eskom peak TOU periods where possible. During each of the scenarios, the same volume of water is pumped to determine the energy that can be saved during peak TOU and consequently the cost saving that can be experienced. The different potential dewatering scenarios that were investigated further, entails site specific circumstances with a high possibility of occurring:

1. During an analysis of one calendar month, it rained for fifteen randomly selected days. The analysis was conducted during raining season with the average rainfall applied.
2. During an analysis of one calendar month, it rained for fifteen randomly selected days. The analysis was conducted during the dry season with the average rainfall applied.
3. Increase in dewatering specific demand for one calendar month. Possible reasons for the increase in demand can be due to production increase, decrease in water supply from the other sources, etc.
4. During an analysis of one calendar month, no rain was experienced while the process water requirement remained the same.
5. An analysis of four calendar months with normal dewatering operation.

4.2.1. Scenario 1 – Raining fifteen days during raining season.

Rain is one of the most significant contributors to water accumulation at an open pit mining operation. RWD and Rockfill dam are uncovered and capable of collecting rain. Substantial contributions of rain water towards RWD and Rockfill dam will assist in maintaining adequate water levels in both storage dams. This will reduce the need of pumping water from the pits, primarily Sandsloot pit, towards the storage dams to fulfil the need of the concentrators. Load shifting potential will therefore be enhanced because less water needs to be pumped from Sandsloot pit towards the storage dams to fulfil in the average demand of the concentrators. This will result in reduced pit dewatering energy costs calculated according to Eskom low demand season tariffs as the low demand tariffs coincide with the raining season.

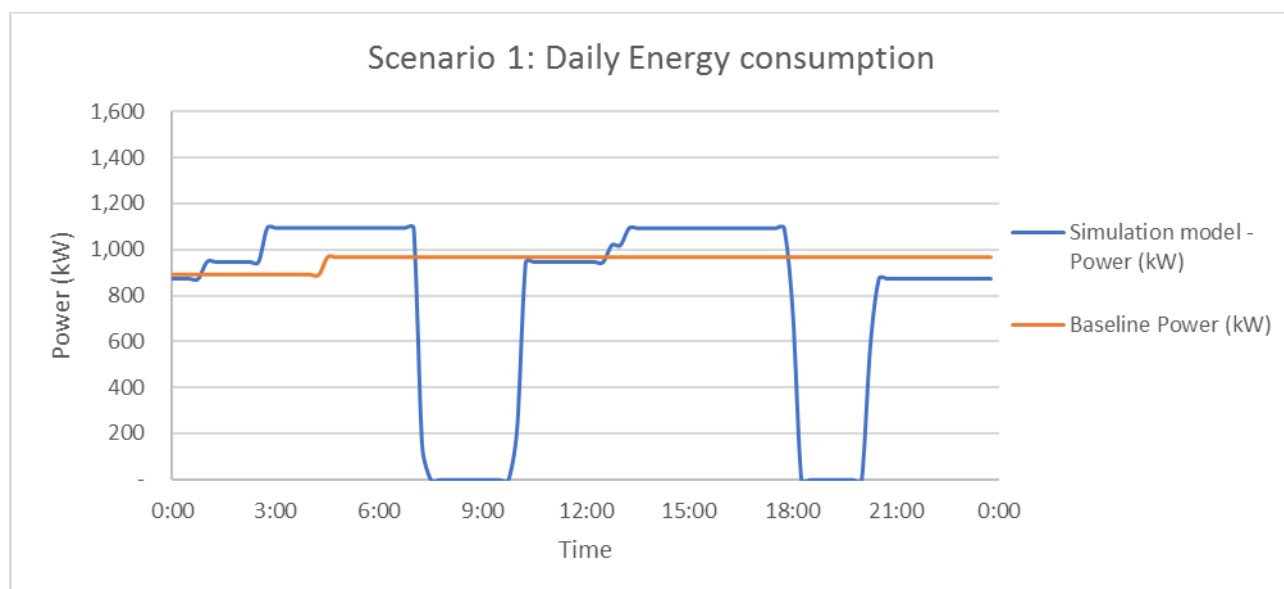


Figure 41: Scenario 1 - Weekday energy consumption

Figure 41 represents the weekday average graph comparing the power consumption of the simulation model for the first scenario with the baseline power consumption. The baseline power consumption graph was developed using the validated Flownex SE model along with the current pumping methodology of pumping water towards the designated locations with no consideration of the TOU periods while taking the site requirement and relevant scenario into account. The simulation model graph was developed using the validated Flownex SE model along with the proposed pumping methodology while taking the site requirement and relevant scenario into account. Figure 41 illustrates that load shifting was applied for the proposed pumping methodology but not the current pumping methodology. Table 6 shows the energy shifted out of the peak TOU period (kWh) and energy cost savings (R) for the proposed pumping methodology. During the theoretical investigation, the same volume of water was pumped for the proposed – and current pumping methodology.

Table 6: Scenario 1 – Energy consumption and saving

	Energy shifted from peak TOU (kWh)	Energy cost savings (R)
Simulation model	104,281.05	93,185.55

4.2.2. Scenario 2 – Raining fifteen days during dry season.

Rain is one of the most significant contributors to water accumulation at an open pit mining operation. RWD and Rockfill dam are uncovered and capable of collecting rain. Substantial contributions of rain water towards RWD and Rockfill dam will assist in maintaining adequate water levels in both storage dams. This will reduce the need of pumping water from the pits, primarily Sandsloot pit, towards the storage dams to fulfil the need of the concentrators. Load shifting potential will therefore be enhanced because less water needs to be pumped from Sandsloot pit towards the storage dams to fulfil in the average demand of the concentrators. This will result in reduced pit dewatering energy costs

calculated according to Eskom high demand season tariffs as the high demand tariffs coincide with the dry season.

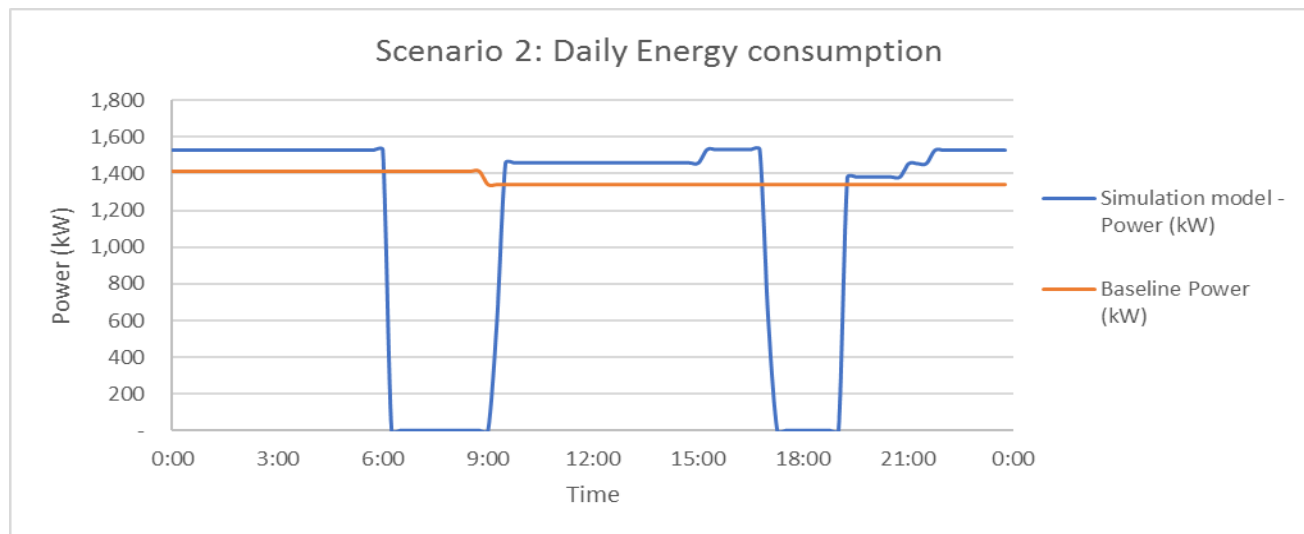


Figure 42: Scenario 2 - Weekday energy consumption

Figure 42 represents the weekday average graph comparing the power consumption of the simulation model for the second scenario with the baseline power consumption. The baseline power consumption graph was developed using the validated Flownex SE model along with the current pumping methodology of pumping water towards the designated locations with no consideration of the TOU periods while taking the site requirement and relevant scenario into account. The simulation model graph was developed using the validated Flownex SE model along with the proposed pumping methodology while taking the site requirement and relevant scenario into account. Figure 42 illustrates that load shifting was applied for the proposed pumping methodology but not the current pumping methodology. Table 7 shows the energy shifted out of the peak TOU period (kWh) and energy cost savings (R) for the proposed pumping methodology. During the theoretical investigation, the same volume of water was pumped for the proposed – and current pumping methodology.

Table 7: Scenario 2 – Energy consumption and saving

	Energy shifted from peak TOU (kWh)	Energy cost savings (R)
Simulation model	151,744.85	415,720.19

4.2.3. Scenario 3 - Increase in pit dewatering specific demand.

An increase in required process water from the pit dewatering operation will result in a decrease in load shift potential. Different reasons can lead to an increase in the required process water from the pit dewatering operation such as: a decrease in water received from other sources (such as the water received from the effluent water treatment plant in Polokwane), an increase in concentrator production, etc. For this scenario, it is assumed that there is no rainfall. A 25% increase in demand was assumed to test the capability of the proposed pumping methodology. Appropriate load shifting

methodology will result in energy cost savings when compared to the current manual methodology calculated according to Eskom low demand season tariffs.

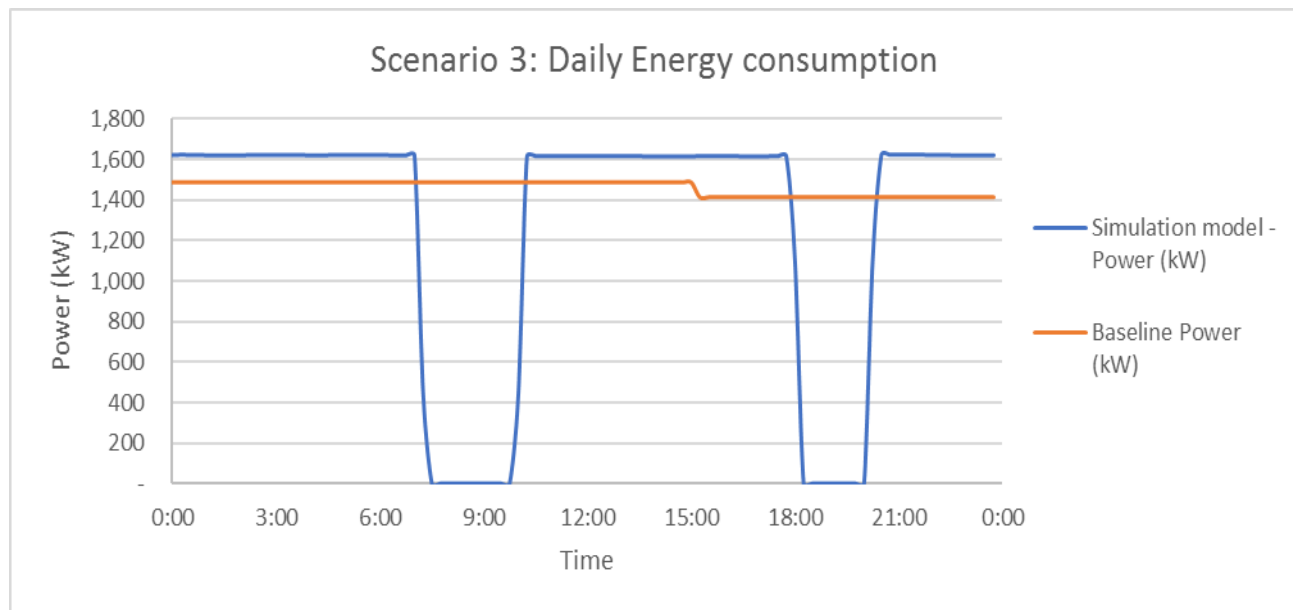


Figure 43: Scenario 3 - Weekday energy consumption

Figure 43 represents the weekday average graph comparing the power consumption of the simulation model for the third scenario with the baseline power consumption. The baseline power consumption graph was developed using the validated Flownex SE model along with the current pumping methodology of pumping water towards the designated locations with no consideration of the TOU periods while taking the site requirement and relevant scenario into account. The simulation model graph was developed using the validated Flownex SE model along with the proposed pumping methodology while taking the site requirement and relevant scenario into account. Figure 43 illustrates that load shifting was applied for the proposed pumping methodology but not the current pumping methodology. Table 8 shows the energy shifted out of the peak TOU period (kWh) and energy cost savings (R) for the proposed pumping methodology. During the theoretical investigation, the same volume of water was pumped for the proposed – and current pumping methodology.

Table 8: Scenario 3 – Energy consumption and saving

	Energy shifted from peak TOU (kWh)	Energy cost savings (R)
Simulation model	155,397.32	138,863.05

4.2.4. Scenario 4 - No rain for one calendar month.

Rain is one of the most significant contributors to water accumulation at an open pit mining operation. If it doesn't rain for a substantial period, more water will have to be pumped from the pit towards the water storage dams. This will limit load shift opportunities to peak TOU period as the pumps will have to run for longer periods. The proposed dewatering methodology however still shows that cost

savings are possible when compared to the current manual control methodology. Electricity costs for this scenario is calculated according to Eskom high demand season tariffs.

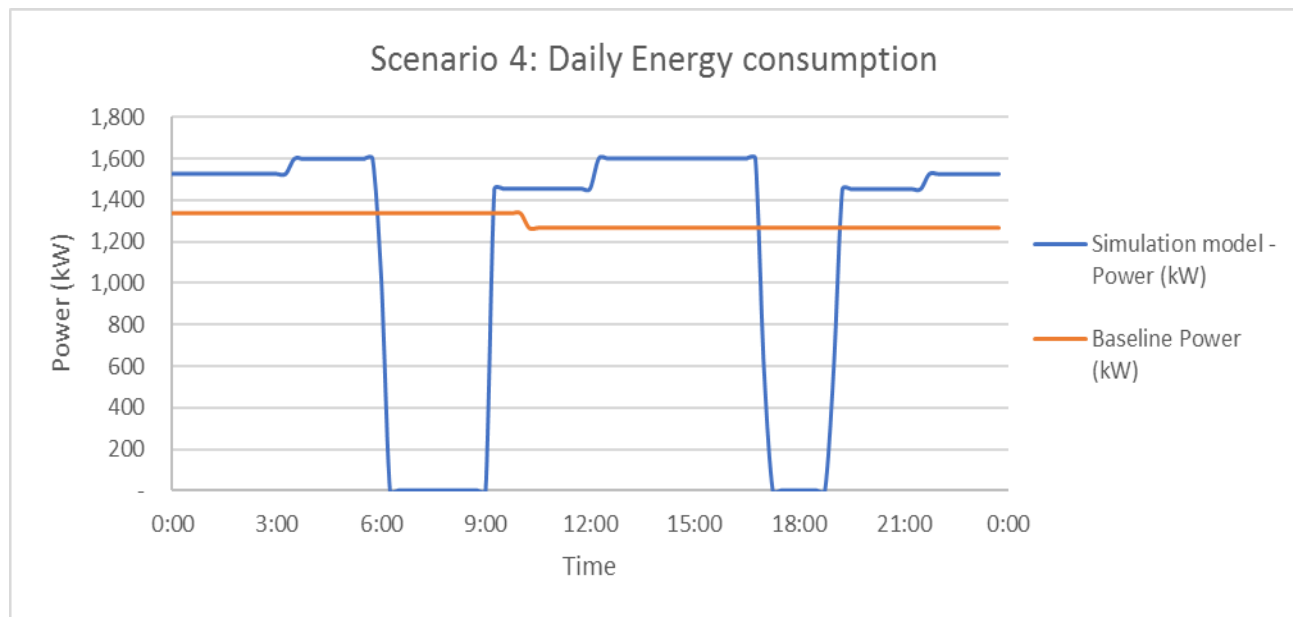


Figure 44: Scenario 4 - Weekday energy consumption

Figure 44 represents the weekday average graph comparing the power consumption of the simulation model for the fourth scenario with the baseline power consumption. The baseline power consumption graph was developed using the validated Flownex SE model along with the current pumping methodology of pumping water towards the designated locations with no consideration of the TOU periods while taking the site requirement and relevant scenario into account. The simulation model graph was developed using the validated Flownex SE model along with the proposed pumping methodology while taking the site requirement and relevant scenario into account. Figure 44 illustrates that load shifting was applied for the proposed pumping methodology but not the current pumping methodology. Table 9 shows the energy shifted out of the peak TOU period (kWh) and energy cost savings (R) for the proposed pumping methodology. During the theoretical investigation, the same volume of water was pumped for the proposed – and current pumping methodology.

Table 9: Scenario 4 – Energy consumption and saving

	Energy shifted from peak TOU (kWh)	Energy cost savings (R)
Simulation model	148,897.24	407,918.88

4.2.5. Scenario 5 – Normal dewatering operation for four consecutive months.

The final scenario considered for further investigation is an analysis of the proposed pumping methodology for four consecutive months. The reason for this particular scenario is to calculate the potential energy cost savings per annum. For this analysis, the following circumstances are applicable:

- The average concentrator demand was requested.

- Average applicable rainfall was experienced.
- Both high – and low Eskom demand seasons were applicable.
- Months with both above and below average rainfall were used.

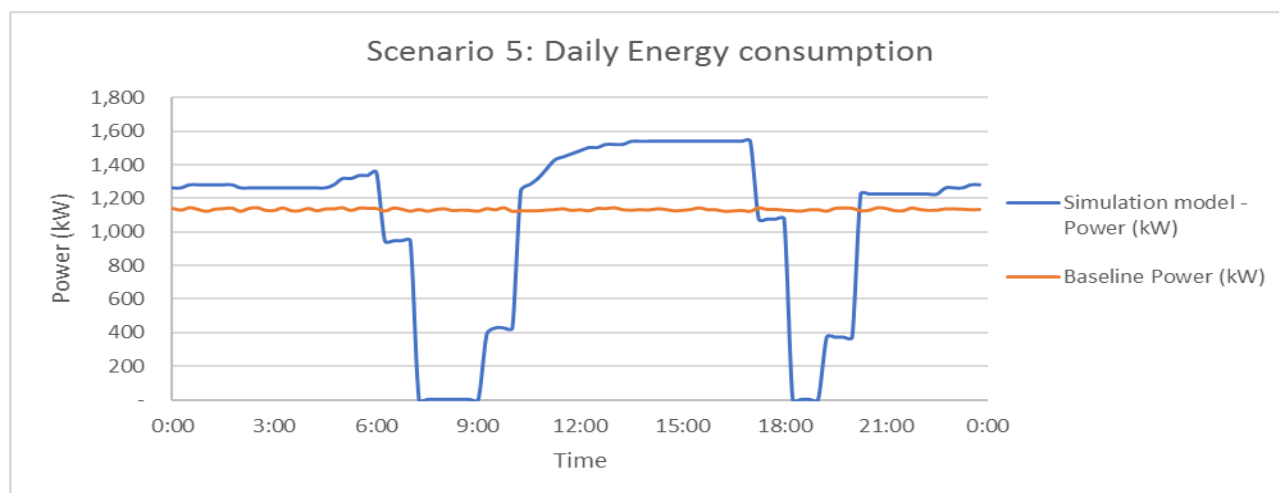


Figure 45: Scenario 5 - Weekday energy consumption

Figure 45 represents the weekday average graph comparing the power consumption of the simulation model for the fifth scenario with the baseline power consumption. The baseline power consumption graph was developed using the validated Flownex SE model along with the current pumping methodology of pumping water towards the designated locations with no consideration of the TOU periods while taking the site requirement and relevant scenario into account. The simulation model graph was developed using the validated Flownex SE model along with the proposed pumping methodology while taking the site requirement and relevant scenario into account. Figure 45 illustrates that load shifting was applied for the proposed pumping methodology but not the current pumping methodology. Table 10 shows the shifted out of the peak TOU period TOU (kWh) and energy cost savings (R) for the proposed pumping methodology. During the theoretical investigation, the same volume of water was pumped for the proposed – and current pumping methodology (one week of simulation results included in Appendix N: Simulation results).

Table 10: Scenario 5 – Energy consumption and saving

	Energy shifted from peak TOU (kWh)	Energy cost savings (R)
Simulation model	498,935.00	702,536.46

After investigation of the fifth scenario was concluded, the potential energy saving per annum can be calculated. Improvement of the dewatering operation through the proposed pumping methodology can result in 1,496,805 kWh energy being shifted away from peak TOU. This will result in a potential energy cost savings of R2,107,609. The cost of acquiring the required telemetry (Appendix L: Telemetry cost) to implement the proposed pumping methodology is R138, 239. The

labour required for installation and implementing the pumping methodology will be provided by the mine. This results in a payback period of one month.

4.3. Summary

From the results presented in this chapter it is clear there is a significant dewatering energy cost savings opportunity at an open pit mine. This opportunity entails shifting the energy consumption away from peak TOU periods. Several potential dewatering scenarios were investigated for the case study mine. For every investigated scenario there were load shifting potential when comparing the current manual pump methodology with the proposed pumping methodology. The magnitude of the saving depended on different variables such as: raining frequency, average rainfall per event, process water demand, etc. The first four scenarios analysed the proposed pumping methodology under strenuous circumstances while the final scenario investigated it under normal circumstances for an extended period.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Mines in general are directly dependant on numerous variables for continuous operation. One of the most significant of these variables is electricity. Different mining associated electricity saving areas were identified in Chapter 1, with pumping an area with decent energy savings possibilities.

Comprehensive research was conducted in the field of mine dewatering. Included in the research are different pump scheduling methods as well as the reasoning behind pump scheduling applications. Several examples of automated underground dewatering systems were discussed but there are no instances of automating the dewatering operation of an open pit mine.

A thorough investigation was conducted into developing an automated pumping methodology along with the benefits coupled with the implementation thereof. It provided the necessary theoretical background as well as operation specific circumstances to take into consideration. Conclusion of the investigation led to:

- A detailed numerical model of the dewatering network as basis for the pumping methodology.
- A detailed simulation model of the dewatering network as verification for the pumping methodology.
- Acquired in-field measurements during normal operation of the dewatering operation of the case study mine as validation for the pumping methodology.
- Simulated five potential dewatering scenarios for the case study mine to ascertain the possible energy cost savings that can be achieved with an improved pumping methodology.

A test phase was not implemented at the mine of the developed pumping methodology due to operational constraints. Implementation of the proposed pumping methodology can result in 1,497 MWh of energy shifted away from peak TOU periods according to the fifth investigated scenario. This will result in an annual energy cost savings of R 2.107m.

5.2. Recommendations

It is recommended to implement the proposed pumping methodology. This will entail: installation of accurate measurement equipment, automated control of instruments and equipment, scheduled maintenance along with regular inspection on all applicable instruments and equipment. Benefits include energy cost savings and possible operational benefits such as improved operational control, equipment reliability and long term sustainability.

Identified areas for further investigation are:

- Condition monitoring of all equipment and instruments: Effective condition monitoring of the mine dewatering pumps will require constant heat and vibration analysis. This will result in increased life expectancy, increased production, decreased equipment downtime, etc.
- Automated pit dewatering methodology for pits being actively mined: Similar implementation requirements and results will be present as mentioned earlier but additional mining specific variables must be taken into consideration. These considerations may include drilling, blasting, loading and hauling activities.
- Optimal pump sizing for increasing mine depth: Continued operation within the pits being actively mined will result in an increasing pressure requirement to produce adequate results. The current solution to the increasing pressure requirement is to add additional pumps in a series configuration. Equipment that is selected to operate closer to its best efficiency point will improve the efficiency of the dewatering system as a whole and will also result in fewer breakdowns. Therefore, investigating optimal pump sizing according to current and future mining conditions will produce a more energy efficient and less labour intensive solution.

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APPENDIX A: CONCENTRATOR REQUIREMENT

Table 11: Average water requirement from RWD and Rockfill dam

Time	RWD (kg/s)	Rockfill (kg/s)	Time	RWD (kg/s)	Rockfill (kg/s)
0:00	414.01	219.27	12:00	423.58	262.68
0:15	418.90	219.60	12:15	415.83	290.14
0:30	430.84	228.00	12:30	420.46	288.51
0:45	430.60	249.77	12:45	424.45	314.26
1:00	420.84	271.55	13:00	421.72	320.24
1:15	426.75	260.75	13:15	398.24	319.41
1:30	415.43	244.49	13:30	406.24	303.44
1:45	418.15	255.94	13:45	407.99	289.00
2:00	419.23	285.84	14:00	420.51	311.44
2:15	409.35	288.63	14:15	413.22	317.88
2:30	405.72	283.43	14:30	414.38	307.64
2:45	413.64	284.28	14:45	420.75	275.71
3:00	420.06	297.62	15:00	421.51	265.97
3:15	418.50	290.10	15:15	406.57	253.72
3:30	418.94	277.50	15:30	413.80	235.17
3:45	418.00	263.95	15:45	408.76	260.48
4:00	415.94	263.83	16:00	412.93	283.63
4:15	409.42	258.66	16:15	419.24	285.18
4:30	414.23	290.65	16:30	417.74	280.40
4:45	425.96	296.61	16:45	425.14	302.77
5:00	417.11	305.13	17:00	427.04	297.64
5:15	426.05	284.62	17:15	429.22	285.80
5:30	418.24	283.19	17:30	422.98	287.64
5:45	422.80	310.20	17:45	433.15	286.81
6:00	415.83	311.85	18:00	416.60	294.12
6:15	421.89	304.85	18:15	428.05	324.49
6:30	417.54	290.50	18:30	426.90	308.08
6:45	440.30	281.08	18:45	419.51	300.10
7:00	417.42	268.04	19:00	416.84	296.91
7:15	423.67	276.40	19:15	415.04	282.77
7:30	422.84	289.44	19:30	417.70	284.45
7:45	425.34	290.92	19:45	420.36	256.61
8:00	413.30	284.02	20:00	426.27	280.42
8:15	407.81	286.20	20:15	427.58	273.74
8:30	415.37	277.77	20:30	427.10	283.52
8:45	425.27	274.73	20:45	428.62	275.28
9:00	431.74	306.45	21:00	415.90	269.13
9:15	425.65	296.07	21:15	420.01	298.11
9:30	434.15	293.77	21:30	419.04	276.65
9:45	436.93	282.71	21:45	426.36	273.55
10:00	421.64	299.79	22:00	424.05	309.94
10:15	433.39	313.47	22:15	422.49	313.19
10:30	419.57	305.48	22:30	419.00	293.17

Time	RWD (kg/s)	Rockfill (kg/s)	Time	RWD (kg/s)	Rockfill (kg/s)
10:45	428.42	331.45	22:45	413.21	258.64
11:00	411.76	339.97	23:00	410.36	243.78
11:15	410.05	279.72	23:15	416.34	252.92
11:30	417.17	304.91	23:30	420.75	254.43
11:45	412.75	276.27	23:45	415.70	233.22

APPENDIX B: SIMULATION MODEL - FLOWNEX SCRIPT

```
//script using directives
//css_ref IPS.Core.dll;
//css_ref IPS.PluginInterface.dll;
//css_ref IPS.Units.dll;
//css_ref IPS.Utilities.CSharp.dll
using System;
using IPS.Properties;
using IPS.Scripting;

//script must be derived from IComponentScript
public class Script: IPS.Scripting.IComponentScript
{
    IPS.Properties.Double m_sim_t;
    IPS.Properties.Double m_days;
    IPS.Properties.Double m_time;
    IPS.Properties.Double m_density;
    IPS.Properties.Double m_sand_a;
    IPS.Properties.Double m_sand_h;
    IPS.Properties.Double m_mass_sand;
    IPS.Properties.Double m_mass_tot_sand;
    IPS.Properties.Double m_mass_min_sand;
    IPS.Properties.Double m_mass_lower_sand;
    IPS.Properties.Double m_mass_upper_sand;
    IPS.Properties.Double m_mass_max_sand;
    IPS.Properties.Double m_a_1160;
    IPS.Properties.Double m_h_1160;
    IPS.Properties.Double m_mass_1160;
    IPS.Properties.Double m_mass_tot_1160;
    IPS.Properties.Double m_mass_min_1160;
    IPS.Properties.Double m_mass_lower_1160;
    IPS.Properties.Double m_mass_upper_1160;
    IPS.Properties.Double m_mass_max_1160;
    IPS.Properties.Double m_RWD_a;
    IPS.Properties.Double m_RWD_h;
    IPS.Properties.Double m_mass_RWD;
    IPS.Properties.Double m_mass_tot_RWD;
    IPS.Properties.Double m_mass_min_RWD;
    IPS.Properties.Double m_mass_lower_RWD;
    IPS.Properties.Double m_mass_upper_RWD;
    IPS.Properties.Double m_mass_max_RWD;
    IPS.Properties.Double m_trailerpump_speed;
    IPS.Properties.Double m_boosterpump_speed;
    IPS.Properties.Double m_pump_on_off;
    IPS.Properties.Double m_TOU;
    IPS.Properties.Double m_mass_next;
    IPS.Properties.Double m_timestep;
    IPS.Properties.Double m_flow;
    IPS.Properties.Double m_valve_RWD;
    IPS.Properties.Double m_valve_1160;
    IPS.Properties.Double m_pump_orientation;
    IPS.Properties.Double m_weekday;

    double dDailyS;
    double dpeak1S;
```

```
double dpeak1E;  
double dpeak2S;  
double dpeak2E;  
double dpumpspeedHIGH;  
double dpumpspeedLOW;  
double dpumpON;  
double dpumpOFF;  
double doffpeak;  
double dpeak;  
double dvalveOPEN;  
double dvalveCLOSED;  
double dpump1160;  
double dpumpRWD;  
double dnopump;  
double dweekday;  
double dnotweekday;  
double d1;  
double d2;  
double d5;  
double d6;  
double d7;  
double d8;  
double d9;  
double d12;  
double d13;  
double d14;  
double d15;  
double d16;  
double d19;  
double d20;  
double d21;  
double d22;  
double d23;  
double d26;  
double d27;  
double d28;  
double d29;  
double d30;
```

```
//do pre simulation initialisation here
```

```
public override void Initialise()  
{  
}
```

```
//do post simulation cleanup here
```

```
public override void Cleanup()  
{  
}
```

```
//script main execution function - called every cycle
```

```
public override void Execute(double Time)  
{
```

```
//Base calculations
```

```
m_days.Value = Math.Floor(m_sim_t.Value/dDailyS);  
m_time.Value = (((m_sim_t.Value/dDailyS) - m_days.Value)*60*60*24);  
m_mass_tot_sand.Value = (m_sand_a.Value * m_sand_h.Value * m_density.Value);
```

```
m_mass_min_sand.Value = (m_mass_tot_sand.Value * 0.15);
m_mass_lower_sand.Value = (m_mass_tot_sand.Value * 0.25);
m_mass_upper_sand.Value = (m_mass_tot_sand.Value * 0.75);
m_mass_max_sand.Value = (m_mass_tot_sand.Value * 0.85);
m_mass_tot_1160.Value = (m_a_1160.Value * m_h_1160.Value * m_density.Value);
m_mass_min_1160.Value = (m_mass_tot_1160.Value * 0.4);
m_mass_lower_1160.Value = (m_mass_tot_1160.Value * 0.45);
m_mass_upper_1160.Value = (m_mass_tot_1160.Value * 0.8);
m_mass_max_1160.Value = (m_mass_tot_1160.Value * 0.85);
m_mass_tot_RWD.Value = (m_RWD_a.Value * m_RWD_h.Value * m_density.Value);
m_mass_min_RWD.Value = (m_mass_tot_RWD.Value * 0.4);
m_mass_lower_RWD.Value = (m_mass_tot_RWD.Value * 0.45);
m_mass_upper_RWD.Value = (m_mass_tot_RWD.Value * 0.8);
m_mass_max_RWD.Value = (m_mass_tot_RWD.Value * 0.85);
```

//Day of the week

```
if (m_days.Value == d1 || m_days.Value == d2 || m_days.Value == d5 || m_days.Value ==
d6 || m_days.Value == d7 || m_days.Value == d8 || m_days.Value == d9 || m_days.Value ==
d12 || m_days.Value == d13 || m_days.Value == d14 || m_days.Value == d15 || m_days.Value ==
d16 || m_days.Value == d19 || m_days.Value == d20 || m_days.Value == d21 || m_days.Value ==
d22 || m_days.Value == d23 || m_days.Value == d26 || m_days.Value == d27 || m_days.Value ==
d28 || m_days.Value == d29 || m_days.Value == d30)
{
    m_weekday.Value = dweekday;
}
else
{
    m_weekday.Value = dnotweekday;
}
```

//Peak time consideration

```
if (m_time.Value >= dpeak1S && m_time.Value <= dpeak1E && m_weekday.Value ==
dweekday)
{
    m_TOU.Value = dpeak;
}
else if (m_time.Value >= dpeak2S && m_time.Value <= dpeak2E && m_weekday.Value ==
dweekday)
{
    m_TOU.Value = dpeak;
}
else
{
    m_TOU.Value = doffpeak;
}
```

//Pump speed control

```
if (m_pump_on_off.Value == dpumpON)
{
    m_trailerpump_speed.Value = dpumpspeedHIGH ;
    m_boosterpump_speed.Value = dpumpspeedHIGH ;
}
else
{
    m_trailerpump_speed.Value = dpumpspeedLOW;
    m_boosterpump_speed.Value = dpumpspeedLOW;
}
```

//Pump orientation

```
if (m_pump_orientation.Value == dpump1160)
{
    m_pump_on_off.Value = dpumpON;
    m_valve_1160.Value = dvalveOPEN;
    m_valve_RWD.Value = dvalveCLOSED;
}
else if (m_pump_orientation.Value == dpumpRWD)
{
    m_pump_on_off.Value = dpumpON;
    m_valve_1160.Value = dvalveCLOSED;
    m_valve_RWD.Value = dvalveOPEN;
}
else if (m_pump_orientation.Value == dnopump)
{
    m_pump_on_off.Value = dpumpOFF;
    m_valve_1160.Value = dvalveCLOSED;
    m_valve_RWD.Value = dvalveCLOSED;
}
else
{
    m_pump_on_off.Value = dpumpOFF;
    m_valve_1160.Value = dvalveCLOSED;
    m_valve_RWD.Value = dvalveCLOSED;
}

if (m_TOU.Value == dpeak)
{
    m_pump_orientation.Value = dnopump;
}
else if (m_mass_1160.Value < m_mass_min_1160.Value)
{
    m_pump_orientation.Value = dpump1160;
}
else if (m_mass_1160.Value < m_mass_lower_1160.Value && m_pump_orientation.Value ==
dpump1160 && m_TOU.Value == dpeak) //removed: "&& m_TOU.Value == dpeak"
{
    m_pump_orientation.Value = dpump1160;
}
else if (m_mass_RWD.Value < m_mass_min_RWD.Value)
{
    m_pump_orientation.Value = dpumpRWD;
}
else if (m_mass_RWD.Value < m_mass_lower_RWD.Value && m_pump_orientation.Value ==
dpumpRWD && m_TOU.Value == dpeak) //removed: "&& m_TOU.Value == dpeak"
{
    m_pump_orientation.Value = dpumpRWD;
}
else if (m_mass_1160.Value < m_mass_max_1160.Value && m_TOU.Value ==
doffpeak && m_pump_orientation.Value == dpump1160)
{
    m_pump_orientation.Value = dpump1160;
}
else if (m_mass_RWD.Value < m_mass_max_RWD.Value && m_TOU.Value ==
doffpeak && m_pump_orientation.Value == dpumpRWD)
```

```
{
    m_pump_orientation.Value = dpumpRWD;
}
else if (m_mass_1160.Value > m_mass_max_1160.Value)
{
    m_pump_orientation.Value = dnpump;
}
else if (m_mass_1160.Value > m_mass_upper_1160.Value && m_pump_orientation.Value ==
dnpump)
{
    m_pump_orientation.Value = dnpump;
}
else if (m_mass_RWD.Value > m_mass_max_RWD.Value)
{
    m_pump_orientation.Value = dnpump;
}
else if (m_mass_RWD.Value > m_mass_upper_RWD.Value && m_pump_orientation.Value ==
dnpump)
{
    m_pump_orientation.Value = dnpump;
}
else if (m_mass_1160.Value < m_mass_lower_1160.Value)
{
    m_pump_orientation.Value = dpump1160;
}
else
{
    m_pump_orientation.Value = dpumpRWD;
}
}

//any processing you want to do before steady state
public override void ExecuteBeforeSteadyState()
{
    Execute(0.0);
}

//any processing you want to do while solving steady state
public override void ExecuteSteadyState()
{
    Execute(0.0);
}

//any processing you want to do after steady state
public override void ExecuteAfterSteadyState()
{
    Execute(0.0);
}

//constructor initialises parameters
public Script()
{
    m_sim_t = new IPS.Properties.Double ();
    m_sim_t.Value = 0;
    m_days = new IPS.Properties.Double ();
    m_days.Value = 0;
    m_time = new IPS.Properties.Double ();
```

```
m_time.Value = 0;
m_sand_a = new IPS.Properties.Double ();
m_sand_a.Value = 0;
m_sand_h = new IPS.Properties.Double ();
m_sand_h.Value = 0;
m_density = new IPS.Properties.Double ();
m_density.Value = 0;
m_mass_sand = new IPS.Properties.Double ();
m_mass_sand.Value = 0;
m_mass_tot_sand = new IPS.Properties.Double ();
m_mass_tot_sand.Value = 0;
m_mass_min_sand = new IPS.Properties.Double ();
m_mass_min_sand.Value = 0;
m_mass_lower_sand = new IPS.Properties.Double ();
m_mass_lower_sand.Value = 0;
m_mass_upper_sand = new IPS.Properties.Double ();
m_mass_upper_sand.Value = 0;
m_mass_max_sand = new IPS.Properties.Double ();
m_mass_max_sand.Value = 0;
m_trailerpump_speed = new IPS.Properties.Double ();
m_trailerpump_speed.Value = 0;
m_boosterpump_speed = new IPS.Properties.Double ();
m_boosterpump_speed.Value = 0;
m_pump_on_off = new IPS.Properties.Double ();
m_pump_on_off.Value = 0;
m_timestep = new IPS.Properties.Double ();
m_timestep.Value = 0;
m_flow = new IPS.Properties.Double ();
m_flow.Value = 0;
m_TOU = new IPS.Properties.Double ();
m_TOU.Value = 0;
m_a_1160 = new IPS.Properties.Double ();
m_a_1160.Value = 0;
m_h_1160 = new IPS.Properties.Double ();
m_h_1160.Value = 0;
m_mass_tot_1160 = new IPS.Properties.Double ();
m_mass_tot_1160.Value = 0;
m_mass_1160 = new IPS.Properties.Double ();
m_mass_1160.Value = 0;
m_mass_min_1160 = new IPS.Properties.Double ();
m_mass_min_1160.Value = 0;
m_mass_lower_1160 = new IPS.Properties.Double ();
m_mass_lower_1160.Value = 0;
m_mass_upper_1160 = new IPS.Properties.Double ();
m_mass_upper_1160.Value = 0;
m_mass_max_1160 = new IPS.Properties.Double ();
m_mass_max_1160.Value = 0;
m_RWD_a = new IPS.Properties.Double ();
m_RWD_a.Value = 0;
m_RWD_h = new IPS.Properties.Double ();
m_RWD_h.Value = 0;
m_mass_tot_RWD = new IPS.Properties.Double ();
m_mass_tot_RWD.Value = 0;
m_mass_RWD = new IPS.Properties.Double ();
m_mass_RWD.Value = 0;
m_mass_min_RWD = new IPS.Properties.Double ();
m_mass_min_RWD.Value = 0;
```

```
m_mass_lower_RWD = new IPS.Properties.Double ();
m_mass_lower_RWD.Value = 0;
m_mass_upper_RWD = new IPS.Properties.Double ();
m_mass_upper_RWD.Value = 0;
m_mass_max_RWD = new IPS.Properties.Double ();
m_mass_max_RWD.Value = 0;
m_valve_RWD = new IPS.Properties.Double ();
m_valve_RWD.Value = 0;
m_valve_1160 = new IPS.Properties.Double ();
m_valve_1160.Value = 0;
m_pump_orientation = new IPS.Properties.Double ();
m_pump_orientation.Value = 0;
m_weekday = new IPS.Properties.Double ();
m_weekday.Value = 0;
```

```
dDailyS = 86400;
dpeak1S = 22500;
dpeak1E = 31500;
dpeak2S = 61200;
dpeak2E = 68400;
dpumpspeedHIGH = 1480;
dpumpspeedLOW = 1000;
dpumpON = 1;
dpumpOFF = 2;
doffpeak = 1;
dpeak = 2;
dvalveOPEN = 1;
dvalveCLOSED = 0;
dpump1160 = 1;
dpumpRWD = 2;
dnopump = 0;
dweekday = 1;
dnotweekday = 2;
d1=0;
d2=1;
d5=4;
d6=5;
d7=6;
d8=7;
d9=8;
d12=11;
d13=12;
d14=13;
d15=14;
d16=15;
d19=18;
d20=19;
d21=20;
d22=21;
d23=22;
d26=25;
d27=26;
d28=27;
d29=28;
d30=29;
```

```
}
```

```
//property declarations to make
//parameters visible to outside world
[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double sim_t
{
    get
    {
        return m_sim_t;
    }
}

[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double days
{
    get
    {
        return m_days;
    }
}

[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double time
{
    get
    {
        return m_time;
    }
}

[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double sand_a
{
    get
    {
        return m_sand_a;
    }
}

[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double sand_h
{
    get
    {
        return m_sand_h;
    }
}

[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double density
{
    get
    {
        return m_density;
    }
}

[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double mass_sand
{
    get
    {
        return m_mass_sand;
    }
}
```

```
    }  
}  
[PropertyUsage(Property.DYNAMIC)]  
public IPS.Properties.Double mass_tot_sand  
{  
    get  
    {  
        return m_mass_tot_sand;  
    }  
}  
[PropertyUsage(Property.DYNAMIC)]  
public IPS.Properties.Double mass_min_sand  
{  
    get  
    {  
        return m_mass_min_sand;  
    }  
}  
[PropertyUsage(Property.DYNAMIC)]  
public IPS.Properties.Double mass_lower_sand  
{  
    get  
    {  
        return m_mass_lower_sand;  
    }  
}  
[PropertyUsage(Property.DYNAMIC)]  
public IPS.Properties.Double mass_upper_sand  
{  
    get  
    {  
        return m_mass_upper_sand;  
    }  
}  
[PropertyUsage(Property.DYNAMIC)]  
public IPS.Properties.Double mass_max_sand  
{  
    get  
    {  
        return m_mass_max_sand;  
    }  
}  
[PropertyUsage(Property.DYNAMIC)]  
public IPS.Properties.Double trailerpump_speed  
{  
    get  
    {  
        return m_trailerpump_speed;  
    }  
}  
[PropertyUsage(Property.DYNAMIC)]  
public IPS.Properties.Double boosterpump_speed  
{  
    get  
    {  
        return m_boosterpump_speed;  
    }  
}
```

```
}
[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double pump_on_off
{
    get
    {
        return m_pump_on_off;
    }
}
[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double TOU
{
    get
    {
        return m_TOU;
    }
}
[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double flow
{
    get
    {
        return m_flow;
    }
}
[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double timestep
{
    get
    {
        return m_timestep;
    }
}
[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double RWD_a
{
    get
    {
        return m_RWD_a;
    }
}
[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double RWD_h
{
    get
    {
        return m_RWD_h;
    }
}
[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double mass_tot_RWD
{
    get
    {
        return m_mass_tot_RWD;
    }
}
```

```
[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double mass_RWD
{
    get
    {
        return m_mass_RWD;
    }
}
[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double mass_min_RWD
{
    get
    {
        return m_mass_min_RWD;
    }
}
[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double mass_lower_RWD
{
    get
    {
        return m_mass_lower_RWD;
    }
}
[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double mass_upper_RWD
{
    get
    {
        return m_mass_upper_RWD;
    }
}
[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double mass_max_RWD
{
    get
    {
        return m_mass_max_RWD;
    }
}
[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double a_1160
{
    get
    {
        return m_a_1160;
    }
}
[PropertyUsage(UseProperty.DYNAMIC)]
public IPS.Properties.Double h_1160
{
    get
    {
        return m_h_1160;
    }
}
[PropertyUsage(UseProperty.DYNAMIC)]
```

```
public IPS.Properties.Double mass_tot_1160
{
    get
    {
        return m_mass_tot_1160;
    }
}
[PropertyUsage(Property.DYNAMIC)]
public IPS.Properties.Double mass_1160
{
    get
    {
        return m_mass_1160;
    }
}
[PropertyUsage(Property.DYNAMIC)]
public IPS.Properties.Double mass_min_1160
{
    get
    {
        return m_mass_min_1160;
    }
}
[PropertyUsage(Property.DYNAMIC)]
public IPS.Properties.Double mass_lower_1160
{
    get
    {
        return m_mass_lower_1160;
    }
}
[PropertyUsage(Property.DYNAMIC)]
public IPS.Properties.Double mass_upper_1160
{
    get
    {
        return m_mass_upper_1160;
    }
}
[PropertyUsage(Property.DYNAMIC)]
public IPS.Properties.Double mass_max_1160
{
    get
    {
        return m_mass_max_1160;
    }
}
[PropertyUsage(Property.DYNAMIC)]
public IPS.Properties.Double valve_1160
{
    get
    {
        return m_valve_1160;
    }
}
[PropertyUsage(Property.DYNAMIC)]
public IPS.Properties.Double valve_RWD
```

```
{
    get
    {
        return m_valve_RWD;
    }
}
[PropertyUsage(Property.DYNAMIC)]
public IPS.Properties.Double pump_orientation
{
    get
    {
        return m_pump_orientation;
    }
}
[PropertyUsage(Property.DYNAMIC)]
public IPS.Properties.Double weekday
{
    get
    {
        return m_weekday;
    }
}
}
```

APPENDIX C: NUMERICAL MODEL - SYSTEM GRAPH

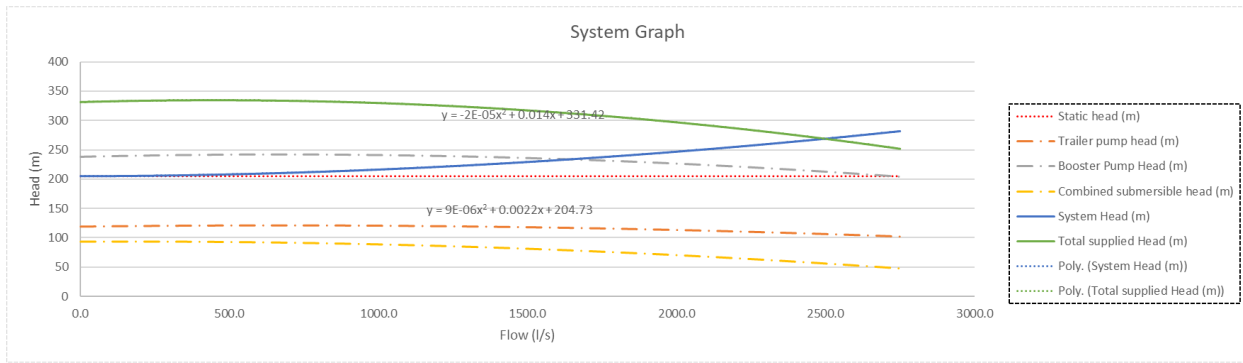


Figure 46: Numerical model system graph - Sandsloot to RWD

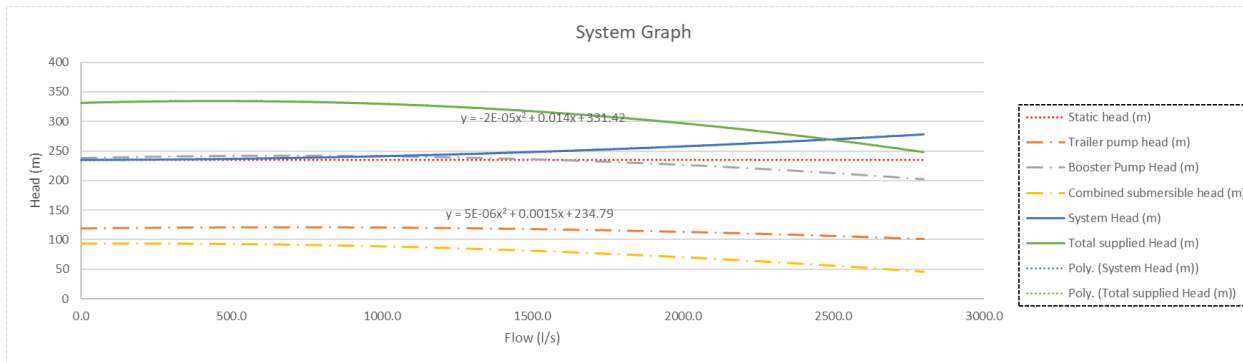


Figure 47: Numerical model system graph - Sandsloot to Rockfill dam

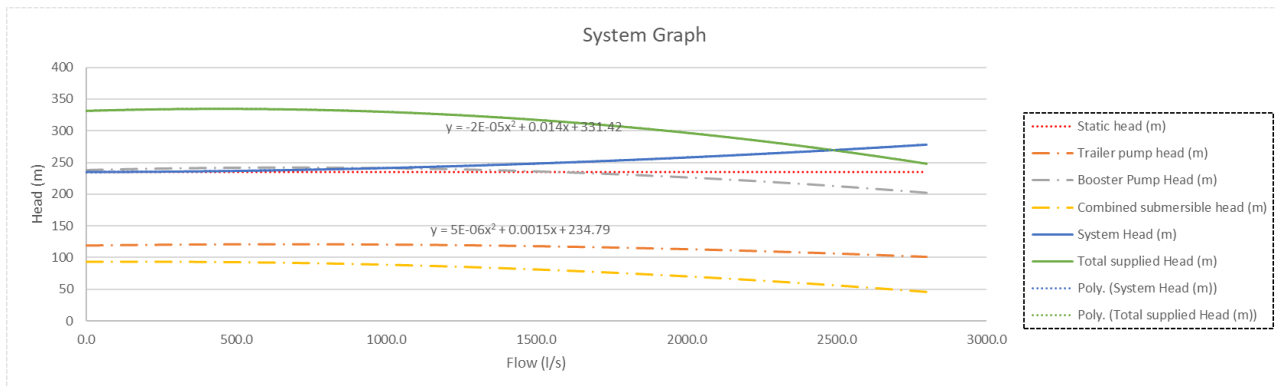


Figure 48: Numerical model system graph - operating condition 1

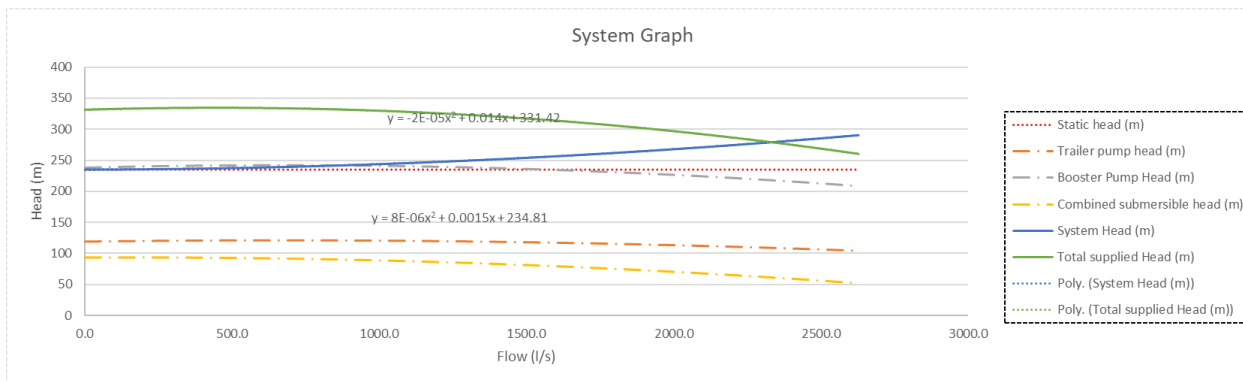


Figure 49: Numerical model system graph - operating condition 2

Assumed an approximate valve opening of 25% for the second operating condition.

APPENDIX D: RAINFALL

Table 12: Average rainfall for Mogalakwena from 2007 to 2017 (mm)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
January	32	109	210	80	104	138.5	131	67	74	56	149
February	36	8	182	4	60	103	86	69	61	27	131
March	0	46	88	53	13	30	40	307	57	125	53
April	28	45	0	168	113	14	124	84	75	3	47
May	0	7	13	27	21	0	0	3	1	18	75
June	0	0	12	0	6	0	0	0	2	12	0
July	7	0	2	0	0	0	0	0	2	1	0
August	0	0	0	0	4	0	0	0	0	0	0
September	35	0	12	0	0	94	0	0	20	0	0
October	86	16	40	6	103	72	103	16	22	24	80
November	180	110	187	169	28	36	119	63	62	86	70
December	107	72	122	117	121.5	204	210	299	31	108	155

APPENDIX E: PIT CAPACITIES

Water Volume Pit 1 (Sandsloot Pit)

Date Measured	Water Volume (m³)	Mega Litres (ML)	Pumping Planned	Waterbody Drop/Rise (+/-)ML	Water Elevation (a.m.s.l)	Water Level (+/-)m	Time of Measure	Water Body Surface Area (m²)	Available Capacity (ML)	Ave. Depth of Water (m)
2017-05-17	1 925 722	1925.722		59.351	894.721	0.487	8h15	122 234	59 319	27.4
2017-05-25	1 939 055	1939.055		13.332	894.830	0.109	7h40	122 407	59 306	27.5
2017-05-31	1 836 890	1836.890		-102.164	893.991	-0.839	8h00	121 125	59 408	26.6
2017-06-07	1 717 412	1717.412		-119.478	892.998	-0.993	8h00	119 486	59 528	25.6
2017-06-14	1 646 889	1646.889		-70.523	892.405	-0.593	8h10	118 377	59 598	25.0
2017-06-21	1 561 450	1561.450		-85.438	891.679	-0.726	8h00	117 004	59 684	24.3
2017-06-28	1 457 567	1457.567		-103.884	890.783	-0.896	8h05	114 776	59 787	23.4
2017-07-12	1 284 085	1284.085		-173.482	889.228	-1.555	8h30	106 979	59 961	21.9
2017-07-19	1 191 769	1191.769		-92.316	888.319	-0.909	7h30	94 526	60 053	21.0
2017-07-26	1 114 810	1114.810		-76.959	887.459	-0.860	8h00	84 395	60 130	20.1
2017-08-02	1 048 230	1048.230		-66.580	886.619	-0.840	07h50	74 142	60 197	19.3
2017-08-10	982 323	982.323		-65.907	885.694	-0.925	7h30	69 732	60 263	18.3
2017-08-16	928 587	928.587		-53.736	884.915	-0.779	7h35	68 322	60 316	17.6
2017-08-23	876 901	876.901		-51.687	884.152	-0.763	7h25	67 185	60 368	16.8
2017-08-30	822 736	822.736		-54.165	883.339	-0.813	7h40	66 075	60 422	16.0
2017-09-07	784 444	784.444		-38.293	882.756	-0.583	8h40	65 273	60 461	15.4
2017-09-13	754 947	754.947		-29.497	882.302	-0.454	7h45	64 680	60 490	14.9
2017-09-19	743 325	743.325		-11.622	882.122	-0.180	7h50	64 436	60 502	14.8
2017-09-27	694 157	694.157		-49.168	881.353	-0.769	7h40	63 466	60 551	14.0
2017-10-04	656 864	656.864		-37.293	880.762	-0.591	8h40	62 721	60 588	13.4
2017-10-11	627 577	627.577		-29.287	880.293	-0.469	9h30	62 168	60 617	12.9
2017-10-25	541 238	541.238		-86.340	878.884	-1.409	7h00	60 319	60 704	11.5
2017-11-02	537 446	537.446		-3.792	878.821	-0.063	7h30	60 220	60 708	11.5
2017-11-08	508 882	508.882		-28.564	878.344	-0.477	7h45	59 512	60 736	11.0
2017-11-15	473 157	473.157		-35.726	877.739	-0.605	8h45	58 597	60 772	10.4
2017-11-22	439 248	439.248		-33.908	877.155	-0.584	7h00	57 531	60 806	9.8
2017-12-04	384 955	384.955		-54.293	876.195	-0.960	7h10	55 597	60 860	8.8
2017-12-12	541 665	541.665		156.710	878.891	2.696	7h14	60 325	60 703	11.5
2017-12-20	692 591	692.591		150.926	881.328	2.437	7h00	63 431	60 552	14.0
2017-12-26	819 709	819.709		127.118	883.293	1.965	14h30	66 014	60 425	15.9
2018-01-10	873 623	873.623		53.914	884.103	0.810	7h00	67 117	60 371	16.7
2018-01-17	896 591	896.591		22.968	884.444	0.341	6h45	67 587	60 348	17.1
2018-01-24	887 614	887.614		-8.977	884.311	-0.133	7h10	67 406	60 357	16.9
2018-01-31	900 107	900.107		12.493	884.496	0.185	8h45	67 665	60 345	17.1
2018-02-07	890 634	890.634		-9.473	884.356	-0.140	7h35	67 453	60 354	17.0
2018-02-14	757 664	757.664		-132.970	882.344	-2.012	7h40	64 733	60 487	15.0
2018-02-21	776 895	776.895		19.231	882.640	0.296	8h00	65 113	60 468	15.3
2018-02-28	700 466	700.466		-76.429	881.452	-1.188	9h00	63 582	60 545	14.1
2018-03-07	688 471	688.471		-11.995	881.263	-0.189	8h00	63 358	60 557	13.9
2018-03-14	679 467	679.467		-9.004	881.121	-0.142	8h10	63 184	60 566	13.8
2018-03-20	858 811	858.811		179.344	883.882	2.761	8h00	66 808	60 386	16.5
2018-03-28	840 889	840.889		-17.922	883.613	-0.269	8h15	66 443	60 404	16.3
2018-04-04	783 987	783.987		-56.902	882.749	-0.864	8h10	65 263	60 461	15.4
2018-04-11	917 674	917.674		133.688	884.755	2.006	7h50	68 090	60 327	17.4
2018-04-17	1 416 558	1416.558		498.883	890.424	5.669	7h55	113 618	59 828	23.1
2018-04-25	1 364 810	1364.810		-51.747	889.965	-0.459	8h05	111 779	59 880	22.6
2018-05-02	1 459 518	1459.518		94.708	890.800	0.835	8h00	114 823	59 785	23.4
2018-05-09	1 465 033	1465.033		5.515	890.848	0.048	7h55	114 959	59 780	23.5
2018-05-16	1 539 725	1539.725		74.692	891.493	0.645	8h30	116 595	59 705	24.1
2018-05-30	1 641 682	1641.682		101.957	892.361	0.868	8h15	118 287	59 603	25.0
2018-06-05	1 679 750	1679.750		38.068	892.682	0.321	8h35	118 872	59 565	25.3
2018-06-13	1 704 518	1704.518		24.768	892.890	0.208	8h20	119 279	59 540	25.5
2018-06-20	1 725 062	1725.062		20.544	893.062	0.172	8h30	119 595	59 520	25.7
2018-06-27	1 670 365	1670.365		-54.698	892.603	-0.459	8h15	118 752	59 575	25.2

Figure 50: Sandsloot Pit - Water volume

Water Volume 1160 Rockfill dam

Date Measured	Water Volume (m³)	Mega Litres (ML)	Pumping Planned	Drop/Rise (+/-) (ML)	Elev. of WaterBody (m) (a.m.s.l.)	+/- (m)	Time	WaterBody Surface Area (m²)	Available Capacity	Ave. Depth of Water (m)
2017/05/17	195 158	195.16		9.15	1153.627	0.333	08h35	27 784	177.48	10.4
2017/05/25	138 431	138.43		-56.73	1151.428	-2.199	07h50	23 832	234.21	8.2
2017/05/31	170 375	170.37		31.94	1152.707	1.279	8h15	26 106	202.27	9.5
2017/06/07	209 080	209.08		38.71	1154.120	1.413	8h15	28 700	163.56	10.9
2017/06/14	183 086	183.09		-25.99	1153.186	-0.934	8h25	26 977	189.55	10.0
2017/06/21	222 599	222.60		39.51	1154.584	1.398	8h15	29 575	150.04	11.4
2017/06/28	210 373	210.37		-12.23	1154.165	-0.419	8h20	28 789	162.27	11.0
2017/07/12	224 347	224.35		13.97	1154.643	0.478	8h50	29 687	148.29	11.4
2017/07/19	236 680	236.68		12.33	1155.053	0.410	7h45	30 468	135.96	11.9
2017/07/26	272 988	272.99		36.31	1156.202	1.149	8h15	32 740	99.65	13.0
2017/08/02	277 095	277.09		4.11	1156.327	0.125	8h05	32 974	95.55	13.1
2017/08/10	216 226	216.23		-60.87	1154.367	-1.960	7h45	29 165	156.42	11.2
2017/08/16	232 161	232.16		15.94	1154.904	0.537	7h50	30 189	140.48	11.7
2017/08/23	229 542	229.54		-2.62	1154.817	-0.087	7h40	30 019	143.10	11.6
2017/08/30	273 676	273.68		44.13	1156.223	1.406	7h55	32 781	98.96	13.0
2017/09/07	260 309	260.31		-13.37	1155.810	-0.413	8h55	31 956	112.33	12.6
2017/09/13	235 098	235.10		-25.21	1155.001	-0.809	8h00	30 376	137.54	11.8
2017/09/19	227 684	227.68		-7.41	1154.755	-0.246	8h05	29 904	144.96	11.6
2017/09/27	267 841	267.84		40.16	1156.044	1.289	7h55	32 420	104.80	12.8
2017/10/04	239 339	239.34		-28.50	1155.140	-0.904	8h55	30 645	133.30	11.9
2017/10/11	253 200	253.20		13.86	1155.586	0.446	9h45	31 516	119.44	12.4
2017/10/25	315 457	315.46		62.26	1157.451	1.865	7h15	35 283	57.18	14.3
2017/11/02	279 476	279.48		-35.98	1156.399	-1.052	7h45	33 130	93.17	13.2
2017/11/08	256 425	256.42		-23.05	1155.688	-0.711	8h00	31 715	116.22	12.5
2017/11/15	298 142	298.14		41.72	1156.953	1.265	9h02	34 256	74.50	13.8
2017/11/22	272 759	272.76		-25.38	1156.195	-0.758	7h15	32 719	99.88	13.0
2017/12/04	305 381	305.38		32.62	1157.163	0.968	7h26	34 686	67.26	14.0
2017/12/12	324 307	324.31		18.93	1157.700	0.537	7h32	35 805	48.33	14.5
2017/12/20	337 734	337.73		13.43	1158.071	0.371	7h26	36 586	34.91	14.9
2017/12/26	328 655	328.66		-9.08	1157.821	-0.250	15h00	36 057	43.99	14.6
2018/01/10	321 521	321.52		-7.13	1157.622	-0.199	7h35	35 639	51.12	14.4
2018/01/17	323 341	323.34		1.82	1157.673	0.051	7h40	35 742	49.30	14.5
2018/01/24	309 279	309.28		-14.06	1157.275	-0.398	7h55	34 917	63.36	14.1
2018/01/31	313 484	313.48		4.20	1157.395	0.120	11h20	35 172	59.16	14.2
2018/02/07	307 049	307.05		-6.44	1157.211	-0.184	10h10	34 784	65.59	14.0
2018/02/14	296 671	296.67		-10.38	1156.910	-0.301	10h20	34 170	75.97	13.7
2018/02/21	302 129	302.13		5.46	1157.069	0.159	9h10	34 496	70.51	13.9
2018/02/28	305 797	305.80		3.67	1157.175	0.106	10h30	34 715	66.84	14.0
2018/03/07	302 509	302.509		-3.29	1157.080	-0.095	8h45	34 520	70.13	13.9
2018/03/14	299 308	299.308		-3.20	1156.987	-0.093	8h00	34 330	73.33	13.8
2018/03/20	292 687	292.687		-6.62	1156.793	-0.194	7h45	33 934	79.95	13.6
2018/03/28	293 536	293.536		0.85	1156.818	0.025	8h00	33 977	79.11	13.6
2018/04/04	330 641	330.641		37.11	1157.876	1.058	7h50	36 170	42.00	14.7
2018/04/11	316 941	316.941		-13.70	1157.493	-0.383	7h30	35 372	55.70	14.3
2018/04/17	324 558	324.558		7.62	1157.707	0.214	7h20	35 816	48.08	14.5
2018/04/25	325 238	325.238		0.68	1157.726	0.019	7h30	35 852	47.40	14.5
2018/05/02	327 934	327.934		2.70	1157.801	0.075	7h23	36 026	44.71	14.6
2018/05/09	329 521	329.521		1.59	1157.845	0.044	7h20	36 119	43.12	14.6
2018/05/16	251 721	251.721		-77.80	1155.539	-2.306	8h15	31 416	120.92	12.3
2018/05/30	263 257	263.257		11.54	1155.902	0.363	7h55	32 139	109.38	12.7
2018/06/05	348 805	348.805		85.55	1158.371	2.469	8h20	37 221	23.84	15.2
2018/06/13	353 549	353.549		4.74	1158.498	0.127	8h00	37 494	19.09	15.3
2018/06/20	300 716	300.716		-52.83	1157.028	-1.470	8h10	34 401	71.92	13.8
2018/06/27	272 432	272.432		-28.28	1156.185	-0.843	7h55	32 709	100.21	13.0

Figure 51: Rockfill dam - Water volume

Water Volume Return Water Dam South (Unlined Dam)

Date Measured	Water Volume (m³)	Mega Litres (ML)	Pumping Planned	Drop/Rise (+/-) (ML)	Elev. of WaterBody (m) (a.m.s.l.)	+/- (m)	Time	WaterBody Surface Area (m²)	Available Capacity	Ave. Depth of Water (m)
2017/05/17	300 565	300.57		132.81	1118.746	0.747	9h55	197 172	150.81	2.55
2017/05/25	293 494	293.49		-7.07	1118.710	-0.036	9h30	195 591	157.88	2.51
2017/05/31	246 205	246.21		-47.29	1118.460	-0.250	9h40	182 567	205.17	2.26
2017/06/07	251 522	251.52		5.32	1118.489	0.029	9h40	184 083	199.85	2.29
2017/06/14	275 904	275.90		24.38	1118.619	0.130	9h50	191 003	175.47	2.42
2017/06/21	243 110	243.11		-32.79	1118.443	-0.176	9h40	181 640	208.26	2.24
2017/06/28	233 915	233.91		-9.19	1118.392	-0.051	9h45	178 957	217.46	2.19
2017/07/12	282 812	282.81		48.90	1118.655	0.263	10h15	192 835	168.56	2.45
2017/07/19	292 517	292.52		9.70	1118.705	0.050	9h10	195 344	158.86	2.50
2017/07/26	288 232	288.23		-4.29	1118.683	-0.022	9h40	194 233	163.14	2.48
2017/08/02	284 357	284.36		-3.87	1118.663	-0.020	9h30	193 235	167.02	2.46
2017/08/10	290 369	290.37		6.01	1118.694	0.031	9h10	194 796	161.00	2.49
2017/08/16	301 352	301.35		10.98	1118.750	0.056	9h15	197 336	150.02	2.55
2017/08/23	281 654	281.65		-19.70	1118.649	-0.101	9h05	192 522	169.72	2.45
2017/08/30	293 103	293.10		11.45	1118.708	0.059	9h20	195 494	158.27	2.51
2017/09/07	255 768	255.77		-37.33	1118.512	-0.196	10h20	185 290	195.61	2.31
2017/09/13	228 745	228.74		-27.02	1118.363	-0.149	9h25	177 428	222.63	2.16
2017/09/19	215 411	215.41		-13.33	1118.287	-0.076	9h30	173 493	235.96	2.09
2017/09/27	164 625	164.63		-50.79	1117.979	-0.308	9h20	155 585	286.75	1.78
2017/10/04	167 280	167.28		2.65	1117.996	0.017	10h20	156 696	284.09	1.80
2017/10/11	269 249	269.25		101.97	1118.584	0.588	10h15	189 163	182.13	2.38
2017/10/25	207 657	207.66		-61.59	1118.342	-0.342	8h10	171 085	243.72	2.04
2017/11/02	219 939	219.94		12.28	1118.313	0.071	8h40	174 823	231.43	2.11
2017/11/08	209 028	209.03		-10.91	1118.250	-0.063	8h57	171 523	242.35	2.05
2017/11/15	204 417	204.42		-4.61	1118.233	-0.017	10h00	170 027	246.96	2.03
2017/11/22	266 417	266.42		62.00	1118.569	0.336	8h10	188 366	184.96	2.37
2017/12/04	294 667	294.67		28.25	1118.716	0.147	8h22	195 881	156.71	2.52
2017/12/12	456 518	456.52		161.85	1119.515	0.799	8h28	205 921	-5.14	3.32
2017/12/20	358 113	358.11		-98.41	1119.033	-0.482	9h00	202 440	93.26	2.83
2017/12/26	298 003	298.00		-60.11	1118.733	-0.300	15h20	196 650	153.37	2.53
2018/01/10	225 913	225.91		-72.09	1118.347	-0.386	8h30	176 579	225.46	2.15
2018/01/17	242 257	242.26		16.34	1118.106	-0.241	8h00	89 527	209.12	1.91
2018/01/24	259 671	259.67		17.41	1118.533	0.427	8h30	186 411	191.70	2.33
2018/01/31	291 929	291.93		32.26	1118.702	0.169	11h45	195 195	159.45	2.50
2018/02/07	329 656	329.66		37.73	1118.892	0.190	11h00	200 969	121.72	2.69
2018/02/14	289 982	289.98		-39.67	1118.692	-0.200	11h10	194 690	161.39	2.49
2018/02/21	304 118	304.12		14.14	1118.764	0.072	9h30	197 820	147.26	2.56
2018/02/28	311 657	311.657		7.54	1118.802	0.038	9h00	198 903	139.72	2.6
2018/03/07	303 130	303.130		-8.53	1118.759	-0.043	9h00	197 656	148.24	2.6
2018/03/14	300 760	300.760		-2.37	1118.747	-0.012	9h15	197 222	150.61	2.5
2018/03/20	297 023	297.023		-3.74	1118.728	-0.019	9h05	196 425	154.35	2.5
2018/03/28	295 257	295.257		-1.77	1118.719	-0.009	9h20	196 029	156.12	2.5
2018/04/04	311 459	311.459		16.20	1118.801	0.082	9h10	198 869	139.91	2.6
2018/04/11	274 568	274.568		-36.89	1118.612	-0.189	8h50	190 638	176.81	2.4
2018/04/17	299 972	299.972		25.40	1118.743	0.131	8h55	197 065	151.40	2.5
2018/04/25	328 853	328.853		28.88	1118.888	0.145	9h05	200 886	122.52	2.7
2018/05/02	260 232	260.232		-68.62	1118.536	-0.352	9h00	186 575	191.14	2.3
2018/05/09	243 472	243.472		-16.76	1118.445	-0.091	8h55	181 752	207.90	2.2
2018/05/16	343 155	343.155		99.68	1118.959	0.514	9h20	201 855	108.22	2.8
2018/05/30	297 612	297.612		-45.54	1118.731	-0.228	9h05	196 550	153.76	2.5
2018/06/05	282 040	282.040		-15.57	1118.651	-0.080	9h25	192 623	169.33	2.5
2018/06/13	249 133	249.133		-32.91	1118.476	-0.175	9h10	183 399	202.24	2.3
2018/06/20	213 335	213.335		-35.80	1118.275	-0.201	9h20	172 886	238.04	2.1
2018/06/27	184 250	184.250		-29.09	1118.102	-0.173	9h05	163 311	267.12	1.9

Figure 52: RWD - Water volume

APPENDIX F: PUMP CURVES

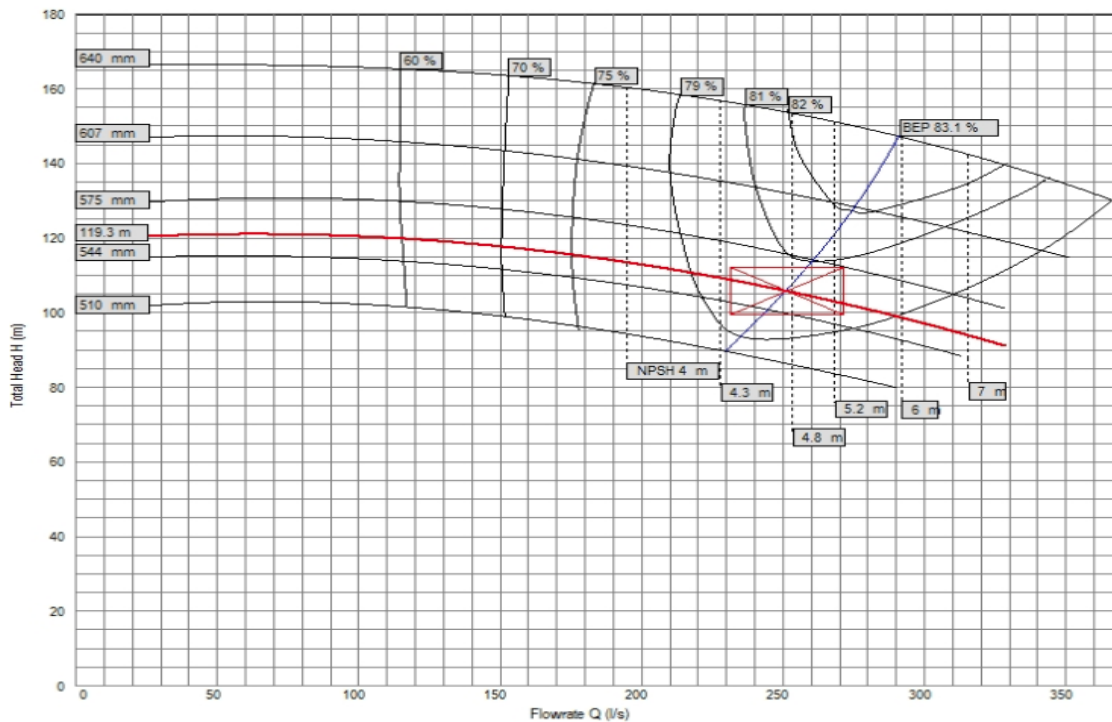


Figure 53: Trailer/booster pump curve

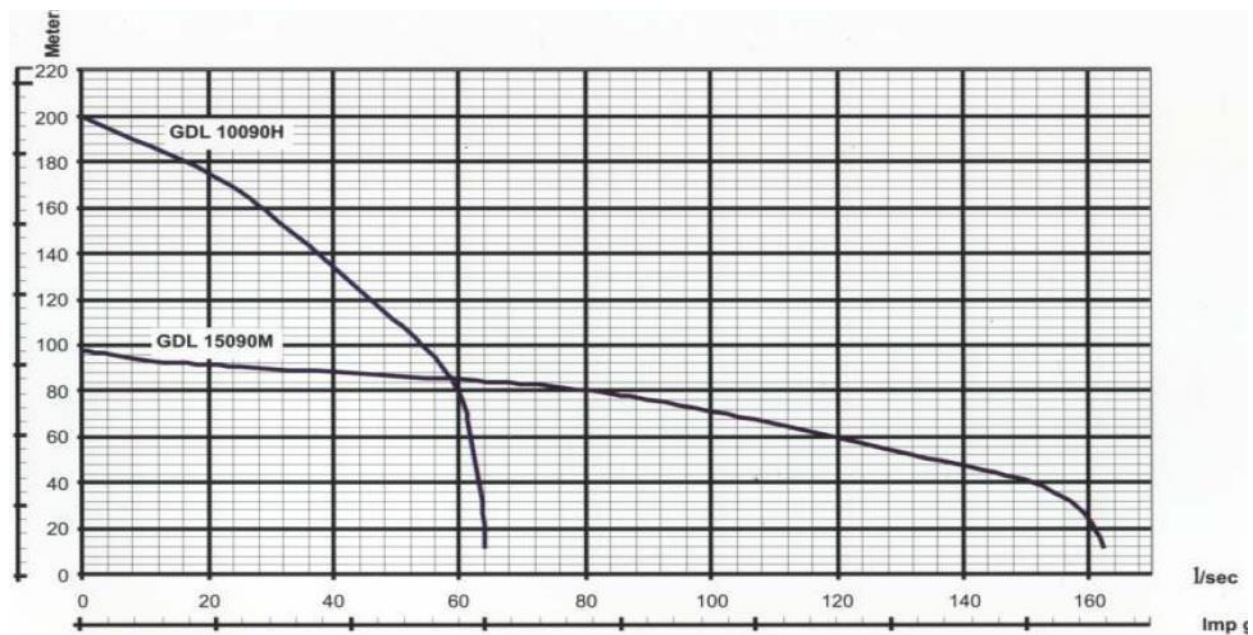


Figure 54: Submersible pump curve

The efficiency of the submersible pump was assumed as 70% during calculations.

The trailer & booster pumps have a maximum pump capacity of 320 l/s. The submersible pumps have a maximum pump capacity of 100 l/s. The maximum amount of submersible pumps that can be connected is three, making the maximum pump capacity of the system 300 l/s.

The submersible pumps have built in 90 kW motors while the trailer & booster pumps are connected to 1 MW motors.

Table 13: Pipe network details

[illegible]

NOTES

- REFER TO PWD DRAWINGS 11-ROAD-PIPEDROOD TO-4000.
- REFER TO TYPICAL ROAD CROSSING DRAWING 11-ROAD-CROSSING-001.
- REFER TO TYPICAL CHANGE IN DIRECTION DRAWING 11-ROAD-CHANGE-DIR TO-1000.
- REFER TO SAN-VALV-CONCRETE 11-ROAD-CONCRETE-001 TO-1000.
- REFER TO DRAWING VALV DRAWING 11-ROAD-CONCRETE-001 TO-1000.
- REFER TO TRANSITION ASSEMBLY DRAWING 11-ROAD-TRANSITION-001 TO-1000.
- PILES TO BE RUN INSIDE BRACKETED PORTAL COLUMNS AT RIVER CROSSING.

GENERAL NOTES

- 1. PILE LINE
- 2. PILE TYPE
- 3. PILE SUPPORT
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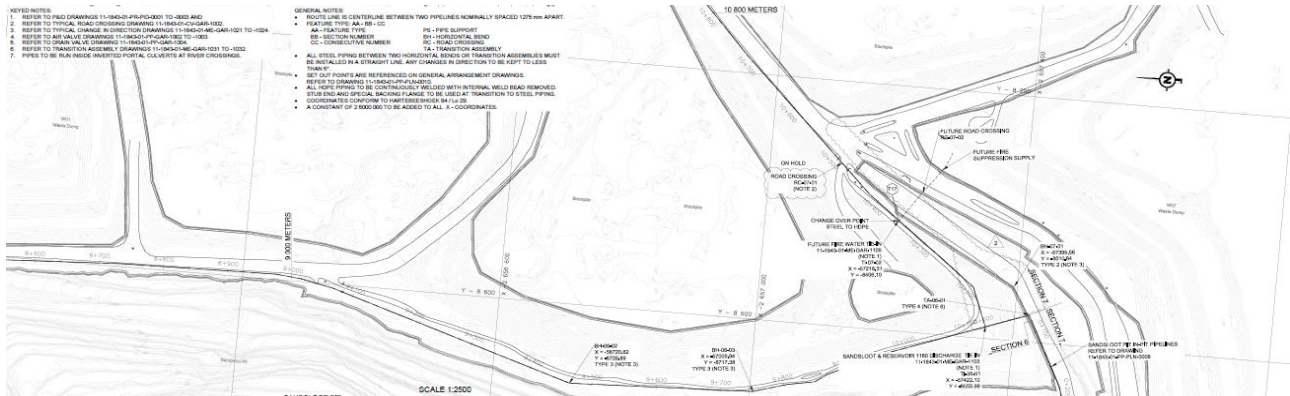


Figure 57: Dewatering pipeline (3 of 6)

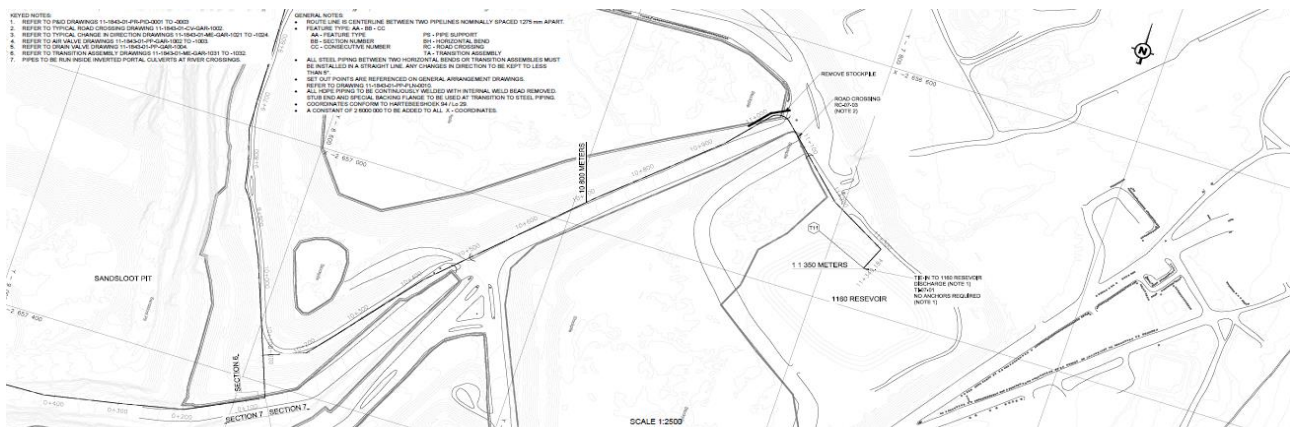


Figure 58: Dewatering pipeline (4 of 6)

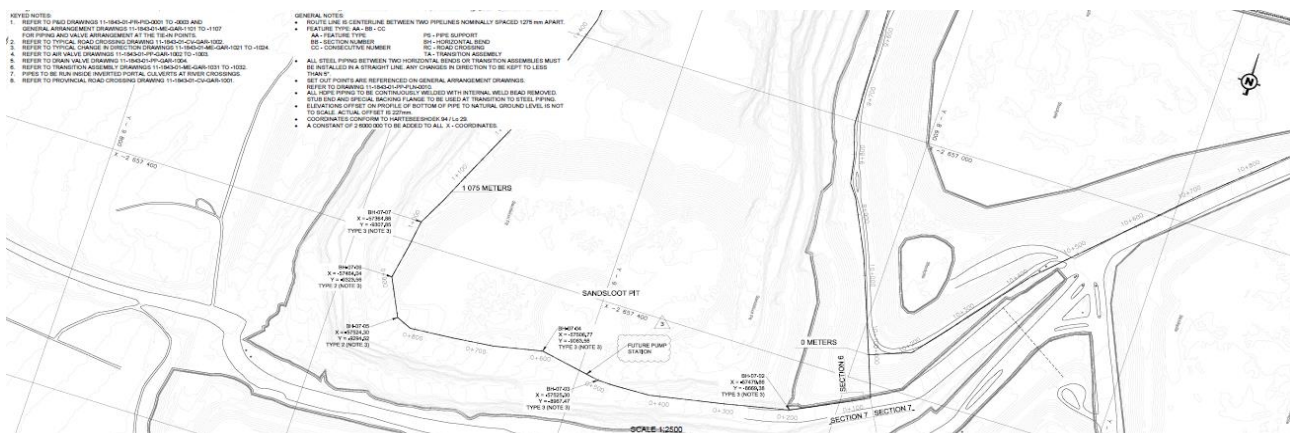


Figure 59: Dewatering pipeline (5 of 6)

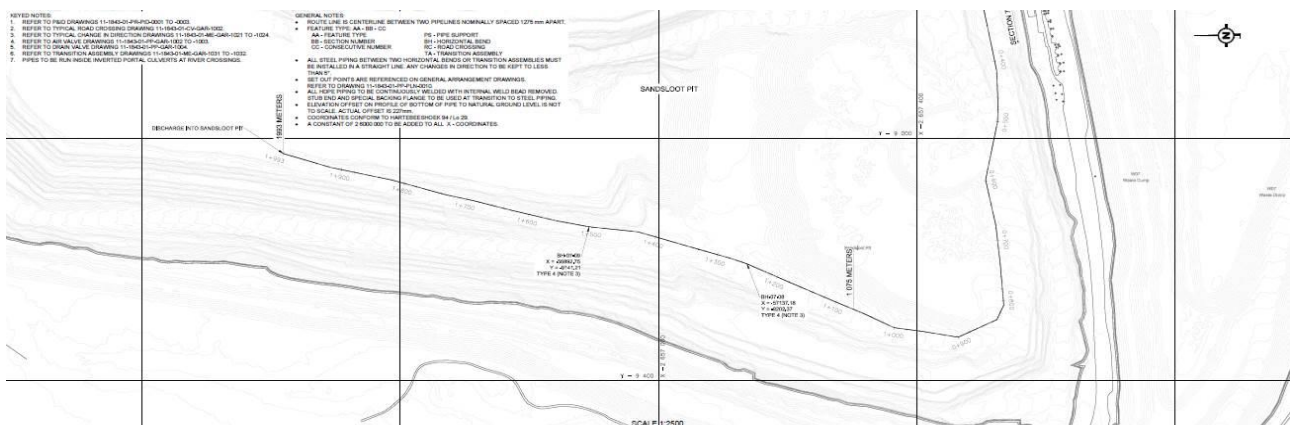


Figure 60: Dewatering pipeline (6 of 6)

APPENDIX H: VOLUME OF PUMPED WATER

Table 14: Volume of pumped water

	<i>Sandsloot to RWD (MI)</i>	<i>Sandsloot to Rockfill dam (MI)</i>
6-27-2018	-	23,745
6-28-2018	-	19,495
6-29-2018	-	22,067
6-30-2018	-	22,790
7-1-2018	21,283	-
7-2-2018	-	21,506
7-3-2018	-	21,372
7-4-2018	-	20,805
7-5-2018	10,998	10,626
7-6-2018	-	9,426
7-7-2018	-	21,407
7-8-2018	-	21,204
7-9-2018	-	21,098
7-10-2018	-	15,738
7-11-2018	-	12,068
7-12-2018	-	20,331
7-13-2018	6,787	13,574
7-14-2018	6,959	13,595
7-15-2018	6,558	13,114
7-16-2018	6,877	13,877
7-17-2018	7,197	14,394
7-18-2018	6,734	13,468
7-19-2018	6,541	13,082
7-20-2018	6,771	13,542
7-21-2018	6,662	13,324
7-22-2018	6,615	13,232
7-23-2018	6,319	12,638
7-24-2018	4,577	17,683
7-25-2018	-	19,739
7-26-2018	370	15,998
7-27-2018	1,416	15,704
7-28-2018	-	20,406
7-29-2018	-	19,931
7-30-2018	-	19,522
7-31-2018	-	20,159
8-1-2018	-	20,431
8-2-2018	-	-

	Sandsloot to RWD (MI)	Sandsloot to Rockfill dam (MI)
8-3-2018	-	-
8-4-2018	-	25,692
8-5-2018	-	19,698
8-6-2018	-	19,168
8-7-2018	-	-
8-8-2018	-	19,310
8-9-2018	-	19,500
8-10-2018	-	20,041
8-11-2018	-	19,892
8-12-2018	-	18,884
8-13-2018	-	19,484
8-14-2018	-	9,570
8-15-2018	-	-

APPENDIX I: SIMULATION COMPONENT DESCRIPTION

1. Container – Open container: This component was used because it resembles an open pit or storage dam that can be influenced by atmospheric conditions.

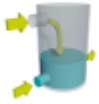


Figure 61: Flownex SE - Open container

2. Turbos and pumps – Variable speed pump: This component allowed for the inclusion of a pump curve and the manipulation of the pump speed.



Figure 62: Flownex SE - Variable speed pump

3. Piping – Pipe: This component allowed the manipulation of different piping characteristics.

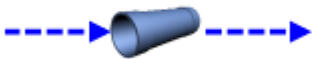


Figure 63: Flownex SE – Pipe

4. Valves – Miller – Gate valve: This component is used because it resembles the equipment used in field.



Figure 64: Flownex SE - Gate valve

5. Container – Reservoir: This component is used because of its mass flow rate capability.



Figure 65: Flownex SE – Reservoir

6. Excel – Excel workbook: This component is used to resemble the average mass flow rate requirement of the concentrators at specific time intervals as well as the mass flow rate of the water entering Sandsloot pit.



Figure 66: Flownex SE - Excel workbook

7. Nodes and boundaries – Boundary condition: This component is used to imitate certain surrounding or atmospheric conditions.



Figure 67: Flownex SE - Boundary condition

8. Scripting – Script: This component is used to implement the proposed pumping methodology illustrated in Figure 35 and provided in Appendix B: Simulation model - Flownex script.



Figure 68: Flownex SE - Script

9. Scripting – Script library – Simulation time: This component is used to indicate the time.



Figure 69: Flownex SE - Simulation time

APPENDIX J: FLOWNEX SE BOUNDARY CONDITIONS

1. 1160 – Concentrator requirement: The temperature is fixed but the flow exiting the reservoir is linked to the Excel component representing the average required flow at a specific time interval from the 1160 storage dam.
2. RWD – Concentrator requirement: The temperature is fixed but the flow exiting the reservoir is linked to the Excel component representing the average required flow at a specific time interval from the RWD storage dam.
3. Boundary condition 19: The pressure is fixed while the mass flow rate represents the water flowing into Sandsloot pit.
4. Boundary condition 39: The pressure is fixed and this boundary condition indicates the water level inside Sandsloot pit.

APPENDIX K: INSTRUMENTATION INSTALLATION

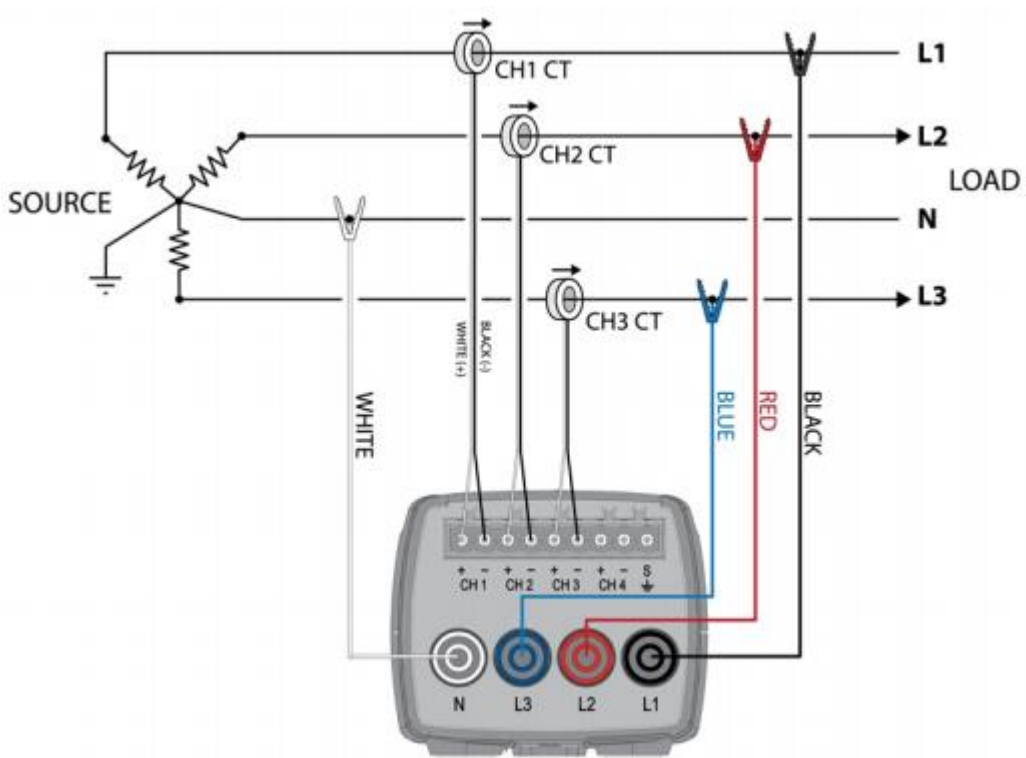


Figure 70: 3 phase, 4 wire wye setup diagram (Dent instruments, 2019)

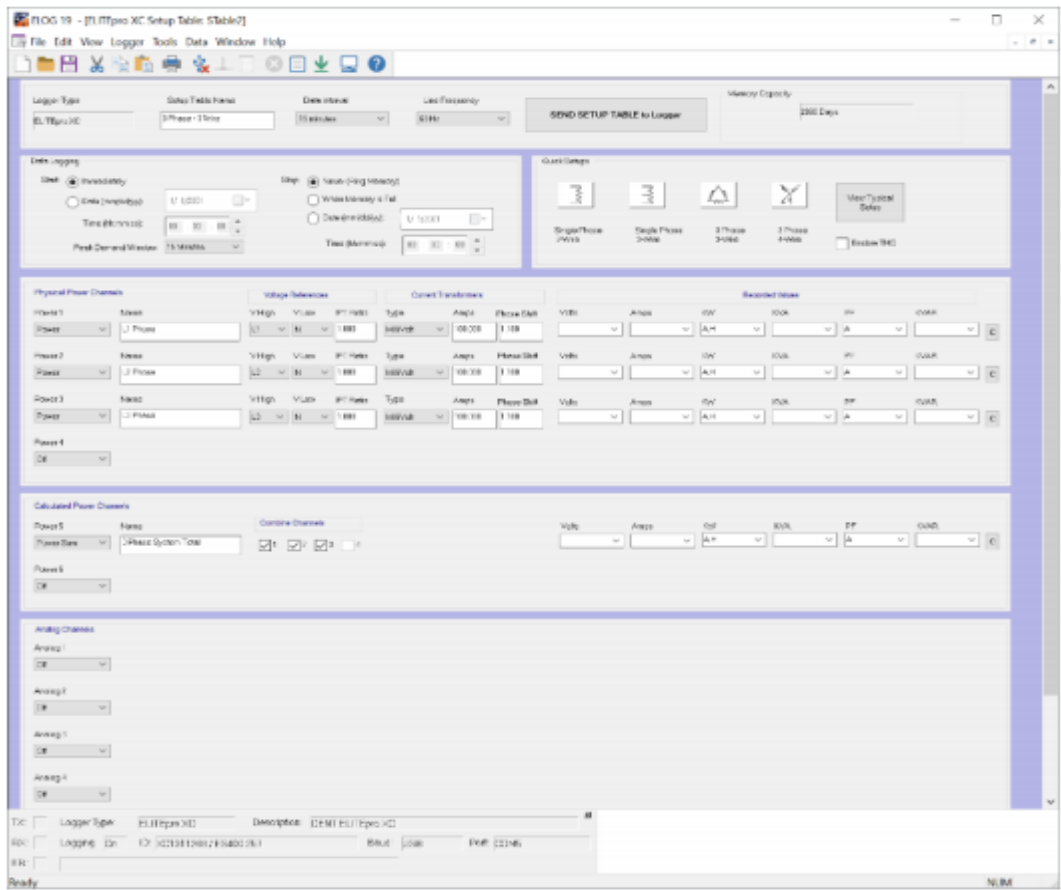


Figure 71: Dent data logger software setup (Dent instruments, 2019)

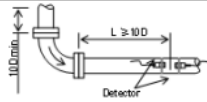
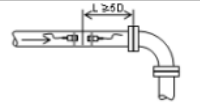
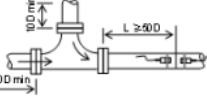
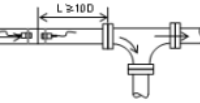
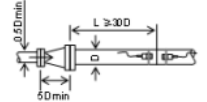
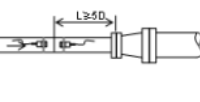
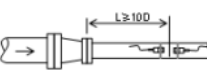
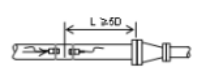
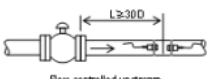
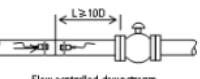
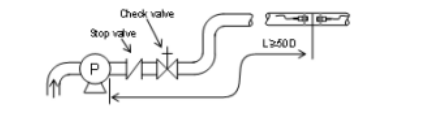
Name	Straight length of upstream piping	Straight length of downstream piping
90° bend		
Tee		
Diffuser		
Reduce		
Valve		
Pump		

Figure 72: SiteLab SL1188 transducer installation (SiteLab, 2015)

Press **Rate** key:
Display Flow Rate. The function is the same with Window M02.

Press **Velocity** key:
Display Velocity. The function is the same with Window M01.

Press **Signal** key:
Display Signal Strength and Signal Quality. The function is the same with Window M90.

Press **Totalizer** key:
Display Net Totalizer. The function is the same with Window M00.

Press **Transit** key:
Display Transit Time Ratio. The function is the same with Window M91.

Press **Stop** key:
Display System Error Code. The function is the same with Window M08.

Press **pipe dia** key:
Enter Pipe Outer Diameter in Window M11.

Press **pipe wall** key:
Enter Pipe Wall Thickness in Window M12.

Press **pipe mat** key:
Enter Pipe Material in Window M14.

Flow 01129m³/h *R
POS 0x1m³

Flow 01129m³/h *R
Vel 10415m/s

Strength + Quality [90
UP:00.0 DN:00.0 Q=00

Flow 01154m³/h *R
NET 0x1m³

TOTV/TOS*100 [91
0.0000%

*R-----
System Normal

Pipe Outer Diameter
50 mm

Pipe Wall Thickness
4 mm

Pipe Material [14
0. Carbon Steel

Press **Fluid Type** key:
Enter Fluid Type in Window M20.

Press **Transducer Mounting** key:
Enter Transducer Mounting in Window M24.

Press **start stop** key:
Enter to start and stop Manual Totalizer in turn.

Press **hold** key:
Display the Display / Hold Totalizer in turn.

Press **dyn** key:
Display Dynamic / Normal Flow Rate and Velocity in turn.

Press **fluid sound** key:
Enter Fluid Sound Velocity in Window M92.

Press **date time** key:
Display Date and Time in Window M60.

Press **cal** key:
Press Ent to start Manual Totalizer, then press Ent to end Manual Totalizer, press Ent to input Standard Totalizer to get the final K factor. Complete the calibration with pressing Ent to store.

Press **set zero** key:
Input code 1234 to set zero.

Fluid Type [20
0. Water

Transducer Mounting
0. U

60 sec
ON 10.123 m³

Flow 01129 m³/h *R
POS 0x1m³

Flow 01129 m³/h Dyn
Vel 10415 m/s

Fluid Sound Velocity
1443.4 m/s

VV-M11-00 HMM1SS
03-04-04 10:05:04

Manual Calibrate
Press Ent When Ready

Set Zero
Please Enter PW

Figure 73: SiteLab SL1188 software setup

APPENDIX M: IN-FIELD MEASUREMENTS

Table 15: In-field measurements

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/01 00:00	689.65	246.23	2018/07/10 07:30	670.70	241.39	2018/07/19 15:30	663.08	233.86
2018/07/01 00:15	684.39	249.59	2018/07/10 07:45	672.94	242.77	2018/07/19 15:45	658.60	234.29
2018/07/01 00:30	690.65	248.81	2018/07/10 08:00	675.28	242.83	2018/07/19 16:00	660.71	234.12
2018/07/01 00:45	692.81	249.39	2018/07/10 08:15	674.48	240.97	2018/07/19 16:15	660.37	232.55
2018/07/01 01:00	687.93	248.75	2018/07/10 08:30	670.19	242.92	2018/07/19 16:30	658.94	232.70
2018/07/01 01:15	689.38	248.11	2018/07/10 08:45	674.03	241.68	2018/07/19 16:45	656.87	233.69
2018/07/01 01:30	688.06	250.28	2018/07/10 09:00	670.93	240.43	2018/07/19 17:00	662.66	232.98
2018/07/01 01:45	691.03	249.93	2018/07/10 09:15	663.91	241.35	2018/07/19 17:15	662.71	233.30
2018/07/01 02:00	687.23	249.26	2018/07/10 09:30	666.05	242.33	2018/07/19 17:30	661.08	233.41
2018/07/01 02:15	689.24	248.67	2018/07/10 09:45	662.42	242.67	2018/07/19 17:45	662.66	233.23
2018/07/01 02:30	689.23	249.70	2018/07/10 10:00	664.21	240.57	2018/07/19 18:00	662.40	232.56
2018/07/01 02:45	689.56	249.65	2018/07/10 10:15	661.38	240.78	2018/07/19 18:15	663.37	235.60
2018/07/01 03:00	692.65	249.51	2018/07/10 10:30	663.08	241.70	2018/07/19 18:30	667.53	235.72
2018/07/01 03:15	691.29	250.66	2018/07/10 10:45	662.89	242.68	2018/07/19 18:45	668.71	235.70
2018/07/01 03:30	687.26	250.98	2018/07/10 11:00	666.07	242.68	2018/07/19 19:00	668.62	234.71
2018/07/01 03:45	694.74	249.88	2018/07/10 11:15	672.91	241.47	2018/07/19 19:15	670.18	235.68
2018/07/01 04:00	694.18	247.75	2018/07/10 11:30	667.74	242.19	2018/07/19 19:30	670.24	234.91
2018/07/01 04:15	689.96	248.51	2018/07/10 11:45	664.00	241.60	2018/07/19 19:45	671.22	234.09
2018/07/01 04:30	691.40	249.04	2018/07/10 12:00	670.84	241.66	2018/07/19 20:00	673.96	235.22
2018/07/01 04:45	694.04	247.20	2018/07/10 12:15	663.80	241.35	2018/07/19 20:15	676.00	234.64
2018/07/01 05:00	693.90	249.00	2018/07/10 12:30	665.95	238.26	2018/07/19 20:30	668.38	235.13
2018/07/01 05:15	690.13	249.76	2018/07/10 12:45	672.82	234.72	2018/07/19 20:45	672.77	235.13
2018/07/01 05:30	689.64	250.53	2018/07/10 13:00	664.68	231.90	2018/07/19 21:00	671.55	235.94
2018/07/01 05:45	691.51	249.12	2018/07/10 13:15	665.58	229.77	2018/07/19 21:15	669.64	234.66
2018/07/01 06:00	691.74	249.08	2018/07/10 13:30	664.70	228.77	2018/07/19 21:30	672.12	235.82
2018/07/01 06:15	691.71	248.34	2018/07/10 13:45	665.06	241.60	2018/07/19 21:45	671.89	235.44
2018/07/01 06:30	687.84	248.21	2018/07/10 14:00	667.50	241.37	2018/07/19 22:00	676.44	235.33
2018/07/01 06:45	690.73	245.92	2018/07/10 14:15	667.95	241.40	2018/07/19 22:15	670.97	234.12
2018/07/01 07:00	686.78	245.09	2018/07/10 14:30	658.95	242.16	2018/07/19 22:30	667.50	232.72
2018/07/01 07:15	685.86	248.77	2018/07/10 14:45	668.53	239.66	2018/07/19 22:45	665.40	235.35
2018/07/01 07:30	687.78	247.19	2018/07/10 15:00	670.21	229.15	2018/07/19 23:00	676.89	233.51
2018/07/01 07:45	685.60	247.31	2018/07/10 15:15	669.25	239.05	2018/07/19 23:15	672.83	236.37
2018/07/01 08:00	687.69	246.26	2018/07/10 15:30	665.08	228.50	2018/07/19 23:30	673.80	234.45
2018/07/01 08:15	685.91	247.02	2018/07/10 15:45	666.61	229.90	2018/07/19 23:45	675.24	234.86
2018/07/01 08:30	686.93	247.37	2018/07/10 16:00	667.55	228.85	2018/07/20 00:00	674.56	234.44
2018/07/01 08:45	684.75	246.78	2018/07/10 16:15	667.49	229.16	2018/07/20 00:15	673.04	235.07
2018/07/01 09:00	682.94	246.59	2018/07/10 16:30	663.61	228.61	2018/07/20 00:30	675.34	234.97
2018/07/01 09:15	681.34	246.50	2018/07/10 16:45	667.81	230.40	2018/07/20 00:45	680.78	234.86
2018/07/01 09:30	679.57	246.98	2018/07/10 17:00	663.01	228.05	2018/07/20 01:00	681.33	235.01
2018/07/01 09:45	677.00	246.36	2018/07/10 17:15	663.17	230.54	2018/07/20 01:15	678.16	236.34
2018/07/01 10:00	673.90	248.03	2018/07/10 17:30	663.64	241.93	2018/07/20 01:30	679.97	234.33
2018/07/01 10:15	673.80	247.05	2018/07/10 17:45	663.03	241.53	2018/07/20 01:45	678.30	232.29
2018/07/01 10:30	675.94	246.53	2018/07/10 18:00	664.43	242.90	2018/07/20 02:00	676.67	233.06
2018/07/01 10:45	674.25	246.34	2018/07/10 18:15			2018/07/20 02:15	676.81	235.53
2018/07/01 11:00	680.02	245.10	2018/07/10 18:30			2018/07/20 02:30	681.45	234.89

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/01 11:15	670.55	245.86	2018/07/10 18:45			2018/07/20 02:45	677.69	232.86
2018/07/01 11:30	670.59	246.79	2018/07/10 19:00			2018/07/20 03:00	675.40	235.83
2018/07/01 11:45	679.54	245.46	2018/07/10 19:15			2018/07/20 03:15	677.63	236.12
2018/07/01 12:00	671.61	247.18	2018/07/10 19:30			2018/07/20 03:30	677.72	236.82
2018/07/01 12:15	676.87	245.80	2018/07/10 19:45			2018/07/20 03:45	682.86	234.35
2018/07/01 12:30	676.51	246.62	2018/07/10 20:00			2018/07/20 04:00	673.63	233.97
2018/07/01 12:45	676.80	245.95	2018/07/10 20:15			2018/07/20 04:15	679.20	232.56
2018/07/01 13:00	678.12	246.90	2018/07/10 20:30			2018/07/20 04:30	675.43	234.56
2018/07/01 13:15	675.64	246.76	2018/07/10 20:45			2018/07/20 04:45	673.58	234.00
2018/07/01 13:30	677.05	245.98	2018/07/10 21:00			2018/07/20 05:00	673.41	233.63
2018/07/01 13:45	678.70	247.40	2018/07/10 21:15			2018/07/20 05:15	675.34	234.48
2018/07/01 14:00	672.77	247.07	2018/07/10 21:30			2018/07/20 05:30	668.78	233.84
2018/07/01 14:15	671.28	245.60	2018/07/10 21:45			2018/07/20 05:45	670.11	236.40
2018/07/01 14:30	680.82	245.70	2018/07/10 22:00			2018/07/20 06:00	675.45	234.15
2018/07/01 14:45	673.75	245.88	2018/07/10 22:15			2018/07/20 06:15	676.32	234.05
2018/07/01 15:00	674.12	246.27	2018/07/10 22:30			2018/07/20 06:30	675.93	234.12
2018/07/01 15:15	681.10	246.01	2018/07/10 22:45			2018/07/20 06:45	671.90	234.35
2018/07/01 15:30	674.94	247.15	2018/07/10 23:00			2018/07/20 07:00	673.57	234.23
2018/07/01 15:45	674.32	246.51	2018/07/10 23:15			2018/07/20 07:15	673.47	232.92
2018/07/01 16:00	678.27	247.14	2018/07/10 23:30			2018/07/20 07:30	670.30	233.46
2018/07/01 16:15	676.87	248.06	2018/07/10 23:45			2018/07/20 07:45	672.33	232.80
2018/07/01 16:30	675.19	246.92	2018/07/11 00:00			2018/07/20 08:00	674.36	233.18
2018/07/01 16:45	677.56	246.61	2018/07/11 00:15			2018/07/20 08:15	676.65	232.79
2018/07/01 17:00	681.08	244.58	2018/07/11 00:30			2018/07/20 08:30	672.21	233.84
2018/07/01 17:15	672.81	245.08	2018/07/11 00:45			2018/07/20 08:45	675.56	232.25
2018/07/01 17:30	674.75	244.58	2018/07/11 01:00			2018/07/20 09:00	671.53	233.45
2018/07/01 17:45	669.45	245.92	2018/07/11 01:15			2018/07/20 09:15	670.35	233.95
2018/07/01 18:00	673.04	245.73	2018/07/11 01:30			2018/07/20 09:30	671.02	234.36
2018/07/01 18:15	675.87	246.78	2018/07/11 01:45			2018/07/20 09:45	666.52	233.94
2018/07/01 18:30	675.25	248.50	2018/07/11 02:00			2018/07/20 10:00	666.77	233.97
2018/07/01 18:45	678.17	245.64	2018/07/11 02:15			2018/07/20 10:15	665.25	233.27
2018/07/01 19:00	676.07	246.81	2018/07/11 02:30			2018/07/20 10:30	669.20	233.59
2018/07/01 19:15	673.74	245.60	2018/07/11 02:45			2018/07/20 10:45	664.63	234.16
2018/07/01 19:30	676.95	246.50	2018/07/11 03:00			2018/07/20 11:00	665.47	233.22
2018/07/01 19:45	677.78	246.78	2018/07/11 03:15			2018/07/20 11:15	665.97	233.58
2018/07/01 20:00	677.94	247.71	2018/07/11 03:30			2018/07/20 11:30	665.19	233.23
2018/07/01 20:15	680.38	247.39	2018/07/11 03:45			2018/07/20 11:45	664.00	232.23
2018/07/01 20:30	678.89	246.68	2018/07/11 04:00			2018/07/20 12:00	664.63	233.34
2018/07/01 20:45	681.05	246.75	2018/07/11 04:15			2018/07/20 12:15	666.60	233.36
2018/07/01 21:00	681.48	247.42	2018/07/11 04:30			2018/07/20 12:30	665.45	233.22
2018/07/01 21:15	680.58	247.97	2018/07/11 04:45			2018/07/20 12:45	662.87	232.12
2018/07/01 21:30	682.64	247.01	2018/07/11 05:00			2018/07/20 13:00	664.51	233.64
2018/07/01 21:45	681.67	248.53	2018/07/11 05:15			2018/07/20 13:15	664.25	233.19
2018/07/01 22:00	683.05	248.72	2018/07/11 05:30			2018/07/20 13:30	661.83	230.53
2018/07/01 22:15	684.48	247.96	2018/07/11 05:45			2018/07/20 13:45	663.64	232.06
2018/07/01 22:30	683.21	245.57	2018/07/11 06:00			2018/07/20 14:00	665.78	232.72
2018/07/01 22:45	677.95	248.33	2018/07/11 06:15			2018/07/20 14:15	668.28	233.76
2018/07/01 23:00	685.25	249.20	2018/07/11 06:30			2018/07/20 14:30	663.56	234.28
2018/07/01 23:15	687.20	247.63	2018/07/11 06:45			2018/07/20 14:45	664.90	232.86

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/01 23:30	685.69	247.54	2018/07/11 07:00			2018/07/20 15:00	664.58	233.28
2018/07/01 23:45	683.56	247.82	2018/07/11 07:15			2018/07/20 15:15	664.94	234.09
2018/07/02 00:00	685.26	249.36	2018/07/11 07:30			2018/07/20 15:30	664.32	233.58
2018/07/02 00:15	688.14	251.36	2018/07/11 07:45			2018/07/20 15:45	663.95	233.02
2018/07/02 00:30	690.23	250.85	2018/07/11 08:00			2018/07/20 16:00	665.56	233.81
2018/07/02 00:45	691.89	251.50	2018/07/11 08:15			2018/07/20 16:15	665.27	233.44
2018/07/02 01:00	693.96	249.13	2018/07/11 08:30		107.72	2018/07/20 16:30	662.39	232.53
2018/07/02 01:15	691.13	245.87	2018/07/11 08:45	329.85	230.36	2018/07/20 16:45	661.45	234.11
2018/07/02 01:30	687.17	246.11	2018/07/11 09:00	665.39	210.98	2018/07/20 17:00	666.19	233.04
2018/07/02 01:45	685.47	249.38	2018/07/11 09:15	663.35	210.15	2018/07/20 17:15	665.92	232.61
2018/07/02 02:00	687.43	248.40	2018/07/11 09:30	662.63	209.65	2018/07/20 17:30	661.21	231.55
2018/07/02 02:15	688.78	246.62	2018/07/11 09:45	663.84	208.95	2018/07/20 17:45	662.56	232.71
2018/07/02 02:30	689.00	248.66	2018/07/11 10:00	663.96	207.84	2018/07/20 18:00	663.46	232.50
2018/07/02 02:45	689.83	247.15	2018/07/11 10:15	662.39	209.41	2018/07/20 18:15	664.33	233.09
2018/07/02 03:00	685.62	246.81	2018/07/11 10:30	665.38	208.63	2018/07/20 18:30	666.83	234.15
2018/07/02 03:15	683.25	248.53	2018/07/11 10:45	665.44	206.69	2018/07/20 18:45	669.94	234.13
2018/07/02 03:30	686.50	246.93	2018/07/11 11:00	662.90	196.74	2018/07/20 19:00	670.01	233.66
2018/07/02 03:45	691.58	247.01	2018/07/11 11:15	659.78	195.61	2018/07/20 19:15	667.53	234.66
2018/07/02 04:00	689.01	245.89	2018/07/11 11:30	666.47	196.49	2018/07/20 19:30	671.87	235.06
2018/07/02 04:15	686.14	246.62	2018/07/11 11:45	657.12	195.97	2018/07/20 19:45	670.59	234.88
2018/07/02 04:30	683.63	247.67	2018/07/11 12:00	665.48	195.50	2018/07/20 20:00	672.60	234.81
2018/07/02 04:45	687.71	247.46	2018/07/11 12:15	665.21	195.87	2018/07/20 20:15	674.05	233.57
2018/07/02 05:00	688.94	246.17	2018/07/11 12:30	664.86	196.55	2018/07/20 20:30	673.64	234.91
2018/07/02 05:15	684.43	246.47	2018/07/11 12:45	658.86	195.56	2018/07/20 20:45	672.99	234.18
2018/07/02 05:30	687.56	247.08	2018/07/11 13:00	663.54	196.83	2018/07/20 21:00	674.96	234.20
2018/07/02 05:45	686.27	248.55	2018/07/11 13:15	659.98	196.41	2018/07/20 21:15	670.28	235.11
2018/07/02 06:00	686.58	248.82	2018/07/11 13:30	663.55	197.27	2018/07/20 21:30	673.87	234.34
2018/07/02 06:15	692.25	246.70	2018/07/11 13:45	665.36	196.22	2018/07/20 21:45	673.45	235.39
2018/07/02 06:30	686.91	246.55	2018/07/11 14:00	662.76	197.21	2018/07/20 22:00	671.82	233.48
2018/07/02 06:45	683.18	247.34	2018/07/11 14:15	667.72	203.78	2018/07/20 22:15	672.71	232.55
2018/07/02 07:00	689.49	246.35	2018/07/11 14:30	665.19	212.74	2018/07/20 22:30	672.98	232.65
2018/07/02 07:15	685.24	246.80	2018/07/11 14:45	661.44	211.84	2018/07/20 22:45	666.99	234.41
2018/07/02 07:30	686.25	246.30	2018/07/11 15:00	666.87	211.42	2018/07/20 23:00	673.35	233.09
2018/07/02 07:45	686.24	246.63	2018/07/11 15:15	662.78	211.80	2018/07/20 23:15	675.89	231.70
2018/07/02 08:00	688.36	246.64	2018/07/11 15:30	661.62	211.39	2018/07/20 23:30	673.51	234.08
2018/07/02 08:15	689.14	247.82	2018/07/11 15:45	664.40	211.53	2018/07/20 23:45	674.59	233.83
2018/07/02 08:30	686.09	248.55	2018/07/11 16:00	666.17	212.93	2018/07/21 00:00	671.63	234.37
2018/07/02 08:45	685.89	248.64	2018/07/11 16:15	663.51	209.36	2018/07/21 00:15	677.24	232.81
2018/07/02 09:00	684.26	245.88	2018/07/11 16:30	665.49	210.58	2018/07/21 00:30	674.01	235.23
2018/07/02 09:15	681.63	246.52	2018/07/11 16:45	655.89	209.39	2018/07/21 00:45	676.50	232.49
2018/07/02 09:30	678.61	246.60	2018/07/11 17:00	663.58	198.00	2018/07/21 01:00	676.64	233.55
2018/07/02 09:45	675.84	247.84	2018/07/11 17:15	664.89	196.96	2018/07/21 01:15	674.14	232.84
2018/07/02 10:00	673.99	247.10	2018/07/11 17:30	658.03	233.42	2018/07/21 01:30	674.44	233.17
2018/07/02 10:15	673.89	245.97	2018/07/11 17:45	663.58	234.89	2018/07/21 01:45	677.58	233.43
2018/07/02 10:30	670.67	245.13	2018/07/11 18:00	663.88	237.50	2018/07/21 02:00	679.53	233.14
2018/07/02 10:45	670.28	246.35	2018/07/11 18:15	665.61	235.65	2018/07/21 02:15	674.93	232.74
2018/07/02 11:00	676.55	245.70	2018/07/11 18:30	663.61	233.74	2018/07/21 02:30	676.46	232.91
2018/07/02 11:15	675.43	245.54	2018/07/11 18:45	660.36	236.24	2018/07/21 02:45	674.66	231.87
2018/07/02 11:30	667.06	246.71	2018/07/11 19:00	662.47	233.41	2018/07/21 03:00	676.65	232.72

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/02 11:45	670.33	245.77	2018/07/11 19:15	661.74	236.73	2018/07/21 03:15	671.38	235.78
2018/07/02 12:00	676.49	245.27	2018/07/11 19:30	662.65	236.41	2018/07/21 03:30	676.59	236.81
2018/07/02 12:15	677.29	245.36	2018/07/11 19:45	665.13	236.43	2018/07/21 03:45	679.57	236.71
2018/07/02 12:30	668.54	244.60	2018/07/11 20:00	666.78	235.61	2018/07/21 04:00	677.31	233.45
2018/07/02 12:45	669.40	245.73	2018/07/11 20:15	666.63	236.28	2018/07/21 04:15	677.51	234.68
2018/07/02 13:00	665.49	246.29	2018/07/11 20:30	666.82	236.84	2018/07/21 04:30	679.90	234.17
2018/07/02 13:15	673.91	246.59	2018/07/11 20:45	669.17	235.64	2018/07/21 04:45	677.52	233.43
2018/07/02 13:30	678.83	246.74	2018/07/11 21:00	669.34	236.85	2018/07/21 05:00	680.85	231.77
2018/07/02 13:45	676.96	245.91	2018/07/11 21:15	671.12	236.69	2018/07/21 05:15	675.32	232.27
2018/07/02 14:00	673.99	244.97	2018/07/11 21:30	669.17	237.78	2018/07/21 05:30	673.98	233.28
2018/07/02 14:15	672.12	245.05	2018/07/11 21:45	669.97	233.57	2018/07/21 05:45	674.16	231.76
2018/07/02 14:30	673.93	245.45	2018/07/11 22:00	667.24	234.61	2018/07/21 06:00	677.95	232.70
2018/07/02 14:45	680.15	245.42	2018/07/11 22:15	669.69	236.19	2018/07/21 06:15	677.60	233.38
2018/07/02 15:00	672.58	246.09	2018/07/11 22:30	669.01	237.73	2018/07/21 06:30	677.66	233.33
2018/07/02 15:15	677.46	246.81	2018/07/11 22:45	670.91	236.59	2018/07/21 06:45	677.41	233.53
2018/07/02 15:30	670.54	246.83	2018/07/11 23:00	670.01	236.81	2018/07/21 07:00	678.23	233.80
2018/07/02 15:45	673.28	247.55	2018/07/11 23:15	668.85	237.32	2018/07/21 07:15	678.14	233.64
2018/07/02 16:00	672.32	246.84	2018/07/11 23:30	672.65	236.22	2018/07/21 07:30	675.01	233.95
2018/07/02 16:15	673.96	247.62	2018/07/11 23:45	671.33	236.42	2018/07/21 07:45	674.82	234.70
2018/07/02 16:30	676.04	247.24	2018/07/12 00:00	670.97	234.46	2018/07/21 08:00	679.58	232.99
2018/07/02 16:45	672.74	247.23	2018/07/12 00:15	671.11	235.58	2018/07/21 08:15	675.71	232.44
2018/07/02 17:00	675.53	245.97	2018/07/12 00:30	667.46	234.52	2018/07/21 08:30	672.88	232.31
2018/07/02 17:15	677.03	244.88	2018/07/12 00:45	670.27	236.05	2018/07/21 08:45	673.01	232.69
2018/07/02 17:30	672.83	243.79	2018/07/12 01:00	669.93	235.81	2018/07/21 09:00	668.87	232.48
2018/07/02 17:45	671.47	246.00	2018/07/12 01:15	672.51	235.95	2018/07/21 09:15	670.68	233.68
2018/07/02 18:00	674.27	249.14	2018/07/12 01:30	674.49	237.06	2018/07/21 09:30	670.87	235.01
2018/07/02 18:15	680.93	249.22	2018/07/12 01:45	672.43	238.86	2018/07/21 09:45	668.99	233.86
2018/07/02 18:30	678.77	248.41	2018/07/12 02:00	675.78	236.11	2018/07/21 10:00	666.92	232.73
2018/07/02 18:45	678.14	248.54	2018/07/12 02:15	671.75	234.37	2018/07/21 10:15	662.86	234.77
2018/07/02 19:00	680.55	246.04	2018/07/12 02:30	673.88	234.91	2018/07/21 10:30	667.46	231.85
2018/07/02 19:15	678.13	248.52	2018/07/12 02:45	675.89	234.70	2018/07/21 10:45	663.25	232.84
2018/07/02 19:30	683.44	248.83	2018/07/12 03:00	674.73	233.61	2018/07/21 11:00	663.20	233.31
2018/07/02 19:45	682.43	247.55	2018/07/12 03:15	675.51	237.04	2018/07/21 11:15	665.38	233.14
2018/07/02 20:00	682.80	246.85	2018/07/12 03:30	675.40	236.26	2018/07/21 11:30	666.24	232.84
2018/07/02 20:15	682.50	247.68	2018/07/12 03:45	673.11	234.91	2018/07/21 11:45	661.56	232.97
2018/07/02 20:30	681.45	247.97	2018/07/12 04:00	674.06	235.02	2018/07/21 12:00	666.00	231.89
2018/07/02 20:45	682.58	248.05	2018/07/12 04:15	671.43	235.63	2018/07/21 12:15	660.69	231.54
2018/07/02 21:00	682.20	247.36	2018/07/12 04:30	672.10	235.27	2018/07/21 12:30	661.25	230.53
2018/07/02 21:15	681.62	247.57	2018/07/12 04:45	674.04	234.44	2018/07/21 12:45	664.58	232.76
2018/07/02 21:30	681.79	248.00	2018/07/12 05:00	672.59	236.22	2018/07/21 13:00	669.21	233.74
2018/07/02 21:45	684.65	248.49	2018/07/12 05:15	672.06	238.26	2018/07/21 13:15	663.03	232.90
2018/07/02 22:00	685.98	248.08	2018/07/12 05:30	677.93	237.40	2018/07/21 13:30	664.02	234.42
2018/07/02 22:15	688.34	248.35	2018/07/12 05:45	674.51	237.85	2018/07/21 13:45	663.29	232.54
2018/07/02 22:30	685.99	247.20	2018/07/12 06:00	675.89	237.33	2018/07/21 14:00	662.98	232.97
2018/07/02 22:45	685.77	247.39	2018/07/12 06:15	678.14	234.80	2018/07/21 14:15	665.12	232.59
2018/07/02 23:00	688.93	248.40	2018/07/12 06:30	673.99	234.47	2018/07/21 14:30	664.79	230.72
2018/07/02 23:15	687.83	248.80	2018/07/12 06:45	672.18	235.75	2018/07/21 14:45	661.98	231.77
2018/07/02 23:30	689.40	246.75	2018/07/12 07:00	674.69	234.92	2018/07/21 15:00	661.72	231.52
2018/07/02 23:45	683.43	246.80	2018/07/12 07:15	673.03	236.82	2018/07/21 15:15	668.81	233.39

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/03 00:00	688.51	247.12	2018/07/12 07:30	671.00	235.31	2018/07/21 15:30	664.66	232.21
2018/07/03 00:15	686.47	246.21	2018/07/12 07:45	671.70	234.48	2018/07/21 15:45	666.51	232.11
2018/07/03 00:30	686.10	246.28	2018/07/12 08:00	670.65	235.37	2018/07/21 16:00	666.25	233.21
2018/07/03 00:45	685.22	247.47	2018/07/12 08:15	672.77	235.12	2018/07/21 16:15	668.19	232.33
2018/07/03 01:00	689.72	246.29	2018/07/12 08:30	672.82	236.43	2018/07/21 16:30	661.55	234.13
2018/07/03 01:15	686.95	247.39	2018/07/12 08:45	670.62	237.62	2018/07/21 16:45	659.96	234.13
2018/07/03 01:30	686.48	247.12	2018/07/12 09:00	672.26	233.78	2018/07/21 17:00	665.87	232.16
2018/07/03 01:45	690.90	249.29	2018/07/12 09:15	666.49	234.96	2018/07/21 17:15	662.79	232.68
2018/07/03 02:00	690.43	248.75	2018/07/12 09:30	662.36	235.29	2018/07/21 17:30	659.96	232.65
2018/07/03 02:15	693.19	246.25	2018/07/12 09:45	665.11	236.58	2018/07/21 17:45	664.84	232.26
2018/07/03 02:30	692.69	246.74	2018/07/12 10:00	667.67	236.35	2018/07/21 18:00	661.65	231.77
2018/07/03 02:45	694.20	246.38	2018/07/12 10:15	665.25	236.98	2018/07/21 18:15	662.52	233.19
2018/07/03 03:00	686.54	245.83	2018/07/12 10:30	666.77	236.54	2018/07/21 18:30	663.36	232.88
2018/07/03 03:15	687.38	246.61	2018/07/12 10:45	665.78	236.62	2018/07/21 18:45	665.24	233.46
2018/07/03 03:30	691.39	246.17	2018/07/12 11:00	667.48	234.55	2018/07/21 19:00	665.13	233.94
2018/07/03 03:45	689.84	246.88	2018/07/12 11:15	664.76	234.62	2018/07/21 19:15	665.20	234.30
2018/07/03 04:00	689.71	245.62	2018/07/12 11:30	662.43	235.47	2018/07/21 19:30	666.66	234.44
2018/07/03 04:15	694.63	248.45	2018/07/12 11:45	661.26	236.55	2018/07/21 19:45	667.54	234.25
2018/07/03 04:30	691.29	248.07	2018/07/12 12:00	667.17	234.46	2018/07/21 20:00	668.32	233.73
2018/07/03 04:45	690.88	248.42	2018/07/12 12:15	665.70	233.90	2018/07/21 20:15	666.91	234.78
2018/07/03 05:00	692.61	245.78	2018/07/12 12:30	665.34	233.75	2018/07/21 20:30	671.98	234.34
2018/07/03 05:15	687.71	246.35	2018/07/12 12:45	663.48	235.37	2018/07/21 20:45	672.05	233.59
2018/07/03 05:30	687.22	246.96	2018/07/12 13:00	663.85	232.94	2018/07/21 21:00	670.24	234.19
2018/07/03 05:45	689.73	247.50	2018/07/12 13:15	661.55	234.00	2018/07/21 21:15	672.77	234.10
2018/07/03 06:00	685.43	248.14	2018/07/12 13:30	662.05	233.83	2018/07/21 21:30	672.09	233.95
2018/07/03 06:15	695.43	246.60	2018/07/12 13:45	667.80	233.61	2018/07/21 21:45	671.08	234.32
2018/07/03 06:30	690.97	246.65	2018/07/12 14:00	664.72	232.53	2018/07/21 22:00	672.76	233.04
2018/07/03 06:45	690.25	246.09	2018/07/12 14:15	655.88	233.11	2018/07/21 22:15	671.72	233.61
2018/07/03 07:00	686.60	246.69	2018/07/12 14:30	661.50	233.13	2018/07/21 22:30	672.46	233.90
2018/07/03 07:15	686.92	247.53	2018/07/12 14:45	667.14	233.39	2018/07/21 22:45	673.64	235.04
2018/07/03 07:30	687.35	245.47	2018/07/12 15:00	668.35	233.29	2018/07/21 23:00	672.88	233.65
2018/07/03 07:45	687.38	247.62	2018/07/12 15:15	660.86	232.52	2018/07/21 23:15	672.77	233.40
2018/07/03 08:00	686.16	248.01	2018/07/12 15:30	659.74	234.68	2018/07/21 23:30	673.05	233.86
2018/07/03 08:15	689.73	248.38	2018/07/12 15:45	661.80	234.15	2018/07/21 23:45	674.89	233.44
2018/07/03 08:30	691.40	248.56	2018/07/12 16:00	663.08	232.96	2018/07/22 00:00	674.67	232.24
2018/07/03 08:45	690.30	248.28	2018/07/12 16:15	665.88	233.18	2018/07/22 00:15	673.02	233.27
2018/07/03 09:00	693.10	246.24	2018/07/12 16:30	664.76	233.70	2018/07/22 00:30	672.78	235.18
2018/07/03 09:15	690.05	248.31	2018/07/12 16:45	659.61	234.65	2018/07/22 00:45	676.96	233.15
2018/07/03 09:30	685.95	247.89	2018/07/12 17:00	665.26	236.90	2018/07/22 01:00	674.65	234.22
2018/07/03 09:45	683.07	246.47	2018/07/12 17:15	666.26	233.72	2018/07/22 01:15	672.11	233.56
2018/07/03 10:00	683.32	247.34	2018/07/12 17:30	657.70	234.87	2018/07/22 01:30	677.01	231.97
2018/07/03 10:15	680.75	247.96	2018/07/12 17:45	657.78	234.22	2018/07/22 01:45	675.78	232.19
2018/07/03 10:30	680.02	247.33	2018/07/12 18:00	663.54	234.60	2018/07/22 02:00	674.90	233.63
2018/07/03 10:45	676.57	247.85	2018/07/12 18:15	662.21	235.00	2018/07/22 02:15	673.97	233.97
2018/07/03 11:00	674.09	247.89	2018/07/12 18:30	663.55	237.30	2018/07/22 02:30	672.86	234.86
2018/07/03 11:15	676.72	246.63	2018/07/12 18:45	666.45	236.13	2018/07/22 02:45	677.22	232.73
2018/07/03 11:30	674.22	245.86	2018/07/12 19:00	666.55	235.22	2018/07/22 03:00	676.95	232.63
2018/07/03 11:45	671.37	247.14	2018/07/12 19:15	666.08	236.46	2018/07/22 03:15	677.11	234.01
2018/07/03 12:00	672.79	246.96	2018/07/12 19:30	666.65	236.43	2018/07/22 03:30	675.48	234.26

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/03 12:15	672.90	246.98	2018/07/12 19:45	667.63	235.26	2018/07/22 03:45	673.59	234.67
2018/07/03 12:30	675.65	246.17	2018/07/12 20:00	670.32	234.63	2018/07/22 04:00	674.66	233.40
2018/07/03 12:45	673.57	245.18	2018/07/12 20:15	669.13	236.42	2018/07/22 04:15	678.18	234.05
2018/07/03 13:00	672.04	246.39	2018/07/12 20:30	668.32	236.71	2018/07/22 04:30	677.83	234.06
2018/07/03 13:15	673.80	246.95	2018/07/12 20:45	671.25	236.93	2018/07/22 04:45	674.72	233.49
2018/07/03 13:30	671.31	246.48	2018/07/12 21:00	670.02	236.70	2018/07/22 05:00	677.34	232.63
2018/07/03 13:45	675.42	246.33	2018/07/12 21:15	668.14	236.42	2018/07/22 05:15	679.12	233.87
2018/07/03 14:00	673.96	247.18	2018/07/12 21:30	670.88	235.57	2018/07/22 05:30	679.94	234.72
2018/07/03 14:15	674.01	247.88	2018/07/12 21:45	670.13	234.81	2018/07/22 05:45	676.55	233.80
2018/07/03 14:30	677.39	246.34	2018/07/12 22:00	669.15	236.37	2018/07/22 06:00	676.82	233.42
2018/07/03 14:45	670.13	245.88	2018/07/12 22:15	674.83	236.45	2018/07/22 06:15	672.65	233.18
2018/07/03 15:00	673.52	244.95	2018/07/12 22:30	676.93	236.16	2018/07/22 06:30	676.91	233.21
2018/07/03 15:15	676.21	247.53	2018/07/12 22:45	678.00	235.69	2018/07/22 06:45	675.71	232.52
2018/07/03 15:30	671.85	246.98	2018/07/12 23:00	675.11	234.31	2018/07/22 07:00	677.67	232.45
2018/07/03 15:45	674.42	246.71	2018/07/12 23:15	672.97	235.68	2018/07/22 07:15	675.62	233.69
2018/07/03 16:00	676.60	246.74	2018/07/12 23:30	673.05	235.35	2018/07/22 07:30	675.89	232.87
2018/07/03 16:15	673.42	245.53	2018/07/12 23:45	679.10	235.94	2018/07/22 07:45	676.89	234.76
2018/07/03 16:30	672.15	246.55	2018/07/13 00:00	676.61	235.87	2018/07/22 08:00	678.91	232.60
2018/07/03 16:45	674.85	248.46	2018/07/13 00:15	675.67	235.65	2018/07/22 08:15	673.32	232.77
2018/07/03 17:00	673.93	247.59	2018/07/13 00:30	674.63	235.94	2018/07/22 08:30	674.77	232.91
2018/07/03 17:15	675.34	244.64	2018/07/13 00:45	677.03	235.70	2018/07/22 08:45	671.44	233.94
2018/07/03 17:30	673.36	245.66	2018/07/13 01:00	675.67	235.66	2018/07/22 09:00	674.25	233.19
2018/07/03 17:45	675.21	247.03	2018/07/13 01:15	674.72	236.68	2018/07/22 09:15	669.91	234.39
2018/07/03 18:00	678.48	245.46	2018/07/13 01:30	676.33	236.05	2018/07/22 09:30	672.19	233.84
2018/07/03 18:15	678.17	247.74	2018/07/13 01:45	676.81	235.17	2018/07/22 09:45	668.33	232.52
2018/07/03 18:30	680.34	248.18	2018/07/13 02:00	674.96	236.67	2018/07/22 10:00	665.88	232.35
2018/07/03 18:45	681.86	248.32	2018/07/13 02:15	676.18	235.56	2018/07/22 10:15	663.43	233.43
2018/07/03 19:00	683.07	246.76	2018/07/13 02:30	676.38	236.03	2018/07/22 10:30	661.87	232.28
2018/07/03 19:15	680.73	246.33	2018/07/13 02:45	674.89	235.57	2018/07/22 10:45	661.38	232.42
2018/07/03 19:30	681.89	246.69	2018/07/13 03:00	673.33	235.71	2018/07/22 11:00	666.46	234.68
2018/07/03 19:45	686.20	247.52	2018/07/13 03:15	677.97	235.21	2018/07/22 11:15	665.14	233.02
2018/07/03 20:00	687.04	247.14	2018/07/13 03:30	674.40	235.12	2018/07/22 11:30	664.12	235.37
2018/07/03 20:15	687.36	247.51	2018/07/13 03:45	672.58	235.31	2018/07/22 11:45	666.28	234.63
2018/07/03 20:30	686.81	247.62	2018/07/13 04:00	673.34	235.68	2018/07/22 12:00	665.98	233.53
2018/07/03 20:45	681.67	247.05	2018/07/13 04:15	674.08	235.73	2018/07/22 12:15	665.85	234.87
2018/07/03 21:00	686.53	247.31	2018/07/13 04:30	674.07	236.14	2018/07/22 12:30	665.91	234.11
2018/07/03 21:15	691.83	248.21	2018/07/13 04:45	676.34	235.41	2018/07/22 12:45	662.35	234.52
2018/07/03 21:30	688.60	248.42	2018/07/13 05:00	674.58	235.84	2018/07/22 13:00	666.59	233.07
2018/07/03 21:45	689.69	248.06	2018/07/13 05:15	675.23	235.38	2018/07/22 13:15	662.76	232.27
2018/07/03 22:00	686.48	246.74	2018/07/13 05:30	674.68	235.49	2018/07/22 13:30	659.70	232.72
2018/07/03 22:15	686.24	246.14	2018/07/13 05:45	673.18	238.67	2018/07/22 13:45	657.46	234.44
2018/07/03 22:30	682.01	248.30	2018/07/13 06:00	677.74	237.55	2018/07/22 14:00	662.95	233.42
2018/07/03 22:45	688.18	247.72	2018/07/13 06:15	674.68	235.59	2018/07/22 14:15	669.36	235.53
2018/07/03 23:00	685.02	248.63	2018/07/13 06:30	673.26	235.88	2018/07/22 14:30	664.98	231.79
2018/07/03 23:15	685.91	247.18	2018/07/13 06:45	672.84	235.74	2018/07/22 14:45	664.58	232.00
2018/07/03 23:30	683.69	247.19	2018/07/13 07:00	670.60	234.79	2018/07/22 15:00	657.99	232.92
2018/07/03 23:45	681.89	247.94	2018/07/13 07:15	671.71	235.93	2018/07/22 15:15	660.92	232.05
2018/07/04 00:00	684.63	246.60	2018/07/13 07:30	674.22	234.50	2018/07/22 15:30	662.53	230.48
2018/07/04 00:15	679.57	247.00	2018/07/13 07:45	670.85	236.11	2018/07/22 15:45	661.94	232.47

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/04 00:30	681.85	248.66	2018/07/13 08:00	672.89	235.87	2018/07/22 16:00	668.82	231.19
2018/07/04 00:45	684.78	248.72	2018/07/13 08:15	670.46	235.79	2018/07/22 16:15	656.60	230.55
2018/07/04 01:00	687.31	248.94	2018/07/13 08:30	671.64	235.41	2018/07/22 16:30	660.02	231.98
2018/07/04 01:15	687.94	248.15	2018/07/13 08:45	671.27	234.73	2018/07/22 16:45	664.12	234.17
2018/07/04 01:30	685.55	248.34	2018/07/13 09:00	671.00	233.36	2018/07/22 17:00	663.57	234.51
2018/07/04 01:45	686.14	247.83	2018/07/13 09:15	666.90	235.47	2018/07/22 17:15	666.09	231.42
2018/07/04 02:00	686.07	247.57	2018/07/13 09:30	666.59	234.83	2018/07/22 17:30	660.58	233.31
2018/07/04 02:15	680.74	248.46	2018/07/13 09:45	664.23	235.45	2018/07/22 17:45	661.27	232.23
2018/07/04 02:30	683.41	249.04	2018/07/13 10:00	662.74	235.53	2018/07/22 18:00	660.95	232.55
2018/07/04 02:45	684.19	247.53	2018/07/13 10:15	660.56	236.06	2018/07/22 18:15	660.84	231.86
2018/07/04 03:00	683.46	246.45	2018/07/13 10:30	659.73	235.64	2018/07/22 18:30	664.01	233.28
2018/07/04 03:15	678.31	247.53	2018/07/13 10:45	665.53	234.20	2018/07/22 18:45	662.53	233.37
2018/07/04 03:30	689.64	246.51	2018/07/13 11:00	665.04	234.93	2018/07/22 19:00	662.09	234.25
2018/07/04 03:45	681.23	249.90	2018/07/13 11:15	661.10	234.35	2018/07/22 19:15	666.16	233.62
2018/07/04 04:00	687.04	246.44	2018/07/13 11:30	660.64	234.33	2018/07/22 19:30	664.40	234.23
2018/07/04 04:15	683.64	247.06	2018/07/13 11:45	665.24	235.74	2018/07/22 19:45	667.06	233.42
2018/07/04 04:30	685.28	246.73	2018/07/13 12:00	662.39	235.15	2018/07/22 20:00	667.30	234.27
2018/07/04 04:45	683.87	247.09	2018/07/13 12:15	662.42	235.04	2018/07/22 20:15	668.64	233.04
2018/07/04 05:00	681.43	245.84	2018/07/13 12:30	665.42	233.99	2018/07/22 20:30	667.67	232.81
2018/07/04 05:15	679.81	247.38	2018/07/13 12:45	658.95	234.70	2018/07/22 20:45	666.19	234.05
2018/07/04 05:30	680.29	247.02	2018/07/13 13:00	659.32	236.31	2018/07/22 21:00	666.83	233.63
2018/07/04 05:45	684.42	248.43	2018/07/13 13:15	663.08	234.02	2018/07/22 21:15	666.52	233.24
2018/07/04 06:00	684.15	248.28	2018/07/13 13:30	658.61	233.16	2018/07/22 21:30	667.43	234.12
2018/07/04 06:15	683.69	246.91	2018/07/13 13:45	658.13	234.03	2018/07/22 21:45	670.21	234.64
2018/07/04 06:30	684.12	246.80	2018/07/13 14:00	662.38	233.02	2018/07/22 22:00	669.95	232.80
2018/07/04 06:45	686.45	246.69	2018/07/13 14:15	658.04	234.03	2018/07/22 22:15	670.77	232.17
2018/07/04 07:00	683.30	247.19	2018/07/13 14:30	661.52	234.05	2018/07/22 22:30	669.83	232.99
2018/07/04 07:15	686.01	246.35	2018/07/13 14:45	665.62	234.79	2018/07/22 22:45	672.42	234.44
2018/07/04 07:30	684.10	246.23	2018/07/13 15:00	659.31	233.61	2018/07/22 23:00	672.99	232.50
2018/07/04 07:45	688.65	247.00	2018/07/13 15:15	657.92	233.56	2018/07/22 23:15	670.47	233.99
2018/07/04 08:00	685.91	247.07	2018/07/13 15:30	659.04	233.73	2018/07/22 23:30	671.73	235.25
2018/07/04 08:15	681.01	246.49	2018/07/13 15:45	663.15	234.77	2018/07/22 23:45	676.66	233.42
2018/07/04 08:30	680.44	246.23	2018/07/13 16:00	658.23	233.34	2018/07/23 00:00	673.50	232.09
2018/07/04 08:45	677.75	248.13	2018/07/13 16:15	664.01	232.63	2018/07/23 00:15	673.06	231.99
2018/07/04 09:00	680.53	245.89	2018/07/13 16:30	661.45	236.62	2018/07/23 00:30	670.84	233.48
2018/07/04 09:15	676.94	247.81	2018/07/13 16:45	665.95	236.64	2018/07/23 00:45	672.33	233.64
2018/07/04 09:30	678.07	245.56	2018/07/13 17:00	663.10	234.36	2018/07/23 01:00	673.42	236.15
2018/07/04 09:45	673.71	246.83	2018/07/13 17:15	665.39	235.30	2018/07/23 01:15	673.96	233.73
2018/07/04 10:00	675.54	246.71	2018/07/13 17:30	668.09	235.60	2018/07/23 01:30	673.49	232.62
2018/07/04 10:15	668.06	246.85	2018/07/13 17:45	662.63	235.65	2018/07/23 01:45	673.65	230.64
2018/07/04 10:30	670.07	247.88	2018/07/13 18:00	664.30	235.14	2018/07/23 02:00	671.43	231.82
2018/07/04 10:45	669.58	244.96	2018/07/13 18:15	663.94	234.69	2018/07/23 02:15	672.43	232.42
2018/07/04 11:00	669.10	247.83	2018/07/13 18:30	666.15	236.36	2018/07/23 02:30	670.16	232.64
2018/07/04 11:15	670.23	245.53	2018/07/13 18:45	665.04	234.00	2018/07/23 02:45	673.48	231.83
2018/07/04 11:30	669.09	247.55	2018/07/13 19:00	665.74	235.05	2018/07/23 03:00	674.98	231.04
2018/07/04 11:45	665.95	247.96	2018/07/13 19:15	664.49	235.32	2018/07/23 03:15	670.10	234.11
2018/07/04 12:00	667.70	246.01	2018/07/13 19:30	668.90	235.44	2018/07/23 03:30	676.23	236.20
2018/07/04 12:15	669.60	246.84	2018/07/13 19:45	667.52	236.11	2018/07/23 03:45	678.82	234.36
2018/07/04 12:30	664.44	244.68	2018/07/13 20:00	669.90	235.37	2018/07/23 04:00	677.67	231.96

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/04 12:45	666.16	246.73	2018/07/13 20:15	670.07	235.12	2018/07/23 04:15	671.70	233.36
2018/07/04 13:00	669.48	246.30	2018/07/13 20:30	671.84	235.94	2018/07/23 04:30	676.70	233.96
2018/07/04 13:15	668.00	247.04	2018/07/13 20:45	668.37	235.56	2018/07/23 04:45	673.63	232.39
2018/07/04 13:30	667.22	247.71	2018/07/13 21:00	672.61	236.71	2018/07/23 05:00	671.72	231.73
2018/07/04 13:45	665.22	246.31	2018/07/13 21:15	671.51	235.41	2018/07/23 05:15	673.24	233.23
2018/07/04 14:00	672.46	246.38	2018/07/13 21:30	672.06	236.89	2018/07/23 05:30	673.98	233.99
2018/07/04 14:15	669.88	246.08	2018/07/13 21:45	670.62	235.67	2018/07/23 05:45	673.33	236.17
2018/07/04 14:30	668.51	246.42	2018/07/13 22:00	673.33	235.03	2018/07/23 06:00	673.49	232.61
2018/07/04 14:45	669.34	246.66	2018/07/13 22:15	671.96	236.05	2018/07/23 06:15	670.85	233.62
2018/07/04 15:00	670.45	244.83	2018/07/13 22:30	672.73	235.85	2018/07/23 06:30	674.23	234.15
2018/07/04 15:15	673.06	239.67	2018/07/13 22:45	672.20	236.20	2018/07/23 06:45	677.30	235.07
2018/07/04 15:30	666.52	241.23	2018/07/13 23:00	672.59	235.41	2018/07/23 07:00	678.33	233.17
2018/07/04 15:45	669.00	243.52	2018/07/13 23:15	671.74	235.83	2018/07/23 07:15	670.67	233.67
2018/07/04 16:00	667.57	244.78	2018/07/13 23:30	671.88	234.00	2018/07/23 07:30	672.15	233.41
2018/07/04 16:15	669.43	245.23	2018/07/13 23:45	669.77	233.31	2018/07/23 07:45	675.79	233.16
2018/07/04 16:30	669.94	244.48	2018/07/14 00:00	670.27	233.91	2018/07/23 08:00	672.72	233.90
2018/07/04 16:45	671.70	245.08	2018/07/14 00:15	674.93	235.79	2018/07/23 08:15	673.14	233.09
2018/07/04 17:00	668.45	244.07	2018/07/14 00:30	673.72	234.54	2018/07/23 08:30	672.65	233.22
2018/07/04 17:15	672.01	246.36	2018/07/14 00:45	673.91	234.64	2018/07/23 08:45	672.28	234.57
2018/07/04 17:30	669.43	245.69	2018/07/14 01:00	671.48	236.39	2018/07/23 09:00	673.82	232.56
2018/07/04 17:45	673.62	246.16	2018/07/14 01:15	673.65	234.91	2018/07/23 09:15	669.17	232.26
2018/07/04 18:00	671.24	248.42	2018/07/14 01:30	673.04	234.08	2018/07/23 09:30	665.72	233.44
2018/07/04 18:15	674.16	244.42	2018/07/14 01:45	672.73	235.36	2018/07/23 09:45	667.95	233.43
2018/07/04 18:30	673.79	244.19	2018/07/14 02:00	676.62	235.72	2018/07/23 10:00	666.27	231.36
2018/07/04 18:45	671.38	245.18	2018/07/14 02:15	672.81	236.91	2018/07/23 10:15	665.07	232.89
2018/07/04 19:00	675.18	244.65	2018/07/14 02:30	674.45	235.62	2018/07/23 10:30	664.48	232.93
2018/07/04 19:15	676.37	246.35	2018/07/14 02:45	674.97	235.52	2018/07/23 10:45	665.54	232.95
2018/07/04 19:30	676.79	245.96	2018/07/14 03:00	678.79	234.12	2018/07/23 11:00	665.66	232.85
2018/07/04 19:45	676.46	246.03	2018/07/14 03:15	674.57	235.51	2018/07/23 11:15	665.47	232.84
2018/07/04 20:00	677.58	243.93	2018/07/14 03:30	672.54	235.57	2018/07/23 11:30	665.40	233.66
2018/07/04 20:15	676.57	244.47	2018/07/14 03:45	677.43	235.26	2018/07/23 11:45	667.10	232.08
2018/07/04 20:30	676.93	246.65	2018/07/14 04:00	673.09	234.20	2018/07/23 12:00	659.54	232.03
2018/07/04 20:45	678.07	245.82	2018/07/14 04:15	674.64	236.09	2018/07/23 12:15	663.66	233.40
2018/07/04 21:00	678.51	245.57	2018/07/14 04:30	676.96	235.56	2018/07/23 12:30	667.13	232.87
2018/07/04 21:15	680.63	245.44	2018/07/14 04:45	675.46	238.12	2018/07/23 12:45	664.23	233.01
2018/07/04 21:30	678.18	245.83	2018/07/14 05:00	677.77	233.86	2018/07/23 13:00	663.11	233.27
2018/07/04 21:45	681.05	244.48	2018/07/14 05:15	674.22	236.33	2018/07/23 13:15	665.17	232.97
2018/07/04 22:00	677.68	244.97	2018/07/14 05:30	673.96	236.55	2018/07/23 13:30	662.58	232.63
2018/07/04 22:15	676.75	246.34	2018/07/14 05:45	676.25	236.16	2018/07/23 13:45	661.72	233.56
2018/07/04 22:30	679.55	248.42	2018/07/14 06:00	675.92	235.13	2018/07/23 14:00	662.59	233.10
2018/07/04 22:45	679.14	247.82	2018/07/14 06:15	675.58	234.99	2018/07/23 14:15	662.18	232.22
2018/07/04 23:00	681.84	246.32	2018/07/14 06:30	672.82	235.17	2018/07/23 14:30	661.13	232.85
2018/07/04 23:15	682.05	245.29	2018/07/14 06:45	677.62	234.92	2018/07/23 14:45	663.89	232.12
2018/07/04 23:30	679.12	246.25	2018/07/14 07:00	678.40	234.69	2018/07/23 15:00	664.40	229.72
2018/07/04 23:45	683.15	245.77	2018/07/14 07:15	674.93	235.91	2018/07/23 15:15	660.05	221.27
2018/07/05 00:00	682.44	246.05	2018/07/14 07:30	678.41	234.51	2018/07/23 15:30	665.86	219.73
2018/07/05 00:15	681.82	245.44	2018/07/14 07:45	678.06	235.75	2018/07/23 15:45	665.52	221.16
2018/07/05 00:30	683.13	245.22	2018/07/14 08:00	675.63	235.51	2018/07/23 16:00	664.65	221.22
2018/07/05 00:45	684.91	245.88	2018/07/14 08:15	673.39	236.08	2018/07/23 16:15	662.33	221.22

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/05 01:00	681.42	246.33	2018/07/14 08:30	673.20	235.94	2018/07/23 16:30	662.95	229.16
2018/07/05 01:15	681.69	247.12	2018/07/14 08:45	672.21	235.68	2018/07/23 16:45	665.53	232.88
2018/07/05 01:30	682.03	246.20	2018/07/14 09:00	674.36	236.25	2018/07/23 17:00	660.87	233.28
2018/07/05 01:45	683.29	246.37	2018/07/14 09:15	667.55	235.01	2018/07/23 17:15	666.44	231.84
2018/07/05 02:00	681.57	247.77	2018/07/14 09:30	670.02	234.70	2018/07/23 17:30	661.85	231.08
2018/07/05 02:15	684.39	246.45	2018/07/14 09:45	663.91	235.03	2018/07/23 17:45	664.06	231.52
2018/07/05 02:30	686.95	246.21	2018/07/14 10:00	662.22	235.41	2018/07/23 18:00	662.25	234.21
2018/07/05 02:45	680.92	244.94	2018/07/14 10:15	657.47	234.99	2018/07/23 18:15	665.02	233.39
2018/07/05 03:00	678.90	243.02	2018/07/14 10:30	663.06	234.82	2018/07/23 18:30	666.96	234.22
2018/07/05 03:15	678.92	245.65	2018/07/14 10:45	663.86	233.36	2018/07/23 18:45	667.18	235.04
2018/07/05 03:30	682.59	247.26	2018/07/14 11:00	663.06	233.88	2018/07/23 19:00	671.98	231.61
2018/07/05 03:45	683.25	246.39	2018/07/14 11:15	661.01	233.91	2018/07/23 19:15	666.66	234.76
2018/07/05 04:00	683.36	244.93	2018/07/14 11:30	664.17	234.22	2018/07/23 19:30	671.38	233.06
2018/07/05 04:15	685.50	247.82	2018/07/14 11:45	662.97	234.09	2018/07/23 19:45	669.01	232.41
2018/07/05 04:30	680.89	246.40	2018/07/14 12:00	661.28	234.16	2018/07/23 20:00	668.15	233.13
2018/07/05 04:45	684.58	245.05	2018/07/14 12:15	669.24	234.15	2018/07/23 20:15	668.71	234.97
2018/07/05 05:00	679.84	245.79	2018/07/14 12:30	668.92	233.50	2018/07/23 20:30	673.90	235.66
2018/07/05 05:15	682.60	245.64	2018/07/14 12:45	664.61	233.50	2018/07/23 20:45	672.71	235.24
2018/07/05 05:30	684.60	249.48	2018/07/14 13:00	663.99	233.68	2018/07/23 21:00	675.33	235.83
2018/07/05 05:45	680.15	252.68	2018/07/14 13:15	661.80	233.50	2018/07/23 21:15	670.74	234.39
2018/07/05 06:00	684.10	251.43	2018/07/14 13:30	665.48	233.92	2018/07/23 21:30	671.54	233.58
2018/07/05 06:15	686.18	251.19	2018/07/14 13:45	663.35	233.70	2018/07/23 21:45	670.46	235.29
2018/07/05 06:30	682.02	251.49	2018/07/14 14:00	663.53	233.39	2018/07/23 22:00	672.72	233.65
2018/07/05 06:45	686.01	252.22	2018/07/14 14:15	662.32	233.90	2018/07/23 22:15	671.53	235.64
2018/07/05 07:00	684.71	252.86	2018/07/14 14:30	672.41	233.49	2018/07/23 22:30	673.59	234.52
2018/07/05 07:15	686.67	251.46	2018/07/14 14:45	663.06	234.20	2018/07/23 22:45	673.86	233.68
2018/07/05 07:30	681.88	253.08	2018/07/14 15:00	667.09	234.59	2018/07/23 23:00	670.77	234.42
2018/07/05 07:45	695.27	252.03	2018/07/14 15:15	662.66	233.67	2018/07/23 23:15	675.01	235.11
2018/07/05 08:00	686.28	252.66	2018/07/14 15:30	667.53	233.66	2018/07/23 23:30	677.65	236.50
2018/07/05 08:15	682.98	253.61	2018/07/14 15:45	660.32	233.28	2018/07/23 23:45	677.89	235.75
2018/07/05 08:30	686.55	252.69	2018/07/14 16:00	665.91	233.35	2018/07/24 00:00	677.05	233.02
2018/07/05 08:45	685.96	252.94	2018/07/14 16:15	666.12	235.47	2018/07/24 00:15	672.08	232.66
2018/07/05 09:00	680.76	251.80	2018/07/14 16:30	664.38	235.49	2018/07/24 00:30	674.65	235.06
2018/07/05 09:15	679.62	251.93	2018/07/14 16:45	664.12	234.51	2018/07/24 00:45	677.33	234.04
2018/07/05 09:30	676.64	253.36	2018/07/14 17:00	656.90	234.82	2018/07/24 01:00	680.54	234.96
2018/07/05 09:45	675.34	253.27	2018/07/14 17:15	664.25	235.50	2018/07/24 01:15	679.21	233.25
2018/07/05 10:00	674.50	253.16	2018/07/14 17:30	660.52	235.03	2018/07/24 01:30	674.59	233.02
2018/07/05 10:15	673.00	252.22	2018/07/14 17:45	663.25	233.44	2018/07/24 01:45	670.67	233.47
2018/07/05 10:30	672.69	252.07	2018/07/14 18:00	661.60	235.61	2018/07/24 02:00	675.78	233.67
2018/07/05 10:45	669.04	252.79	2018/07/14 18:15	664.55	236.15	2018/07/24 02:15	676.03	233.89
2018/07/05 11:00	671.94	253.83	2018/07/14 18:30	667.65	235.35	2018/07/24 02:30	678.27	233.91
2018/07/05 11:15	673.31	253.47	2018/07/14 18:45	663.72	236.93	2018/07/24 02:45	672.69	233.22
2018/07/05 11:30	674.58	252.38	2018/07/14 19:00	670.10	235.33	2018/07/24 03:00	675.16	233.39
2018/07/05 11:45	675.01	251.79	2018/07/14 19:15	666.25	235.21	2018/07/24 03:15	675.35	233.43
2018/07/05 12:00	670.46	250.78	2018/07/14 19:30	664.77	234.85	2018/07/24 03:30	675.39	236.49
2018/07/05 12:15	669.23	250.35	2018/07/14 19:45	662.12	234.43	2018/07/24 03:45	675.92	236.84
2018/07/05 12:30	601.87	244.68	2018/07/14 20:00	663.52	235.07	2018/07/24 04:00	680.76	233.23
2018/07/05 12:45			2018/07/14 20:15	669.09	234.77	2018/07/24 04:15	675.64	233.96
2018/07/05 13:00			2018/07/14 20:30	666.20	234.30	2018/07/24 04:30	673.79	233.17

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/05 13:15			2018/07/14 20:45	665.42	234.38	2018/07/24 04:45	673.73	235.23
2018/07/05 13:30			2018/07/14 21:00	665.38	234.37	2018/07/24 05:00	676.52	233.43
2018/07/05 13:45			2018/07/14 21:15	665.79	235.04	2018/07/24 05:15	671.18	234.14
2018/07/05 14:00			2018/07/14 21:30	667.14	235.06	2018/07/24 05:30	675.54	234.02
2018/07/05 14:15			2018/07/14 21:45	667.30	235.27	2018/07/24 05:45	671.12	234.51
2018/07/05 14:30			2018/07/14 22:00	668.16	234.06	2018/07/24 06:00	675.39	232.78
2018/07/05 14:45			2018/07/14 22:15	667.17	235.04	2018/07/24 06:15	674.54	233.75
2018/07/05 15:00			2018/07/14 22:30	670.41	234.50	2018/07/24 06:30	672.95	233.65
2018/07/05 15:15			2018/07/14 22:45	667.76	235.33	2018/07/24 06:45	675.92	235.41
2018/07/05 15:30			2018/07/14 23:00	669.78	234.24	2018/07/24 07:00	675.28	233.24
2018/07/05 15:45			2018/07/14 23:15	670.69	234.71	2018/07/24 07:15	673.56	232.99
2018/07/05 16:00			2018/07/14 23:30	669.35	234.99	2018/07/24 07:30	672.80	234.89
2018/07/05 16:15			2018/07/14 23:45	671.63	234.65	2018/07/24 07:45	676.39	234.10
2018/07/05 16:30			2018/07/15 00:00	666.86	234.99	2018/07/24 08:00	678.87	233.52
2018/07/05 16:45			2018/07/15 00:15	669.57	234.33	2018/07/24 08:15	673.59	234.99
2018/07/05 17:00			2018/07/15 00:30	668.73	235.11	2018/07/24 08:30	674.81	234.78
2018/07/05 17:15			2018/07/15 00:45	672.81	233.92	2018/07/24 08:45	681.68	232.66
2018/07/05 17:30			2018/07/15 01:00	668.57	234.79	2018/07/24 09:00	671.92	232.72
2018/07/05 17:45			2018/07/15 01:15	668.43	234.00	2018/07/24 09:15	669.08	233.15
2018/07/05 18:00			2018/07/15 01:30	669.70	234.21	2018/07/24 09:30	668.15	234.02
2018/07/05 18:15			2018/07/15 01:45	667.58	235.27	2018/07/24 09:45	664.76	233.49
2018/07/05 18:30			2018/07/15 02:00	675.02	233.72	2018/07/24 10:00	665.64	232.31
2018/07/05 18:45			2018/07/15 02:15	669.82	235.13	2018/07/24 10:15	661.14	232.60
2018/07/05 19:00			2018/07/15 02:30	672.66	234.44	2018/07/24 10:30	668.21	234.35
2018/07/05 19:15			2018/07/15 02:45	671.26	235.15	2018/07/24 10:45	662.68	232.69
2018/07/05 19:30			2018/07/15 03:00	677.05	235.01	2018/07/24 11:00	661.20	232.96
2018/07/05 19:45			2018/07/15 03:15	673.37	233.34	2018/07/24 11:15	663.32	232.56
2018/07/05 20:00			2018/07/15 03:30	672.52	234.14	2018/07/24 11:30	663.56	232.88
2018/07/05 20:15			2018/07/15 03:45	669.84	234.47	2018/07/24 11:45	667.09	232.10
2018/07/05 20:30			2018/07/15 04:00	672.77	234.43	2018/07/24 12:00	658.61	232.05
2018/07/05 20:45			2018/07/15 04:15	672.16	235.40	2018/07/24 12:15	660.67	232.58
2018/07/05 21:00			2018/07/15 04:30	672.53	234.27	2018/07/24 12:30	663.54	233.69
2018/07/05 21:15			2018/07/15 04:45	671.29	234.68	2018/07/24 12:45	663.94	233.05
2018/07/05 21:30			2018/07/15 05:00	677.88	234.25	2018/07/24 13:00	662.86	233.31
2018/07/05 21:45			2018/07/15 05:15	671.24	234.57	2018/07/24 13:15	667.66	233.54
2018/07/05 22:00			2018/07/15 05:30	673.82	235.00	2018/07/24 13:30	661.86	232.43
2018/07/05 22:15			2018/07/15 05:45	673.70	234.66	2018/07/24 13:45	665.02	233.22
2018/07/05 22:30			2018/07/15 06:00	671.35	234.17	2018/07/24 14:00	665.16	232.23
2018/07/05 22:45			2018/07/15 06:15	675.34	234.63	2018/07/24 14:15	662.31	232.72
2018/07/05 23:00			2018/07/15 06:30	675.10	237.69	2018/07/24 14:30	662.31	232.20
2018/07/05 23:15			2018/07/15 06:45	671.02	236.99	2018/07/24 14:45	663.56	232.39
2018/07/05 23:30			2018/07/15 07:00	676.62	234.35	2018/07/24 15:00	662.70	233.16
2018/07/05 23:45			2018/07/15 07:15	670.85	234.65	2018/07/24 15:15	667.11	233.93
2018/07/06 00:00			2018/07/15 07:30	672.50	235.34	2018/07/24 15:30	663.71	231.29
2018/07/06 00:15			2018/07/15 07:45	670.06	234.57	2018/07/24 15:45	664.55	229.98
2018/07/06 00:30			2018/07/15 08:00	670.65	235.55	2018/07/24 16:00	667.21	222.30
2018/07/06 00:45			2018/07/15 08:15	670.21	235.28	2018/07/24 16:15	662.74	221.72
2018/07/06 01:00			2018/07/15 08:30	670.10	235.46	2018/07/24 16:30	664.77	225.80
2018/07/06 01:15			2018/07/15 08:45	670.52	235.80	2018/07/24 16:45	672.18	234.20

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/06 01:30			2018/07/15 09:00	668.35	235.08	2018/07/24 17:00	662.96	234.83
2018/07/06 01:45			2018/07/15 09:15	666.20	235.71	2018/07/24 17:15	667.20	233.28
2018/07/06 02:00			2018/07/15 09:30	668.86	234.71	2018/07/24 17:30	660.21	232.29
2018/07/06 02:15			2018/07/15 09:45	666.46	235.34	2018/07/24 17:45	664.37	232.38
2018/07/06 02:30			2018/07/15 10:00	665.26	234.35	2018/07/24 18:00	657.49	233.51
2018/07/06 02:45			2018/07/15 10:15	664.21	235.64	2018/07/24 18:15	661.21	233.53
2018/07/06 03:00			2018/07/15 10:30	665.93	235.02	2018/07/24 18:30	662.10	233.63
2018/07/06 03:15			2018/07/15 10:45	664.16	235.51	2018/07/24 18:45	662.52	234.62
2018/07/06 03:30			2018/07/15 11:00	662.16	233.63	2018/07/24 19:00	666.25	233.22
2018/07/06 03:45			2018/07/15 11:15	661.39	233.90	2018/07/24 19:15	661.95	235.42
2018/07/06 04:00			2018/07/15 11:30	660.43	233.71	2018/07/24 19:30	664.09	233.45
2018/07/06 04:15			2018/07/15 11:45	656.03	233.46	2018/07/24 19:45	667.29	234.11
2018/07/06 04:30			2018/07/15 12:00	659.75	233.36	2018/07/24 20:00	669.85	234.49
2018/07/06 04:45			2018/07/15 12:15	663.66	234.35	2018/07/24 20:15	667.65	234.18
2018/07/06 05:00			2018/07/15 12:30	656.59	232.61	2018/07/24 20:30	668.70	235.14
2018/07/06 05:15			2018/07/15 12:45	662.23	233.85	2018/07/24 20:45	670.21	234.82
2018/07/06 05:30			2018/07/15 13:00	659.76	232.33	2018/07/24 21:00	668.10	235.47
2018/07/06 05:45			2018/07/15 13:15	660.65	234.22	2018/07/24 21:15	671.99	234.65
2018/07/06 06:00			2018/07/15 13:30	660.74	233.47	2018/07/24 21:30	669.09	234.63
2018/07/06 06:15			2018/07/15 13:45	663.62	234.41	2018/07/24 21:45	668.22	234.80
2018/07/06 06:30			2018/07/15 14:00	658.85	235.58	2018/07/24 22:00	670.03	233.30
2018/07/06 06:45			2018/07/15 14:15	664.02	235.08	2018/07/24 22:15	669.32	234.38
2018/07/06 07:00			2018/07/15 14:30	665.46	234.95	2018/07/24 22:30	672.95	233.45
2018/07/06 07:15			2018/07/15 14:45	659.65	233.57	2018/07/24 22:45	673.37	233.83
2018/07/06 07:30			2018/07/15 15:00	662.22	234.54	2018/07/24 23:00	676.57	233.86
2018/07/06 07:45			2018/07/15 15:15	663.40	233.24	2018/07/24 23:15	671.05	235.01
2018/07/06 08:00			2018/07/15 15:30	656.77	233.10	2018/07/24 23:30	674.92	233.05
2018/07/06 08:15			2018/07/15 15:45	660.79	232.69	2018/07/24 23:45	676.25	234.73
2018/07/06 08:30			2018/07/15 16:00	659.93	234.20	2018/07/25 00:00	675.74	235.02
2018/07/06 08:45			2018/07/15 16:15	657.34	235.46	2018/07/25 00:15	672.50	232.75
2018/07/06 09:00			2018/07/15 16:30	662.98	234.85	2018/07/25 00:30	673.28	233.93
2018/07/06 09:15			2018/07/15 16:45	663.86	235.59	2018/07/25 00:45	678.70	233.74
2018/07/06 09:30			2018/07/15 17:00	663.33	236.23	2018/07/25 01:00	674.79	234.68
2018/07/06 09:45			2018/07/15 17:15	663.47	235.05	2018/07/25 01:15	675.66	234.13
2018/07/06 10:00			2018/07/15 17:30	664.39	234.41	2018/07/25 01:30	675.03	235.62
2018/07/06 10:15			2018/07/15 17:45	662.62	236.16	2018/07/25 01:45	675.40	233.44
2018/07/06 10:30			2018/07/15 18:00	665.17	235.94	2018/07/25 02:00	674.49	234.69
2018/07/06 10:45			2018/07/15 18:15	666.40	236.38	2018/07/25 02:15	674.89	233.60
2018/07/06 11:00			2018/07/15 18:30	667.14	235.30	2018/07/25 02:30	673.85	233.23
2018/07/06 11:15			2018/07/15 18:45	666.39	234.88	2018/07/25 02:45	673.78	233.41
2018/07/06 11:30			2018/07/15 19:00	670.30	234.67	2018/07/25 03:00	673.19	233.31
2018/07/06 11:45			2018/07/15 19:15	668.46	235.74	2018/07/25 03:15	674.22	233.08
2018/07/06 12:00			2018/07/15 19:30	670.11	235.17	2018/07/25 03:30	674.20	234.04
2018/07/06 12:15			2018/07/15 19:45	669.34	235.60	2018/07/25 03:45	676.89	235.64
2018/07/06 12:30			2018/07/15 20:00	670.66	235.27	2018/07/25 04:00	675.87	233.75
2018/07/06 12:45			2018/07/15 20:15	674.98	236.47	2018/07/25 04:15	677.30	235.37
2018/07/06 13:00			2018/07/15 20:30	674.46	235.15	2018/07/25 04:30	673.57	233.23
2018/07/06 13:15		76.68	2018/07/15 20:45	673.71	234.23	2018/07/25 04:45	676.10	233.79
2018/07/06 13:30		212.74	2018/07/15 21:00	669.42	235.13	2018/07/25 05:00	676.91	233.94

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/06 13:45	520.38	243.18	2018/07/15 21:15	670.71	235.81	2018/07/25 05:15	670.61	233.83
2018/07/06 14:00	670.92	247.04	2018/07/15 21:30	671.72	234.48	2018/07/25 05:30	674.81	233.33
2018/07/06 14:15	670.18	246.87	2018/07/15 21:45	672.07	235.09	2018/07/25 05:45	668.68	233.77
2018/07/06 14:30	670.27	247.57	2018/07/15 22:00	673.93	233.95	2018/07/25 06:00	677.80	232.56
2018/07/06 14:45	674.37	247.54	2018/07/15 22:15	673.74	234.34	2018/07/25 06:15	675.78	233.67
2018/07/06 15:00	673.04	247.04	2018/07/15 22:30	669.29	235.92	2018/07/25 06:30	670.44	234.05
2018/07/06 15:15	670.08	248.65	2018/07/15 22:45	674.40	233.78	2018/07/25 06:45	674.66	236.15
2018/07/06 15:30	672.82	248.03	2018/07/15 23:00	673.91	233.13	2018/07/25 07:00	681.94	235.36
2018/07/06 15:45	669.81	249.28	2018/07/15 23:15	673.85	234.89	2018/07/25 07:15	676.55	234.80
2018/07/06 16:00	673.46	248.80	2018/07/15 23:30	679.69	236.25	2018/07/25 07:30	673.05	234.46
2018/07/06 16:15	670.88	248.78	2018/07/15 23:45	679.98	236.84	2018/07/25 07:45	675.61	233.94
2018/07/06 16:30	670.31	248.85	2018/07/16 00:00	676.16	235.18	2018/07/25 08:00	675.73	233.10
2018/07/06 16:45	670.13	249.97	2018/07/16 00:15	676.34	234.92	2018/07/25 08:15	670.27	233.97
2018/07/06 17:00	673.37	250.25	2018/07/16 00:30	676.81	237.62	2018/07/25 08:30	674.29	234.56
2018/07/06 17:15	674.29	250.38	2018/07/16 00:45	678.97	238.34	2018/07/25 08:45	672.02	234.11
2018/07/06 17:30	671.65	250.00	2018/07/16 01:00	681.37	235.01	2018/07/25 09:00	670.05	232.60
2018/07/06 17:45	674.62	249.02	2018/07/16 01:15	676.91	233.71	2018/07/25 09:15	669.93	233.02
2018/07/06 18:00	675.53	249.44	2018/07/16 01:30	676.73	234.86	2018/07/25 09:30	666.36	233.47
2018/07/06 18:15	672.46	249.65	2018/07/16 01:45	677.53	234.49	2018/07/25 09:45	662.49	233.46
2018/07/06 18:30	670.76	251.20	2018/07/16 02:00	676.53	235.11	2018/07/25 10:00	662.44	233.80
2018/07/06 18:45	674.60	251.03	2018/07/16 02:15	674.96	234.58	2018/07/25 10:15	655.51	231.98
2018/07/06 19:00	674.74	248.88	2018/07/16 02:30	676.80	235.44	2018/07/25 10:30	662.98	233.63
2018/07/06 19:15	673.54	249.34	2018/07/16 02:45	677.41	234.97	2018/07/25 10:45	663.09	232.89
2018/07/06 19:30	676.36	250.39	2018/07/16 03:00	679.47	233.86	2018/07/25 11:00	660.61	233.24
2018/07/06 19:45	675.17	250.33	2018/07/16 03:15	672.42	235.12	2018/07/25 11:15	663.94	232.89
2018/07/06 20:00	676.99	251.23	2018/07/16 03:30	677.25	234.36	2018/07/25 11:30	661.43	233.91
2018/07/06 20:15	675.02	251.02	2018/07/16 03:45	671.99	235.15	2018/07/25 11:45	663.95	232.70
2018/07/06 20:30	679.10	250.05	2018/07/16 04:00	677.38	234.00	2018/07/25 12:00	665.85	233.62
2018/07/06 20:45	678.12	249.61	2018/07/16 04:15	673.99	236.09	2018/07/25 12:15	663.98	233.38
2018/07/06 21:00	676.37	250.15	2018/07/16 04:30	677.09	235.62	2018/07/25 12:30	656.87	233.97
2018/07/06 21:15	675.71	251.01	2018/07/16 04:45	675.61	234.46	2018/07/25 12:45	661.47	232.01
2018/07/06 21:30	679.97	249.90	2018/07/16 05:00	673.38	235.75	2018/07/25 13:00	664.87	232.83
2018/07/06 21:45	679.92	250.48	2018/07/16 05:15	673.31	235.84	2018/07/25 13:15	660.97	232.82
2018/07/06 22:00	679.01	249.82	2018/07/16 05:30	673.68	234.48	2018/07/25 13:30	665.22	232.49
2018/07/06 22:15	675.89	245.81	2018/07/16 05:45	676.48	235.59	2018/07/25 13:45	658.96	232.74
2018/07/06 22:30	678.92	243.55	2018/07/16 06:00	676.66	235.80	2018/07/25 14:00	657.19	233.08
2018/07/06 22:45	682.75	243.51	2018/07/16 06:15	674.06	234.47	2018/07/25 14:15	658.94	234.06
2018/07/06 23:00	676.30	243.65	2018/07/16 06:30	676.70	235.01	2018/07/25 14:30	660.91	234.17
2018/07/06 23:15	674.72	243.24	2018/07/16 06:45	672.85	234.28	2018/07/25 14:45	665.69	225.83
2018/07/06 23:30	677.05	244.57	2018/07/16 07:00	674.17	234.64	2018/07/25 15:00	664.73	220.67
2018/07/06 23:45	674.37	245.16	2018/07/16 07:15	673.31	234.71	2018/07/25 15:15	661.60	220.50
2018/07/07 00:00	675.06	246.33	2018/07/16 07:30	676.49	236.68	2018/07/25 15:30	659.50	225.26
2018/07/07 00:15	678.59	245.12	2018/07/16 07:45	675.53	235.08	2018/07/25 15:45	504.00	
2018/07/07 00:30	678.17	245.05	2018/07/16 08:00	675.69	235.06	2018/07/25 16:00		
2018/07/07 00:45	673.62	243.95	2018/07/16 08:15	675.68	235.55	2018/07/25 16:15		
2018/07/07 01:00	675.57	244.76	2018/07/16 08:30	677.47	235.43	2018/07/25 16:30		
2018/07/07 01:15	679.96	245.66	2018/07/16 08:45	671.33	234.33	2018/07/25 16:45		
2018/07/07 01:30	680.99	246.41	2018/07/16 09:00	676.61	231.23	2018/07/25 17:00		
2018/07/07 01:45	683.62	245.09	2018/07/16 09:15	666.31	231.86	2018/07/25 17:15		

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/07 02:00	680.83	246.35	2018/07/16 09:30	665.98	237.39	2018/07/25 17:30		
2018/07/07 02:15	677.38	245.49	2018/07/16 09:45	665.88	236.52	2018/07/25 17:45		
2018/07/07 02:30	680.42	245.72	2018/07/16 10:00	664.49	235.48	2018/07/25 18:00		
2018/07/07 02:45	678.75	245.51	2018/07/16 10:15	661.17	237.43	2018/07/25 18:15		
2018/07/07 03:00	676.54	245.18	2018/07/16 10:30	665.32	235.33	2018/07/25 18:30		
2018/07/07 03:15	678.85	247.00	2018/07/16 10:45	661.47	236.64	2018/07/25 18:45		
2018/07/07 03:30	680.93	251.73	2018/07/16 11:00	658.07	236.88	2018/07/25 19:00		
2018/07/07 03:45	680.64	252.67	2018/07/16 11:15	662.43	234.97	2018/07/25 19:15		
2018/07/07 04:00	680.45	249.84	2018/07/16 11:30	660.61	234.99	2018/07/25 19:30		
2018/07/07 04:15	679.08	251.73	2018/07/16 11:45	662.82	235.87	2018/07/25 19:45		
2018/07/07 04:30	684.12	251.12	2018/07/16 12:00	665.05	233.75	2018/07/25 20:00		
2018/07/07 04:45	681.02	251.57	2018/07/16 12:15	660.32	233.09	2018/07/25 20:15		
2018/07/07 05:00	681.68	251.40	2018/07/16 12:30	663.19	233.62	2018/07/25 20:30		
2018/07/07 05:15	680.25	250.71	2018/07/16 12:45	661.39	233.97	2018/07/25 20:45		
2018/07/07 05:30	682.25	251.78	2018/07/16 13:00	660.96	234.09	2018/07/25 21:00		181.91
2018/07/07 05:45	679.89	253.61	2018/07/16 13:15	663.95	234.65	2018/07/25 21:15	451.45	229.15
2018/07/07 06:00	679.75	252.08	2018/07/16 13:30	659.68	235.11	2018/07/25 21:30	668.39	234.25
2018/07/07 06:15	680.48	251.70	2018/07/16 13:45	660.91	234.40	2018/07/25 21:45	667.02	234.72
2018/07/07 06:30	682.97	250.97	2018/07/16 14:00	662.20	233.78	2018/07/25 22:00	667.22	230.20
2018/07/07 06:45	675.87	251.10	2018/07/16 14:15	662.52	234.08	2018/07/25 22:15	671.35	222.14
2018/07/07 07:00	678.95	251.31	2018/07/16 14:30	659.77	234.15	2018/07/25 22:30	671.37	232.37
2018/07/07 07:15	681.53	249.93	2018/07/16 14:45	660.14	234.21	2018/07/25 22:45	670.51	232.33
2018/07/07 07:30	678.58	249.24	2018/07/16 15:00	661.14	234.64	2018/07/25 23:00	667.96	234.16
2018/07/07 07:45	677.81	249.67	2018/07/16 15:15	662.02	234.21	2018/07/25 23:15	670.52	235.01
2018/07/07 08:00	680.92	250.33	2018/07/16 15:30	659.80	234.74	2018/07/25 23:30	669.52	236.15
2018/07/07 08:15	676.31	250.72	2018/07/16 15:45	663.91	233.07	2018/07/25 23:45	672.00	235.90
2018/07/07 08:30	675.58	252.23	2018/07/16 16:00	659.93	233.46	2018/07/26 00:00	670.62	235.19
2018/07/07 08:45	678.19	251.27	2018/07/16 16:15	665.41	234.34	2018/07/26 00:15	667.59	235.69
2018/07/07 09:00	680.09	249.66	2018/07/16 16:30	665.61	233.65	2018/07/26 00:30	670.88	235.08
2018/07/07 09:15	675.27	249.46	2018/07/16 16:45	665.43	235.28	2018/07/26 00:45	671.67	236.25
2018/07/07 09:30	672.76	249.62	2018/07/16 17:00	662.52	235.24	2018/07/26 01:00	673.41	235.64
2018/07/07 09:45	668.17	250.28	2018/07/16 17:15	664.81	234.37	2018/07/26 01:15	675.66	235.39
2018/07/07 10:00	667.94	250.63	2018/07/16 17:30	664.87	234.66	2018/07/26 01:30	670.89	235.75
2018/07/07 10:15	670.29	250.01	2018/07/16 17:45	667.80	235.38	2018/07/26 01:45	672.59	234.97
2018/07/07 10:30	664.52	249.20	2018/07/16 18:00	669.66	236.09	2018/07/26 02:00	673.00	234.98
2018/07/07 10:45	667.67	250.88	2018/07/16 18:15	670.23	235.34	2018/07/26 02:15	673.13	235.16
2018/07/07 11:00	669.21	245.43	2018/07/16 18:30	671.92	234.38	2018/07/26 02:30	670.66	234.30
2018/07/07 11:15	669.42	245.58	2018/07/16 18:45	670.87	236.01	2018/07/26 02:45	672.43	234.60
2018/07/07 11:30	664.08	247.97	2018/07/16 19:00	671.98	235.65	2018/07/26 03:00	676.11	234.61
2018/07/07 11:45	676.86	247.43	2018/07/16 19:15	669.97	236.81	2018/07/26 03:15	672.56	234.20
2018/07/07 12:00	669.58	246.63	2018/07/16 19:30	672.81	236.27	2018/07/26 03:30	673.38	235.36
2018/07/07 12:15	663.20	247.29	2018/07/16 19:45	671.66	235.54	2018/07/26 03:45	675.51	235.89
2018/07/07 12:30	670.00	247.62	2018/07/16 20:00	676.00	236.93	2018/07/26 04:00	673.00	236.03
2018/07/07 12:45	667.89	247.79	2018/07/16 20:15	669.89	236.20	2018/07/26 04:15	674.94	237.55
2018/07/07 13:00	668.57	247.71	2018/07/16 20:30	672.27	237.51	2018/07/26 04:30	672.94	235.24
2018/07/07 13:15	672.47	246.80	2018/07/16 20:45	674.92	235.64	2018/07/26 04:45	669.97	235.65
2018/07/07 13:30	671.14	247.67	2018/07/16 21:00	673.75	237.28	2018/07/26 05:00	674.34	235.45
2018/07/07 13:45	667.59	247.33	2018/07/16 21:15	676.10	236.26	2018/07/26 05:15	674.67	236.81
2018/07/07 14:00	667.31	248.25	2018/07/16 21:30	671.55	236.26	2018/07/26 05:30	672.82	235.54

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/07 14:15	668.97	247.50	2018/07/16 21:45	680.45	236.04	2018/07/26 05:45	672.98	237.58
2018/07/07 14:30	673.36	247.78	2018/07/16 22:00	676.73	235.91	2018/07/26 06:00	668.60	235.89
2018/07/07 14:45	673.79	247.52	2018/07/16 22:15	673.07	236.09	2018/07/26 06:15	674.84	235.08
2018/07/07 15:00	667.73	247.67	2018/07/16 22:30	673.99	235.87	2018/07/26 06:30	673.71	235.46
2018/07/07 15:15	664.22	247.94	2018/07/16 22:45	679.29	235.56	2018/07/26 06:45	672.61	236.18
2018/07/07 15:30	663.34	237.47	2018/07/16 23:00	673.14	237.79	2018/07/26 07:00	673.79	235.89
2018/07/07 15:45	659.06	245.78	2018/07/16 23:15	676.32	234.18	2018/07/26 07:15	677.12	236.25
2018/07/07 16:00	662.52	245.83	2018/07/16 23:30	676.27	235.41	2018/07/26 07:30	671.63	236.27
2018/07/07 16:15	666.90	247.73	2018/07/16 23:45	678.78	237.47	2018/07/26 07:45	674.73	228.97
2018/07/07 16:30	670.16	245.91	2018/07/17 00:00	681.53	233.31	2018/07/26 08:00	674.27	222.63
2018/07/07 16:45	664.16	247.05	2018/07/17 00:15	671.37	234.96	2018/07/26 08:15	676.64	220.73
2018/07/07 17:00	663.74	246.50	2018/07/17 00:30	678.52	235.58	2018/07/26 08:30	671.70	221.82
2018/07/07 17:15	668.08	245.68	2018/07/17 00:45	680.95	233.51	2018/07/26 08:45	671.61	168.67
2018/07/07 17:30	665.32	245.08	2018/07/17 01:00	673.61	234.17	2018/07/26 09:00	670.48	
2018/07/07 17:45	663.86	246.58	2018/07/17 01:15	680.72	236.53	2018/07/26 09:15		
2018/07/07 18:00	664.75	247.91	2018/07/17 01:30	681.01	236.15	2018/07/26 09:30		
2018/07/07 18:15	667.11	247.08	2018/07/17 01:45	682.80	234.11	2018/07/26 09:45		
2018/07/07 18:30	665.40	247.35	2018/07/17 02:00	674.55	235.39	2018/07/26 10:00		
2018/07/07 18:45	669.88	247.78	2018/07/17 02:15	674.54	237.35	2018/07/26 10:15		
2018/07/07 19:00	672.68	245.33	2018/07/17 02:30	683.56	234.92	2018/07/26 10:30		
2018/07/07 19:15	672.58	244.95	2018/07/17 02:45	679.90	234.94	2018/07/26 10:45		
2018/07/07 19:30	672.91	247.63	2018/07/17 03:00	679.52	233.95	2018/07/26 11:00		
2018/07/07 19:45	674.47	246.68	2018/07/17 03:15	678.46	233.79	2018/07/26 11:15		
2018/07/07 20:00	674.62	246.37	2018/07/17 03:30	677.14	232.91	2018/07/26 11:30		
2018/07/07 20:15	671.43	246.85	2018/07/17 03:45	675.20	233.60	2018/07/26 11:45		
2018/07/07 20:30	674.91	246.98	2018/07/17 04:00	676.03	233.92	2018/07/26 12:00		
2018/07/07 20:45	674.98	246.71	2018/07/17 04:15	674.72	235.81	2018/07/26 12:15		
2018/07/07 21:00	673.22	245.71	2018/07/17 04:30	677.55	233.91	2018/07/26 12:30		
2018/07/07 21:15	671.96	245.98	2018/07/17 04:45	671.94	234.49	2018/07/26 12:45		
2018/07/07 21:30	673.10	247.13	2018/07/17 05:00	676.72	234.43	2018/07/26 13:00		
2018/07/07 21:45	674.02	247.17	2018/07/17 05:15	678.41	235.61	2018/07/26 13:15		
2018/07/07 22:00	677.65	245.08	2018/07/17 05:30	675.79	235.57	2018/07/26 13:30		
2018/07/07 22:15	676.51	246.95	2018/07/17 05:45	673.26	237.17	2018/07/26 13:45		
2018/07/07 22:30	674.68	246.55	2018/07/17 06:00	676.11	234.55	2018/07/26 14:00		231.35
2018/07/07 22:45	674.21	244.50	2018/07/17 06:15	672.84	235.11	2018/07/26 14:15	660.44	232.77
2018/07/07 23:00	672.87	246.20	2018/07/17 06:30	675.60	234.36	2018/07/26 14:30	658.29	233.08
2018/07/07 23:15	675.25	248.81	2018/07/17 06:45	669.67	236.16	2018/07/26 14:45	659.61	233.82
2018/07/07 23:30	678.62	246.32	2018/07/17 07:00	669.47	235.99	2018/07/26 15:00	669.78	233.29
2018/07/07 23:45	678.26	244.67	2018/07/17 07:15	676.60	236.37	2018/07/26 15:15	658.44	234.07
2018/07/08 00:00	675.49	244.64	2018/07/17 07:30	671.26	235.28	2018/07/26 15:30	666.17	231.63
2018/07/08 00:15	677.40	245.59	2018/07/17 07:45	675.28	235.07	2018/07/26 15:45	660.58	231.95
2018/07/08 00:30	677.27	248.17	2018/07/17 08:00	675.00	235.12	2018/07/26 16:00	662.18	233.00
2018/07/08 00:45	682.34	245.10	2018/07/17 08:15	677.67	234.57	2018/07/26 16:15	664.04	231.91
2018/07/08 01:00	675.98	247.32	2018/07/17 08:30	675.70	235.02	2018/07/26 16:30	664.59	234.20
2018/07/08 01:15	678.25	246.39	2018/07/17 08:45	675.76	234.55	2018/07/26 16:45	664.18	235.11
2018/07/08 01:30	676.29	247.39	2018/07/17 09:00	673.90	234.11	2018/07/26 17:00	661.24	234.74
2018/07/08 01:45	677.26	244.94	2018/07/17 09:15	670.95	235.49	2018/07/26 17:15	665.29	233.24
2018/07/08 02:00	675.94	245.28	2018/07/17 09:30	674.36	233.93	2018/07/26 17:30	665.14	231.22
2018/07/08 02:15	678.20	245.09	2018/07/17 09:45	668.31	234.80	2018/07/26 17:45	659.26	231.40

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/08 02:30	676.99	246.23	2018/07/17 10:00	668.16	233.82	2018/07/26 18:00	662.79	233.14
2018/07/08 02:45	678.11	247.34	2018/07/17 10:15	665.79	234.58	2018/07/26 18:15	659.29	234.76
2018/07/08 03:00	680.71	245.26	2018/07/17 10:30	666.72	234.89	2018/07/26 18:30	662.04	232.82
2018/07/08 03:15	676.38	246.59	2018/07/17 10:45	666.36	233.84	2018/07/26 18:45	661.48	234.44
2018/07/08 03:30	679.19	246.53	2018/07/17 11:00	664.27	234.67	2018/07/26 19:00	663.81	234.18
2018/07/08 03:45	677.97	245.80	2018/07/17 11:15	664.54	234.05	2018/07/26 19:15	661.52	232.97
2018/07/08 04:00	674.87	246.58	2018/07/17 11:30	660.58	232.48	2018/07/26 19:30	664.79	233.52
2018/07/08 04:15	678.89	245.69	2018/07/17 11:45	661.86	232.88	2018/07/26 19:45	660.55	232.97
2018/07/08 04:30	676.34	245.89	2018/07/17 12:00	663.13	233.89	2018/07/26 20:00	666.39	234.30
2018/07/08 04:45	678.13	246.98	2018/07/17 12:15	666.54	233.51	2018/07/26 20:15	664.99	233.77
2018/07/08 05:00	679.41	246.26	2018/07/17 12:30	664.81	233.38	2018/07/26 20:30	666.64	233.46
2018/07/08 05:15	678.63	248.16	2018/07/17 12:45	663.65	233.25	2018/07/26 20:45	668.20	233.25
2018/07/08 05:30	678.90	246.22	2018/07/17 13:00	665.52	233.45	2018/07/26 21:00	666.39	233.64
2018/07/08 05:45	674.01	246.33	2018/07/17 13:15	664.09	233.05	2018/07/26 21:15	665.64	233.28
2018/07/08 06:00	679.32	246.47	2018/07/17 13:30	663.86	233.41	2018/07/26 21:30	663.80	234.74
2018/07/08 06:15	675.33	247.17	2018/07/17 13:45	666.82	233.81	2018/07/26 21:45	667.75	233.85
2018/07/08 06:30	681.31	247.35	2018/07/17 14:00	669.42	233.12	2018/07/26 22:00	666.24	233.81
2018/07/08 06:45	678.96	246.20	2018/07/17 14:15	666.63	233.65	2018/07/26 22:15	664.55	233.57
2018/07/08 07:00	676.80	246.84	2018/07/17 14:30	664.63	234.22	2018/07/26 22:30	666.07	234.82
2018/07/08 07:15	681.66	246.46	2018/07/17 14:45	662.82	232.95	2018/07/26 22:45	668.12	234.01
2018/07/08 07:30	675.79	245.80	2018/07/17 15:00	662.29	233.71	2018/07/26 23:00	669.15	232.21
2018/07/08 07:45	677.54	245.70	2018/07/17 15:15	665.77	234.66	2018/07/26 23:15	670.20	233.34
2018/07/08 08:00	676.64	246.42	2018/07/17 15:30	664.89	235.17	2018/07/26 23:30	670.16	233.02
2018/07/08 08:15	676.44	246.13	2018/07/17 15:45	663.98	234.45	2018/07/26 23:45	672.12	234.61
2018/07/08 08:30	675.82	246.34	2018/07/17 16:00	664.39	234.34	2018/07/27 00:00	671.39	236.49
2018/07/08 08:45	676.02	246.29	2018/07/17 16:15	666.02	234.43	2018/07/27 00:15	670.98	234.76
2018/07/08 09:00	674.16	245.89	2018/07/17 16:30	668.74	234.19	2018/07/27 00:30	673.25	234.52
2018/07/08 09:15	672.71	246.45	2018/07/17 16:45	668.74	234.39	2018/07/27 00:45	672.65	233.50
2018/07/08 09:30	673.12	245.62	2018/07/17 17:00	662.02	232.63	2018/07/27 01:00	671.38	233.21
2018/07/08 09:45	670.40	245.97	2018/07/17 17:15	662.74	233.22	2018/07/27 01:15	672.48	233.27
2018/07/08 10:00	670.55	246.11	2018/07/17 17:30	665.65	234.52	2018/07/27 01:30	670.76	234.68
2018/07/08 10:15	665.61	247.62	2018/07/17 17:45	665.03	232.75	2018/07/27 01:45	670.20	233.04
2018/07/08 10:30	670.70	245.95	2018/07/17 18:00	665.79	233.46	2018/07/27 02:00	673.57	233.37
2018/07/08 10:45	663.20	246.92	2018/07/17 18:15	667.79	231.65	2018/07/27 02:15	673.16	234.19
2018/07/08 11:00	669.49	246.41	2018/07/17 18:30	665.14	235.40	2018/07/27 02:30	670.58	232.67
2018/07/08 11:15	666.77	247.11	2018/07/17 18:45	668.28	234.40	2018/07/27 02:45	670.91	233.05
2018/07/08 11:30	665.78	246.34	2018/07/17 19:00	669.48	235.64	2018/07/27 03:00	670.81	232.42
2018/07/08 11:45	664.93	237.34	2018/07/17 19:15	671.83	235.06	2018/07/27 03:15	673.59	233.91
2018/07/08 12:00	666.09	233.45	2018/07/17 19:30	670.34	236.84	2018/07/27 03:30	671.27	233.40
2018/07/08 12:15	664.69	233.24	2018/07/17 19:45	670.94	234.35	2018/07/27 03:45	672.86	232.52
2018/07/08 12:30	663.62	238.25	2018/07/17 20:00	668.30	236.31	2018/07/27 04:00	672.57	232.28
2018/07/08 12:45	665.15	235.37	2018/07/17 20:15	673.78	235.67	2018/07/27 04:15	675.38	235.17
2018/07/08 13:00	663.46	246.03	2018/07/17 20:30	670.49	236.02	2018/07/27 04:30	674.15	234.13
2018/07/08 13:15	673.19	244.16	2018/07/17 20:45	673.30	234.30	2018/07/27 04:45	672.85	236.80
2018/07/08 13:30	663.25	233.76	2018/07/17 21:00	669.26	234.43	2018/07/27 05:00	675.31	232.03
2018/07/08 13:45	663.52	232.71	2018/07/17 21:15	668.83	235.66	2018/07/27 05:15	670.74	234.36
2018/07/08 14:00	670.79	232.82	2018/07/17 21:30	671.12	235.38	2018/07/27 05:30	669.56	233.35
2018/07/08 14:15	673.00	240.83	2018/07/17 21:45	670.87	235.89	2018/07/27 05:45	671.28	235.70
2018/07/08 14:30	669.80	242.22	2018/07/17 22:00	673.33	233.89	2018/07/27 06:00	667.37	233.97

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/08 14:45	664.35	246.11	2018/07/17 22:15	669.93	236.27	2018/07/27 06:15	666.67	234.49
2018/07/08 15:00	667.75	246.16	2018/07/17 22:30	671.93	235.68	2018/07/27 06:30	671.76	234.68
2018/07/08 15:15	663.27	246.90	2018/07/17 22:45	673.49	233.34	2018/07/27 06:45	672.52	235.95
2018/07/08 15:30	670.03	247.61	2018/07/17 23:00	670.24	236.04	2018/07/27 07:00	671.36	236.45
2018/07/08 15:45	668.43	247.33	2018/07/17 23:15	671.66	235.41	2018/07/27 07:15	677.80	234.44
2018/07/08 16:00	672.11	247.74	2018/07/17 23:30	673.45	235.83	2018/07/27 07:30	681.08	234.65
2018/07/08 16:15	660.90	248.49	2018/07/17 23:45	674.73	235.39	2018/07/27 07:45	677.52	235.18
2018/07/08 16:30	666.52	247.37	2018/07/18 00:00	675.14	234.58	2018/07/27 08:00	672.72	234.16
2018/07/08 16:45	666.86	246.78	2018/07/18 00:15	674.07	234.45	2018/07/27 08:15	669.55	235.74
2018/07/08 17:00	667.31	246.25	2018/07/18 00:30	668.70	235.66	2018/07/27 08:30	674.65	235.76
2018/07/08 17:15	664.77	246.11	2018/07/18 00:45	675.10	236.28	2018/07/27 08:45	671.64	233.87
2018/07/08 17:30	667.80	245.90	2018/07/18 01:00	673.03	237.22	2018/07/27 09:00	670.20	232.43
2018/07/08 17:45	664.73	247.12	2018/07/18 01:15	675.38	234.41	2018/07/27 09:15	667.40	235.25
2018/07/08 18:00	669.64	247.28	2018/07/18 01:30	672.24	234.12	2018/07/27 09:30	666.46	235.45
2018/07/08 18:15	666.43	247.77	2018/07/18 01:45	673.10	235.43	2018/07/27 09:45	667.41	233.47
2018/07/08 18:30	669.97	247.97	2018/07/18 02:00	673.87	234.90	2018/07/27 10:00	663.00	234.57
2018/07/08 18:45	670.99	246.52	2018/07/18 02:15	674.97	235.64	2018/07/27 10:15	659.77	234.95
2018/07/08 19:00	670.99	246.31	2018/07/18 02:30	675.63	235.22	2018/07/27 10:30	660.25	234.90
2018/07/08 19:15	669.22	247.27	2018/07/18 02:45	676.42	235.52	2018/07/27 10:45	663.27	233.91
2018/07/08 19:30	673.26	246.33	2018/07/18 03:00	675.77	234.04	2018/07/27 11:00	668.29	233.45
2018/07/08 19:45	671.02	245.94	2018/07/18 03:15	675.22	235.07	2018/07/27 11:15	659.95	234.63
2018/07/08 20:00	673.38	246.44	2018/07/18 03:30	675.68	235.17	2018/07/27 11:30	665.89	233.93
2018/07/08 20:15	670.95	246.60	2018/07/18 03:45	674.01	235.33	2018/07/27 11:45	661.93	233.27
2018/07/08 20:30	669.80	247.00	2018/07/18 04:00	675.68	232.85	2018/07/27 12:00	669.23	232.10
2018/07/08 20:45	673.23	247.08	2018/07/18 04:15	672.02	235.69	2018/07/27 12:15	669.41	231.79
2018/07/08 21:00	673.88	247.14	2018/07/18 04:30	677.28	235.47	2018/07/27 12:30	660.76	231.91
2018/07/08 21:15	672.10	247.03	2018/07/18 04:45	676.76	234.98	2018/07/27 12:45	657.78	232.25
2018/07/08 21:30	670.20	246.52	2018/07/18 05:00	674.57	234.28	2018/07/27 13:00	660.42	233.01
2018/07/08 21:45	671.21	246.96	2018/07/18 05:15	672.88	234.30	2018/07/27 13:15	665.10	231.58
2018/07/08 22:00	670.42	248.73	2018/07/18 05:30	671.45	235.29	2018/07/27 13:30	665.97	232.51
2018/07/08 22:15	674.36	245.88	2018/07/18 05:45	672.53	235.48	2018/07/27 13:45	671.01	233.06
2018/07/08 22:30	673.67	246.15	2018/07/18 06:00	672.24	233.84	2018/07/27 14:00	664.09	232.16
2018/07/08 22:45	671.73	246.10	2018/07/18 06:15	667.01	234.66	2018/07/27 14:15	666.40	232.07
2018/07/08 23:00	675.07	247.29	2018/07/18 06:30	673.39	234.65	2018/07/27 14:30	663.65	232.16
2018/07/08 23:15	675.78	246.51	2018/07/18 06:45	667.98	235.22	2018/07/27 14:45	669.68	231.74
2018/07/08 23:30	672.68	246.30	2018/07/18 07:00	673.58	235.23	2018/07/27 15:00	665.50	231.69
2018/07/08 23:45	675.88	246.40	2018/07/18 07:15	670.50	235.62	2018/07/27 15:15	664.07	232.44
2018/07/09 00:00	673.94	247.69	2018/07/18 07:30	672.32	234.09	2018/07/27 15:30	663.65	231.82
2018/07/09 00:15	677.85	247.73	2018/07/18 07:45	672.87	233.51	2018/07/27 15:45	665.48	232.58
2018/07/09 00:30	676.63	249.33	2018/07/18 08:00	671.51	233.85	2018/07/27 16:00	661.73	233.12
2018/07/09 00:45	677.57	250.12	2018/07/18 08:15	667.74	235.17	2018/07/27 16:15	665.42	233.27
2018/07/09 01:00	678.69	247.34	2018/07/18 08:30	668.84	234.91	2018/07/27 16:30	666.95	231.42
2018/07/09 01:15	678.40	248.13	2018/07/18 08:45	671.35	235.89	2018/07/27 16:45	665.21	232.19
2018/07/09 01:30	677.12	248.05	2018/07/18 09:00	669.41	234.34	2018/07/27 17:00	659.04	231.69
2018/07/09 01:45	680.20	248.56	2018/07/18 09:15	667.91	235.33	2018/07/27 17:15	662.52	231.94
2018/07/09 02:00	678.62	247.76	2018/07/18 09:30	670.00	235.78	2018/07/27 17:30	663.92	234.29
2018/07/09 02:15	679.11	248.14	2018/07/18 09:45	667.76	235.48	2018/07/27 17:45	662.95	233.81
2018/07/09 02:30	679.01	248.39	2018/07/18 10:00	670.79	235.63	2018/07/27 18:00	661.43	234.59
2018/07/09 02:45	677.40	248.66	2018/07/18 10:15	665.97	236.18	2018/07/27 18:15	660.78	232.31

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/09 03:00	682.34	245.97	2018/07/18 10:30	665.69	235.57	2018/07/27 18:30	658.98	232.89
2018/07/09 03:15	674.23	246.25	2018/07/18 10:45	660.34	234.55	2018/07/27 18:45	661.55	233.63
2018/07/09 03:30	677.46	247.30	2018/07/18 11:00	659.05	233.51	2018/07/27 19:00	661.33	233.24
2018/07/09 03:45	677.91	248.51	2018/07/18 11:15	659.21	233.49	2018/07/27 19:15	661.61	233.22
2018/07/09 04:00	677.45	246.56	2018/07/18 11:30	659.87	234.72	2018/07/27 19:30	661.73	233.35
2018/07/09 04:15	672.46	245.88	2018/07/18 11:45	663.49	233.59	2018/07/27 19:45	663.58	233.06
2018/07/09 04:30	677.04	245.28	2018/07/18 12:00	659.14	234.84	2018/07/27 20:00	664.89	233.10
2018/07/09 04:45	674.84	245.91	2018/07/18 12:15	661.20	234.06	2018/07/27 20:15	664.47	232.16
2018/07/09 05:00	678.34	246.11	2018/07/18 12:30	661.05	233.27	2018/07/27 20:30	663.19	233.53
2018/07/09 05:15	677.18	246.43	2018/07/18 12:45	662.90	233.59	2018/07/27 20:45	664.48	233.11
2018/07/09 05:30	678.18	246.04	2018/07/18 13:00	663.98	234.94	2018/07/27 21:00	667.77	232.86
2018/07/09 05:45	672.43	246.00	2018/07/18 13:15	668.35	233.40	2018/07/27 21:15	665.26	232.65
2018/07/09 06:00	675.77	246.12	2018/07/18 13:30	664.21	232.80	2018/07/27 21:30	666.85	232.74
2018/07/09 06:15	675.76	247.65	2018/07/18 13:45	657.75	234.25	2018/07/27 21:45	665.97	232.58
2018/07/09 06:30	676.63	247.78	2018/07/18 14:00	668.79	234.08	2018/07/27 22:00	668.69	233.17
2018/07/09 06:45	674.69	247.35	2018/07/18 14:15	663.12	232.58	2018/07/27 22:15	668.37	234.00
2018/07/09 07:00	676.07	247.32	2018/07/18 14:30	661.90	231.77	2018/07/27 22:30	670.00	233.35
2018/07/09 07:15	674.59	245.77	2018/07/18 14:45	658.43	232.80	2018/07/27 22:45	669.72	232.28
2018/07/09 07:30	677.62	246.52	2018/07/18 15:00	659.65	234.44	2018/07/27 23:00	668.85	232.29
2018/07/09 07:45	680.13	246.28	2018/07/18 15:15	662.28	234.81	2018/07/27 23:15	671.11	233.12
2018/07/09 08:00	674.05	246.51	2018/07/18 15:30	661.13	232.44	2018/07/27 23:30	670.72	232.76
2018/07/09 08:15	676.34	247.60	2018/07/18 15:45	656.68	235.09	2018/07/27 23:45	669.18	232.88
2018/07/09 08:30	676.46	247.84	2018/07/18 16:00	663.22	233.84	2018/07/28 00:00	672.81	232.00
2018/07/09 08:45	675.60	247.65	2018/07/18 16:15	662.79	233.75	2018/07/28 00:15	670.57	234.79
2018/07/09 09:00	672.87	245.41	2018/07/18 16:30	659.12	234.17	2018/07/28 00:30	669.11	232.20
2018/07/09 09:15	670.74	246.04	2018/07/18 16:45	657.84	233.40	2018/07/28 00:45	668.95	232.45
2018/07/09 09:30	671.44	244.19	2018/07/18 17:00	659.70	230.91	2018/07/28 01:00	667.56	233.56
2018/07/09 09:45	668.23	238.17	2018/07/18 17:15	657.56	232.10	2018/07/28 01:15	671.38	232.84
2018/07/09 10:00	667.13	243.77	2018/07/18 17:30	659.22	234.34	2018/07/28 01:30	670.08	233.29
2018/07/09 10:15	668.73	243.81	2018/07/18 17:45	660.85	233.28	2018/07/28 01:45	675.06	232.29
2018/07/09 10:30	664.40	243.48	2018/07/18 18:00	662.75	234.83	2018/07/28 02:00	675.38	232.39
2018/07/09 10:45	666.54	242.95	2018/07/18 18:15	666.81	235.05	2018/07/28 02:15	672.28	232.53
2018/07/09 11:00	666.39	243.26	2018/07/18 18:30	663.73	236.53	2018/07/28 02:30	673.74	232.52
2018/07/09 11:15	662.68	243.12	2018/07/18 18:45	668.92	234.06	2018/07/28 02:45	671.38	232.22
2018/07/09 11:30	665.48	244.19	2018/07/18 19:00	669.02	233.72	2018/07/28 03:00	670.53	232.25
2018/07/09 11:45	666.83	242.16	2018/07/18 19:15	668.69	235.83	2018/07/28 03:15	670.86	231.81
2018/07/09 12:00	661.47	242.68	2018/07/18 19:30	668.44	235.86	2018/07/28 03:30	670.32	232.45
2018/07/09 12:15	662.49	242.20	2018/07/18 19:45	671.51	235.22	2018/07/28 03:45	671.26	232.35
2018/07/09 12:30	661.07	240.27	2018/07/18 20:00	670.92	234.68	2018/07/28 04:00	671.64	232.88
2018/07/09 12:45	666.16	242.03	2018/07/18 20:15	668.55	234.06	2018/07/28 04:15	675.04	232.36
2018/07/09 13:00	660.60	239.33	2018/07/18 20:30	669.40	236.01	2018/07/28 04:30	672.20	233.28
2018/07/09 13:15	663.08	230.12	2018/07/18 20:45	672.28	234.83	2018/07/28 04:45	668.93	232.54
2018/07/09 13:30	657.53	232.72	2018/07/18 21:00	672.91	235.46	2018/07/28 05:00	674.32	232.18
2018/07/09 13:45	663.25	243.29	2018/07/18 21:15	672.78	235.52	2018/07/28 05:15	672.58	233.53
2018/07/09 14:00	662.88	242.52	2018/07/18 21:30	675.91	235.83	2018/07/28 05:30	674.28	232.82
2018/07/09 14:15	662.01	243.00	2018/07/18 21:45	670.76	234.42	2018/07/28 05:45	681.25	233.08
2018/07/09 14:30	666.13	243.26	2018/07/18 22:00	676.23	235.60	2018/07/28 06:00	677.46	232.28
2018/07/09 14:45	666.32	242.75	2018/07/18 22:15	674.94	234.70	2018/07/28 06:15	671.41	232.55
2018/07/09 15:00	660.03	243.40	2018/07/18 22:30	676.72	235.24	2018/07/28 06:30	673.29	233.97

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/09 15:15	662.75	243.45	2018/07/18 22:45	678.51	233.98	2018/07/28 06:45	671.80	232.06
2018/07/09 15:30	663.62	242.14	2018/07/18 23:00	671.77	234.59	2018/07/28 07:00	671.59	233.18
2018/07/09 15:45	666.43	243.93	2018/07/18 23:15	675.04	233.43	2018/07/28 07:15	668.16	232.37
2018/07/09 16:00	668.84	243.88	2018/07/18 23:30	673.92	234.43	2018/07/28 07:30	673.53	233.71
2018/07/09 16:15	665.88	242.47	2018/07/18 23:45	678.28	235.91	2018/07/28 07:45	675.33	233.88
2018/07/09 16:30	665.34	243.43	2018/07/19 00:00	673.93	235.53	2018/07/28 08:00	673.19	233.41
2018/07/09 16:45	664.92	243.60	2018/07/19 00:15	674.65	236.17	2018/07/28 08:15	668.69	232.30
2018/07/09 17:00	668.03	242.41	2018/07/19 00:30	679.28	234.22	2018/07/28 08:30	675.94	232.80
2018/07/09 17:15	666.17	242.55	2018/07/19 00:45	672.40	235.67	2018/07/28 08:45	669.26	232.75
2018/07/09 17:30	664.20	242.96	2018/07/19 01:00	674.93	234.64	2018/07/28 09:00	669.60	232.31
2018/07/09 17:45	666.59	242.58	2018/07/19 01:15	677.56	234.00	2018/07/28 09:15	665.95	232.47
2018/07/09 18:00	666.28	242.90	2018/07/19 01:30	676.64	233.81	2018/07/28 09:30	664.51	232.03
2018/07/09 18:15	669.48	242.92	2018/07/19 01:45	670.07	236.08	2018/07/28 09:45	662.70	233.53
2018/07/09 18:30	669.78	243.66	2018/07/19 02:00	676.57	232.74	2018/07/28 10:00	659.36	233.69
2018/07/09 18:45	671.37	242.21	2018/07/19 02:15	670.70	235.26	2018/07/28 10:15	659.66	231.70
2018/07/09 19:00	671.06	241.32	2018/07/19 02:30	675.92	234.66	2018/07/28 10:30	663.09	233.38
2018/07/09 19:15	668.40	243.79	2018/07/19 02:45	674.55	234.32	2018/07/28 10:45	663.87	232.26
2018/07/09 19:30	669.41	240.95	2018/07/19 03:00	674.19	232.57	2018/07/28 11:00	660.62	230.68
2018/07/09 19:45	666.65	243.57	2018/07/19 03:15	671.92	235.04	2018/07/28 11:15	662.31	231.94
2018/07/09 20:00	669.22	243.31	2018/07/19 03:30	671.46	235.45	2018/07/28 11:30	662.53	231.41
2018/07/09 20:15	669.53	242.26	2018/07/19 03:45	675.52	234.00	2018/07/28 11:45	664.09	230.44
2018/07/09 20:30	670.10	243.44	2018/07/19 04:00	672.97	235.16	2018/07/28 12:00	660.38	231.86
2018/07/09 20:45	670.40	243.70	2018/07/19 04:15	673.01	235.04	2018/07/28 12:15	666.62	229.84
2018/07/09 21:00	668.05	242.21	2018/07/19 04:30	674.70	235.12	2018/07/28 12:30	664.00	230.58
2018/07/09 21:15	666.21	242.79	2018/07/19 04:45	676.17	235.16	2018/07/28 12:45	661.40	232.20
2018/07/09 21:30	668.56	242.84	2018/07/19 05:00	676.30	233.78	2018/07/28 13:00	664.93	232.08
2018/07/09 21:45	667.69	243.40	2018/07/19 05:15	672.40	235.18	2018/07/28 13:15	664.17	230.78
2018/07/09 22:00	667.84	241.23	2018/07/19 05:30	675.09	234.24	2018/07/28 13:30	661.58	231.89
2018/07/09 22:15	671.53	241.79	2018/07/19 05:45	670.99	234.50	2018/07/28 13:45	661.39	234.88
2018/07/09 22:30	670.67	243.07	2018/07/19 06:00	673.22	234.16	2018/07/28 14:00	665.04	234.25
2018/07/09 22:45	668.55	244.29	2018/07/19 06:15	669.67	234.57	2018/07/28 14:15	670.78	231.83
2018/07/09 23:00	672.75	243.66	2018/07/19 06:30	673.48	234.58	2018/07/28 14:30	659.64	231.96
2018/07/09 23:15	670.66	240.08	2018/07/19 06:45	672.44	235.64	2018/07/28 14:45	656.49	233.33
2018/07/09 23:30	670.53	240.39	2018/07/19 07:00	675.73	235.09	2018/07/28 15:00	667.26	232.66
2018/07/09 23:45	669.23	241.38	2018/07/19 07:15	673.10	234.31	2018/07/28 15:15	662.65	232.50
2018/07/10 00:00	671.59	242.65	2018/07/19 07:30	675.36	234.68	2018/07/28 15:30	669.48	232.30
2018/07/10 00:15	673.49	243.02	2018/07/19 07:45	672.54	234.89	2018/07/28 15:45	664.14	231.41
2018/07/10 00:30	674.12	242.38	2018/07/19 08:00	670.78	234.33	2018/07/28 16:00	660.56	231.05
2018/07/10 00:45	673.63	240.17	2018/07/19 08:15	672.93	233.64	2018/07/28 16:15	661.33	231.38
2018/07/10 01:00	673.64	242.16	2018/07/19 08:30	673.17	234.38	2018/07/28 16:30	660.01	232.26
2018/07/10 01:15	672.44	241.37	2018/07/19 08:45	671.13	234.75	2018/07/28 16:45	666.57	232.62
2018/07/10 01:30	674.16	243.42	2018/07/19 09:00	672.18	233.42	2018/07/28 17:00	665.69	232.17
2018/07/10 01:45	678.14	241.45	2018/07/19 09:15	667.30	234.55	2018/07/28 17:15	670.03	231.03
2018/07/10 02:00	674.58	240.13	2018/07/19 09:30	669.51	233.91	2018/07/28 17:30	662.19	231.65
2018/07/10 02:15	673.02	241.46	2018/07/19 09:45	664.62	233.37	2018/07/28 17:45	658.96	232.72
2018/07/10 02:30	675.09	243.45	2018/07/19 10:00	662.51	232.70	2018/07/28 18:00	659.45	232.71
2018/07/10 02:45	675.79	242.26	2018/07/19 10:15	663.78	233.87	2018/07/28 18:15	661.38	233.32
2018/07/10 03:00	674.53	240.43	2018/07/19 10:30	659.31	234.22	2018/07/28 18:30	660.71	234.28
2018/07/10 03:15	671.63	242.37	2018/07/19 10:45	662.10	233.32	2018/07/28 18:45	662.52	232.23

Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)	Date/time	Power (kW)	Flow (l/s)
2018/07/10 03:30	677.03	240.71	2018/07/19 11:00	661.75	232.91	2018/07/28 19:00	659.46	233.91
2018/07/10 03:45	670.69	241.91	2018/07/19 11:15	662.20	232.88	2018/07/28 19:15	660.29	233.89
2018/07/10 04:00	669.79	240.67	2018/07/19 11:30	663.28	232.90	2018/07/28 19:30	662.15	232.65
2018/07/10 04:15	670.48	240.76	2018/07/19 11:45	661.15	233.45	2018/07/28 19:45	658.89	231.28
2018/07/10 04:30	672.49	242.22	2018/07/19 12:00	661.64	232.24	2018/07/28 20:00	662.88	232.27
2018/07/10 04:45	670.67	241.37	2018/07/19 12:15	661.09	232.89	2018/07/28 20:15	659.49	233.87
2018/07/10 05:00	672.43	240.59	2018/07/19 12:30	662.27	233.10	2018/07/28 20:30	666.22	232.38
2018/07/10 05:15	671.89	242.55	2018/07/19 12:45	666.66	233.97	2018/07/28 20:45	664.46	233.38
2018/07/10 05:30	676.15	241.70	2018/07/19 13:00	664.76	233.84	2018/07/28 21:00	664.36	234.82
2018/07/10 05:45	670.62	241.48	2018/07/19 13:15	659.67	234.03	2018/07/28 21:15	668.21	233.69
2018/07/10 06:00	674.18	241.53	2018/07/19 13:30	667.07	232.87	2018/07/28 21:30	668.62	234.13
2018/07/10 06:15	671.31	241.94	2018/07/19 13:45	658.36	232.59	2018/07/28 21:45	668.42	235.20
2018/07/10 06:30	671.59	242.45	2018/07/19 14:00	658.32	232.63	2018/07/28 22:00	669.71	232.73
2018/07/10 06:45	671.63	243.15	2018/07/19 14:15	656.63	233.41	2018/07/28 22:15	670.03	234.11
2018/07/10 07:00	673.60	241.75	2018/07/19 14:30	661.69	233.25	2018/07/28 22:30	670.12	233.92
2018/07/10 07:15	672.86	241.07	2018/07/19 14:45	662.01	232.95	2018/07/28 22:45	671.76	233.40

APPENDIX N: SIMULATION RESULTS

Table 16: Simulation results

Time	Sandsloot level (%)	1160 level (%)	RWD level (%)	Booster pump power (kW)	Total mass flow (l/s)	Time	Sandsloot level (%)	1160 level (%)	RWD level (%)	Booster pump power (kW)	Total mass flow (l/s)
0	59.7%	59.7%	59.9%	669.48	250.56	303300	58.7%	61.1%	60.3%	675.96	253.03
900	59.7%	59.8%	59.9%	683.71	258.03	304200	58.7%	61.1%	60.3%	675.95	253.02
1800	59.7%	59.8%	59.9%	683.73	258.05	305100	58.7%	61.0%	60.3%	675.95	253.02
2700	59.7%	59.9%	59.9%	683.73	258.05	306000	58.7%	61.0%	60.4%	675.95	253.02
3600	59.7%	60.0%	59.8%	683.73	258.05	306900	58.7%	61.0%	60.4%	675.95	253.02
4500	59.7%	60.0%	59.8%	683.72	258.04	307800	58.7%	61.0%	60.4%	675.94	253.02
5400	59.7%	60.1%	59.8%	683.72	258.04	308700	58.7%	60.9%	60.5%	675.94	253.01
6300	59.7%	60.1%	59.8%	683.71	258.04	309600	58.7%	60.9%	60.5%	675.94	253.01
7200	59.7%	60.2%	59.8%	683.71	258.03	310500	58.6%	60.9%	60.5%	675.93	253.01
8100	59.7%	60.2%	59.7%	683.71	258.03	311400	58.6%	60.9%	60.5%	675.93	253.01
9000	59.7%	60.3%	59.7%	683.70	258.03	312300	58.6%	60.8%	60.6%	675.93	253.01
9900	59.7%	60.4%	59.7%	683.70	258.03	313200	58.6%	60.8%	60.6%	675.92	253.00
10800	59.7%	60.4%	59.7%	683.69	258.02	314100	58.6%	60.8%	60.6%	675.92	253.00
11700	59.7%	60.5%	59.7%	683.69	258.02	315000	58.6%	60.8%	60.6%	675.92	253.00
12600	59.7%	60.5%	59.6%	683.69	258.02	315900	58.6%	60.7%	60.7%	675.91	253.00
13500	59.7%	60.6%	59.6%	683.68	258.02	316800	58.6%	60.7%	60.7%	675.91	253.00
14400	59.7%	60.6%	59.6%	683.68	258.01	317700	58.6%	60.7%	60.7%	675.91	252.99
15300	59.7%	60.7%	59.6%	683.68	258.01	318600	58.6%	60.7%	60.7%	675.90	252.99
16200	59.6%	60.7%	59.5%	683.67	258.01	319500	58.6%	60.6%	60.8%	675.90	252.99
17100	59.6%	60.8%	59.5%	683.67	258.01	320400	58.6%	60.6%	60.8%	675.90	252.99
18000	59.6%	60.8%	59.5%	683.66	258.00	321300	58.6%	60.6%	60.8%	0.20	0.16
18900	59.6%	60.9%	59.5%	683.66	258.00	322200	58.6%	60.6%	60.7%	-	0.21
19800	59.6%	61.0%	59.5%	683.66	258.00	323100	58.6%	60.6%	60.7%	0.00	0.00
20700	59.6%	61.0%	59.4%	683.65	258.00	324000	58.6%	60.5%	60.7%	0.00	0.00
21600	59.6%	61.1%	59.4%	683.65	257.99	324900	58.6%	60.5%	60.7%	0.00	0.00
22500	59.6%	61.1%	59.4%	683.64	257.99	325800	58.6%	60.5%	60.7%	0.00	0.00
23400	59.6%	61.2%	59.4%	683.64	257.99	326700	58.6%	60.5%	60.6%	-	0.00
24300	59.6%	61.2%	59.3%	683.64	257.99	327600	58.6%	60.4%	60.7%	673.86	251.70
25200	59.6%	61.3%	59.3%	683.63	257.98	328500	58.6%	60.4%	60.7%	675.91	252.99
26100	59.6%	61.3%	59.3%	683.63	257.98	329400	58.6%	60.4%	60.7%	675.92	253.00
27000	59.6%	61.4%	59.3%	683.62	257.98	330300	58.6%	60.4%	60.7%	675.92	253.00
27900	59.6%	61.4%	59.3%	683.62	257.98	331200	58.6%	60.3%	60.8%	675.91	253.00
28800	59.6%	61.5%	59.2%	683.62	257.97	332100	58.6%	60.3%	60.8%	675.91	253.00
29700	59.6%	61.5%	59.2%	683.61	257.97	333000	58.6%	60.3%	60.8%	675.91	252.99
30600	59.6%	61.6%	59.2%	683.61	257.97	333900	58.6%	60.3%	60.8%	675.90	252.99
31500	59.6%	61.6%	59.2%	683.61	257.97	334800	58.6%	60.2%	60.9%	675.90	252.99
32400	59.6%	61.7%	59.1%	683.60	257.96	335700	58.6%	60.2%	60.9%	675.90	252.99
33300	59.5%	61.8%	59.1%	683.60	257.96	336600	58.6%	60.2%	60.9%	675.89	252.99
34200	59.5%	61.8%	59.1%	683.59	257.96	337500	58.6%	60.2%	60.9%	675.89	252.98
35100	59.5%	61.9%	59.1%	683.59	257.96	338400	58.6%	60.1%	61.0%	675.89	252.98
36000	59.5%	61.9%	59.1%	683.59	257.95	339300	58.6%	60.1%	61.0%	675.88	252.98
36900	59.5%	62.0%	59.0%	683.58	257.95	340200	58.6%	60.1%	61.0%	675.88	252.98
37800	59.5%	62.0%	59.0%	683.58	257.95	341100	58.6%	60.1%	61.0%	675.88	252.98
38700	59.5%	62.1%	59.0%	683.57	257.95	342000	58.6%	60.1%	61.1%	675.87	252.97
39600	59.5%	62.1%	59.0%	683.57	257.94	342900	58.6%	60.0%	61.1%	675.87	252.97

Time	Sandsloot level (%)	1160 level (%)	RWD level (%)	Booster pump power (kW)	Total mass flow (l/s)	Time	Sandsloot level (%)	1160 level (%)	RWD level (%)	Booster pump power (kW)	Total mass flow (l/s)
40500	59.5%	62.2%	58.9%	683.57	257.94	343800	58.5%	60.0%	61.1%	675.87	252.97
41400	59.5%	62.2%	58.9%	683.56	257.94	344700	58.5%	60.0%	61.1%	675.87	252.97
42300	59.5%	62.3%	58.9%	683.56	257.94	345600	58.5%	60.0%	61.2%	675.86	252.97
43200	59.5%	62.3%	58.9%	683.55	257.93	346500	58.5%	59.9%	61.2%	675.86	252.96
44100	59.5%	62.4%	58.9%	683.55	257.93	347400	58.5%	59.9%	61.2%	675.86	252.96
45000	59.5%	62.4%	58.8%	683.55	257.93	348300	58.5%	59.9%	61.2%	675.85	252.96
45900	59.5%	62.5%	58.8%	683.54	257.93	349200	58.5%	59.9%	61.3%	675.85	252.96
46800	59.5%	62.5%	58.8%	683.54	257.92	350100	58.5%	59.9%	61.3%	675.85	252.96
47700	59.5%	62.6%	58.8%	683.54	257.92	351000	58.5%	59.8%	61.3%	675.84	252.95
48600	59.5%	62.6%	58.8%	683.53	257.92	351900	58.5%	59.8%	61.3%	675.84	252.95
49500	59.5%	62.7%	58.7%	683.53	257.92	352800	58.5%	59.8%	61.4%	675.84	252.95
50400	59.5%	62.7%	58.7%	683.52	257.91	353700	58.5%	59.8%	61.4%	675.83	252.95
51300	59.4%	62.8%	58.7%	683.52	257.91	354600	58.5%	59.8%	61.4%	675.83	252.95
52200	59.4%	62.9%	58.7%	683.52	257.91	355500	58.5%	59.7%	61.5%	675.83	252.94
53100	59.4%	62.9%	58.6%	683.51	257.91	356400	58.5%	59.7%	61.5%	675.82	252.94
54000	59.4%	63.0%	58.6%	683.51	257.90	357300	58.5%	59.7%	61.5%	675.82	252.94
54900	59.4%	63.0%	58.6%	683.50	257.90	358200	58.5%	59.7%	61.5%	675.82	252.94
55800	59.4%	63.1%	58.6%	683.50	257.90	359100	58.5%	59.6%	61.6%	675.82	252.94
56700	59.4%	63.1%	58.6%	683.50	257.90	360000	58.5%	59.6%	61.6%	675.81	252.93
57600	59.4%	63.2%	58.5%	683.49	257.89	360900	58.5%	59.6%	61.6%	675.81	252.93
58500	59.4%	63.2%	58.5%	683.49	257.89	361800	58.5%	59.6%	61.6%	675.81	252.93
59400	59.4%	63.3%	58.5%	683.49	257.89	362700	58.4%	59.5%	61.7%	675.80	252.93
60300	59.4%	63.3%	58.5%	683.48	257.89	363600	58.4%	59.5%	61.7%	675.80	252.93
61200	59.4%	63.4%	58.5%	683.48	257.88	364500	58.4%	59.5%	61.7%	675.80	252.92
62100	59.4%	63.4%	58.4%	683.47	257.88	365400	58.4%	59.5%	61.7%	675.79	252.92
63000	59.4%	63.5%	58.4%	683.47	257.88	366300	58.4%	59.5%	61.8%	675.79	252.92
63900	59.4%	63.6%	58.4%	683.47	257.87	367200	58.4%	59.4%	61.8%	675.79	252.92
64800	59.4%	63.6%	58.4%	683.46	257.87	368100	58.4%	59.4%	61.8%	0.20	0.16
65700	59.4%	63.7%	58.3%	683.46	257.87	369000	58.4%	59.4%	61.7%	-	0.21
66600	59.4%	63.7%	58.3%	683.45	257.87	369900	58.4%	59.4%	61.7%	0.00	0.00
67500	59.4%	63.8%	58.3%	683.45	257.86	370800	58.4%	59.3%	61.7%	0.00	0.00
68400	59.4%	63.8%	58.3%	683.45	257.86	371700	58.5%	59.3%	61.7%	0.00	0.00
69300	59.3%	63.9%	58.3%	683.44	257.86	372600	58.5%	59.3%	61.7%	0.00	0.00
70200	59.3%	63.9%	58.2%	683.44	257.86	373500	58.5%	59.3%	61.6%	0.00	0.00
71100	59.3%	64.0%	58.2%	683.43	257.85	374400	58.5%	59.2%	61.6%	0.00	0.00
72000	59.3%	64.0%	58.2%	683.43	257.85	375300	58.5%	59.2%	61.6%	0.00	0.00
72900	59.3%	64.1%	58.2%	683.43	257.85	376200	58.5%	59.2%	61.6%	0.00	0.00
73800	59.3%	64.1%	58.1%	683.42	257.85	377100	58.5%	59.2%	61.5%	0.00	0.00
74700	59.3%	64.2%	58.1%	683.42	257.84	378000	58.5%	59.1%	61.5%	-	0.00
75600	59.3%	64.2%	58.1%	683.42	257.84	378900	58.5%	59.1%	61.5%	673.77	251.64
76500	59.3%	64.3%	58.1%	683.41	257.84	379800	58.5%	59.1%	61.6%	675.82	252.94
77400	59.3%	64.4%	58.1%	683.41	257.84	380700	58.5%	59.1%	61.6%	675.83	252.94
78300	59.3%	64.4%	58.0%	683.40	257.83	381600	58.5%	59.0%	61.6%	675.83	252.94
79200	59.3%	64.5%	58.0%	683.40	257.83	382500	58.5%	59.0%	61.6%	675.82	252.94
80100	59.3%	64.5%	58.0%	683.40	257.83	383400	58.5%	59.0%	61.7%	675.82	252.94
81000	59.3%	64.6%	58.0%	683.39	257.83	384300	58.5%	59.0%	61.7%	675.82	252.94
81900	59.3%	64.6%	57.9%	683.39	257.82	385200	58.5%	58.9%	61.7%	675.81	252.93
82800	59.3%	64.7%	57.9%	683.38	257.82	386100	58.5%	58.9%	61.7%	675.81	252.93
83700	59.3%	64.7%	57.9%	683.38	257.82	387000	58.5%	58.9%	61.8%	675.81	252.93

Time	Sandsloot level (%)	1160 level (%)	RWD level (%)	Booster pump power (kW)	Total mass flow (l/s)	Time	Sandsloot level (%)	1160 level (%)	RWD level (%)	Booster pump power (kW)	Total mass flow (l/s)
84600	59.3%	64.8%	57.9%	683.38	257.82	387900	58.4%	58.9%	61.8%	675.80	252.93
85500	59.3%	64.8%	57.9%	683.37	257.81	388800	58.4%	58.8%	61.8%	675.80	252.93
86400	59.2%	64.9%	57.8%	683.37	257.81	389700	58.4%	58.8%	61.9%	675.80	252.92
87300	59.2%	64.9%	57.8%	683.36	257.81	390600	58.4%	58.8%	61.9%	675.79	252.92
88200	59.2%	65.0%	57.8%	683.36	257.81	391500	58.4%	58.8%	61.9%	675.79	252.92
89100	59.2%	65.1%	57.8%	683.36	257.80	392400	58.4%	58.7%	61.9%	675.79	252.92
90000	59.2%	65.1%	57.7%	683.35	257.80	393300	58.4%	58.7%	62.0%	675.78	252.92
90900	59.2%	65.2%	57.7%	683.35	257.80	394200	58.4%	58.7%	62.0%	675.78	252.91
91800	59.2%	65.2%	57.7%	683.35	257.80	395100	58.4%	58.7%	62.0%	675.78	252.91
92700	59.2%	65.3%	57.7%	683.34	257.79	396000	58.4%	58.6%	62.0%	675.78	252.91
93600	59.2%	65.4%	57.7%	683.34	257.79	396900	58.4%	58.6%	62.1%	675.77	252.91
94500	59.2%	65.4%	57.6%	683.33	257.79	397800	58.4%	58.6%	62.1%	675.77	252.91
95400	59.2%	65.5%	57.6%	683.33	257.79	398700	58.4%	58.6%	62.1%	675.77	252.90
96300	59.2%	65.5%	57.6%	683.33	257.78	399600	58.4%	58.5%	62.1%	675.76	252.90
97200	59.2%	65.6%	57.6%	683.32	257.78	400500	58.4%	58.5%	62.2%	675.76	252.90
98100	59.2%	65.6%	57.6%	683.32	257.78	401400	58.4%	58.5%	62.2%	675.76	252.90
99000	59.2%	65.7%	57.5%	683.31	257.78	402300	58.4%	58.5%	62.2%	675.75	252.90
99900	59.2%	65.7%	57.5%	683.31	257.77	403200	58.4%	58.4%	62.2%	675.75	252.89
100800	59.2%	65.8%	57.5%	683.31	257.77	404100	58.4%	58.4%	62.3%	675.75	252.89
101700	59.2%	65.8%	57.5%	683.30	257.77	405000	58.4%	58.4%	62.3%	675.74	252.89
102600	59.2%	65.9%	57.4%	683.30	257.77	405900	58.3%	58.4%	62.3%	675.74	252.89
103500	59.2%	65.9%	57.4%	683.29	257.76	406800	58.4%	58.4%	62.3%	0.20	0.16
104400	59.1%	66.0%	57.4%	683.29	257.76	407700	58.4%	58.3%	62.3%	-	0.21
105300	59.1%	66.1%	57.4%	683.29	257.76	408600	58.4%	58.3%	62.3%	0.00	0.00
106200	59.1%	66.1%	57.4%	683.28	257.76	409500	58.4%	58.3%	62.2%	0.00	0.00
107100	59.1%	66.2%	57.3%	683.28	257.75	410400	58.4%	58.3%	62.2%	0.00	0.00
108000	59.1%	66.2%	57.3%	683.28	257.75	411300	58.4%	58.2%	62.2%	0.00	0.00
108900	59.1%	66.2%	57.3%	0.21	0.17	412200	58.4%	58.2%	62.2%	0.00	0.00
109800	59.1%	66.2%	57.3%	-	0.21	413100	58.4%	58.2%	62.1%	-	0.00
110700	59.1%	66.1%	57.2%	0.00	0.00	414000	58.4%	58.2%	62.1%	-	0.00
111600	59.2%	66.1%	57.2%	0.00	0.00	414900	58.4%	58.1%	62.1%	673.71	251.61
112500	59.2%	66.1%	57.2%	0.00	0.00	415800	58.4%	58.1%	62.2%	675.76	252.90
113400	59.2%	66.1%	57.2%	0.00	0.00	416700	58.4%	58.1%	62.2%	675.77	252.91
114300	59.2%	66.0%	57.2%	0.00	0.00	417600	58.4%	58.1%	62.2%	675.77	252.90
115200	59.2%	66.0%	57.1%	0.00	0.00	418500	58.4%	58.0%	62.2%	675.76	252.90
116100	59.2%	66.0%	57.1%	0.00	0.00	419400	58.4%	58.0%	62.3%	675.76	252.90
117000	59.2%	66.0%	57.1%	0.00	0.00	420300	58.4%	58.0%	62.3%	675.76	252.90
117900	59.2%	66.0%	57.1%	0.00	0.00	421200	58.4%	58.0%	62.3%	675.75	252.90
118800	59.2%	65.9%	57.0%	0.31	0.33	422100	58.4%	57.9%	62.3%	675.75	252.89
119700	59.2%	65.9%	57.1%	673.32	251.36	423000	58.4%	57.9%	62.4%	675.75	252.89
120600	59.2%	65.9%	57.1%	675.63	252.82	423900	58.4%	57.9%	62.4%	675.74	252.89
121500	59.2%	65.9%	57.1%	675.86	252.96	424800	58.4%	57.9%	62.4%	675.74	252.89
122400	59.2%	65.8%	57.2%	676.01	253.06	425700	58.3%	57.8%	62.4%	675.74	252.89
123300	59.2%	65.8%	57.2%	676.10	253.12	426600	58.3%	57.8%	62.5%	675.73	252.88
124200	59.2%	65.8%	57.2%	676.16	253.15	427500	58.3%	57.8%	62.5%	675.73	252.88
125100	59.2%	65.8%	57.2%	676.20	253.18	428400	58.3%	57.8%	62.5%	675.73	252.88
126000	59.2%	65.7%	57.3%	676.22	253.19	429300	58.3%	57.8%	62.6%	675.73	252.88
126900	59.2%	65.7%	57.3%	676.23	253.20	430200	58.3%	57.7%	62.6%	675.72	252.88
127800	59.2%	65.7%	57.3%	676.24	253.21	431100	58.3%	57.7%	62.6%	675.72	252.87

Time	Sandsloot level (%)	1160 level (%)	RWD level (%)	Booster pump power (kW)	Total mass flow (l/s)	Time	Sandsloot level (%)	1160 level (%)	RWD level (%)	Booster pump power (kW)	Total mass flow (l/s)
128700	59.2%	65.7%	57.3%	676.24	253.21	432000	58.3%	57.7%	62.6%	675.72	252.87
129600	59.1%	65.6%	57.4%	676.25	253.21	432900	58.3%	57.7%	62.7%	675.71	252.87
130500	59.1%	65.6%	57.4%	676.25	253.21	433800	58.3%	57.6%	62.7%	675.71	252.87
131400	59.1%	65.6%	57.4%	676.24	253.21	434700	58.3%	57.6%	62.7%	675.71	252.87
132300	59.1%	65.6%	57.4%	676.24	253.21	435600	58.3%	57.6%	62.7%	675.70	252.86
133200	59.1%	65.5%	57.5%	676.24	253.21	436500	58.3%	57.6%	62.8%	675.70	252.86
134100	59.1%	65.5%	57.5%	676.24	253.20	437400	58.3%	57.6%	62.8%	675.70	252.86
135000	59.1%	65.5%	57.5%	676.23	253.20	438300	58.3%	57.5%	62.8%	675.69	252.86
135900	59.1%	65.5%	57.5%	676.23	253.20	439200	58.3%	57.5%	62.8%	675.69	252.86
136800	59.1%	65.4%	57.6%	676.23	253.20	440100	58.3%	57.5%	62.9%	675.69	252.85
137700	59.1%	65.4%	57.6%	676.23	253.20	441000	58.3%	57.5%	62.9%	675.68	252.85
138600	59.1%	65.4%	57.6%	676.22	253.19	441900	58.3%	57.5%	62.9%	675.68	252.85
139500	59.1%	65.4%	57.6%	676.22	253.19	442800	58.3%	57.4%	62.9%	675.68	252.85
140400	59.1%	65.3%	57.7%	676.22	253.19	443700	58.2%	57.4%	63.0%	675.68	252.85
141300	59.1%	65.3%	57.7%	676.21	253.19	444600	58.2%	57.4%	63.0%	675.67	252.84
142200	59.1%	65.3%	57.7%	676.21	253.19	445500	58.2%	57.4%	63.0%	675.67	252.84
143100	59.1%	65.3%	57.7%	676.21	253.18	446400	58.2%	57.3%	63.0%	675.67	252.84
144000	59.1%	65.2%	57.8%	676.20	253.18	447300	58.2%	57.3%	63.1%	675.66	252.84
144900	59.1%	65.2%	57.8%	676.20	253.18	448200	58.2%	57.3%	63.1%	675.66	252.84
145800	59.1%	65.2%	57.8%	676.20	253.18	449100	58.2%	57.3%	63.1%	675.66	252.83
146700	59.1%	65.2%	57.8%	676.19	253.18	450000	58.2%	57.2%	63.1%	675.65	252.83
147600	59.1%	65.1%	57.8%	0.20	0.16	450900	58.2%	57.2%	63.2%	675.65	252.83
148500	59.1%	65.1%	57.8%	-	0.21	451800	58.2%	57.2%	63.2%	675.65	252.83
149400	59.1%	65.1%	57.8%	0.00	0.00	452700	58.2%	57.2%	63.2%	675.64	252.83
150300	59.1%	65.1%	57.8%	0.00	0.00	453600	58.2%	57.2%	63.2%	675.64	252.82
151200	59.1%	65.0%	57.7%	0.00	0.00	454500	58.2%	57.1%	63.2%	0.20	0.16
152100	59.1%	65.0%	57.7%	0.00	0.00	455400	58.2%	57.1%	63.2%	-	0.21
153000	59.1%	65.0%	57.7%	0.00	0.00	456300	58.2%	57.1%	63.2%	0.00	0.00
153900	59.1%	65.0%	57.7%	0.00	0.00	457200	58.2%	57.1%	63.2%	0.00	0.00
154800	59.1%	64.9%	57.6%	0.00	0.00	458100	58.2%	57.0%	63.1%	0.00	0.00
155700	59.1%	64.9%	57.7%	674.16	251.89	459000	58.2%	57.0%	63.1%	0.00	0.00
156600	59.1%	64.9%	57.7%	676.21	253.19	459900	58.2%	57.0%	63.1%	0.00	0.00
157500	59.1%	64.9%	57.7%	676.22	253.19	460800	58.2%	57.0%	63.1%	0.00	0.00
158400	59.1%	64.8%	57.7%	676.22	253.19	461700	58.3%	56.9%	63.0%	0.00	0.00
159300	59.1%	64.8%	57.8%	676.22	253.19	462600	58.3%	56.9%	63.0%	0.00	0.00
160200	59.1%	64.8%	57.8%	676.21	253.19	463500	58.3%	56.9%	63.0%	0.00	0.00
161100	59.1%	64.8%	57.8%	676.21	253.19	464400	58.3%	56.9%	63.0%	-	0.00
162000	59.1%	64.8%	57.9%	676.21	253.18	465300	58.3%	56.8%	63.0%	673.62	251.55
162900	59.1%	64.7%	57.9%	676.20	253.18	466200	58.3%	56.8%	63.0%	675.67	252.84
163800	59.1%	64.7%	57.9%	676.20	253.18	467100	58.3%	56.8%	63.1%	675.68	252.85
164700	59.1%	64.7%	57.9%	676.20	253.18	468000	58.3%	56.8%	63.1%	675.68	252.85
165600	59.1%	64.7%	58.0%	676.19	253.18	468900	58.2%	56.7%	63.1%	675.68	252.85
166500	59.1%	64.6%	58.0%	676.19	253.17	469800	58.2%	56.7%	63.1%	675.67	252.84
167400	59.0%	64.6%	58.0%	676.19	253.17	470700	58.2%	56.7%	63.2%	675.67	252.84
168300	59.0%	64.6%	58.0%	676.19	253.17	471600	58.2%	56.7%	63.2%	675.67	252.84
169200	59.0%	64.6%	58.1%	676.18	253.17	472500	58.2%	56.6%	63.2%	675.66	252.84
170100	59.0%	64.5%	58.1%	676.18	253.17	473400	58.2%	56.6%	63.2%	675.66	252.84
171000	59.0%	64.5%	58.1%	676.18	253.16	474300	58.2%	56.6%	63.3%	675.66	252.83
171900	59.0%	64.5%	58.1%	676.17	253.16	475200	58.2%	56.6%	63.3%	675.65	252.83

Time	Sandsloot level (%)	1160 level (%)	RWD level (%)	Booster pump power (kW)	Total mass flow (l/s)	Time	Sandsloot level (%)	1160 level (%)	RWD level (%)	Booster pump power (kW)	Total mass flow (l/s)
172800	59.0%	64.5%	58.2%	676.17	253.16	476100	58.2%	56.5%	63.3%	675.65	252.83
173700	59.0%	64.5%	58.2%	676.17	253.16	477000	58.2%	56.5%	63.3%	675.65	252.83
174600	59.0%	64.4%	58.2%	676.16	253.16	477900	58.2%	56.5%	63.4%	675.64	252.83
175500	59.0%	64.4%	58.2%	676.16	253.15	478800	58.2%	56.5%	63.4%	675.64	252.82
176400	59.0%	64.4%	58.3%	676.16	253.15	479700	58.2%	56.4%	63.4%	675.64	252.82
177300	59.0%	64.4%	58.3%	676.15	253.15	480600	58.2%	56.4%	63.4%	675.64	252.82
178200	59.0%	64.4%	58.3%	676.15	253.15	481500	58.2%	56.4%	63.5%	675.63	252.82
179100	59.0%	64.3%	58.3%	676.15	253.15	482400	58.2%	56.4%	63.5%	675.63	252.82
180000	59.0%	64.3%	58.4%	676.14	253.15	483300	58.2%	56.3%	63.5%	675.63	252.81
180900	59.0%	64.3%	58.4%	676.14	253.14	484200	58.2%	56.3%	63.5%	675.62	252.81
181800	59.0%	64.3%	58.4%	676.14	253.14	485100	58.2%	56.3%	63.6%	675.62	252.81
182700	59.0%	64.3%	58.4%	676.14	253.14	486000	58.2%	56.3%	63.6%	675.62	252.81
183600	59.0%	64.2%	58.5%	676.13	253.14	486900	58.2%	56.2%	63.6%	675.61	252.81
184500	59.0%	64.2%	58.5%	676.13	253.14	487800	58.1%	56.2%	63.6%	675.61	252.80
185400	58.9%	64.2%	58.5%	676.13	253.13	488700	58.1%	56.2%	63.7%	675.61	252.80
186300	58.9%	64.2%	58.5%	676.12	253.13	489600	58.1%	56.2%	63.7%	675.60	252.80
187200	58.9%	64.1%	58.6%	676.12	253.13	490500	58.1%	56.1%	63.7%	675.60	252.80
188100	58.9%	64.1%	58.6%	676.12	253.13	491400	58.1%	56.1%	63.7%	675.60	252.80
189000	58.9%	64.1%	58.6%	676.11	253.13	492300	58.1%	56.1%	63.8%	675.59	252.80
189900	58.9%	64.1%	58.6%	676.11	253.12	493200	58.1%	56.1%	63.8%	0.20	0.16
190800	58.9%	64.0%	58.7%	676.11	253.12	494100	58.1%	56.1%	63.7%	-	0.21
191700	58.9%	64.0%	58.7%	676.10	253.12	495000	58.1%	56.0%	63.7%	0.00	0.00
192600	58.9%	64.0%	58.7%	676.10	253.12	495900	58.1%	56.0%	63.7%	0.00	0.00
193500	58.9%	64.0%	58.7%	676.10	253.12	496800	58.2%	56.0%	63.7%	0.00	0.00
194400	58.9%	63.9%	58.7%	0.20	0.16	497700	58.2%	56.0%	63.6%	0.00	0.00
195300	58.9%	63.9%	58.7%	-	0.21	498600	58.2%	55.9%	63.6%	0.00	0.00
196200	58.9%	63.9%	58.7%	0.00	0.00	499500	58.2%	55.9%	63.6%	0.00	0.00
197100	58.9%	63.9%	58.7%	0.00	0.00	500400	58.2%	55.9%	63.6%	-	0.00
198000	58.9%	63.8%	58.6%	0.00	0.00	501300	58.2%	55.9%	63.6%	673.56	251.51
198900	58.9%	63.8%	58.6%	-	0.00	502200	58.2%	55.8%	63.6%	675.61	252.81
199800	58.9%	63.8%	58.6%	-	0.00	503100	58.2%	55.8%	63.7%	675.62	252.81
200700	59.0%	63.8%	58.6%	-	0.00	504000	58.2%	55.8%	63.7%	675.62	252.81
201600	59.0%	63.8%	58.5%	0.00	0.00	504900	58.2%	55.8%	63.7%	675.62	252.81
202500	59.0%	63.7%	58.5%	0.00	0.00	505800	58.2%	55.7%	63.7%	675.61	252.81
203400	59.0%	63.7%	58.5%	0.00	0.00	506700	58.1%	55.7%	63.8%	675.61	252.81
204300	59.0%	63.7%	58.5%	0.00	0.00	507600	58.1%	55.7%	63.8%	675.61	252.80
205200	59.0%	63.7%	58.5%	0.00	0.00	508500	58.1%	55.7%	63.8%	675.60	252.80
206100	59.0%	63.6%	58.5%	674.08	251.84	509400	58.1%	55.6%	63.8%	675.60	252.80
207000	59.0%	63.6%	58.5%	676.13	253.14	510300	58.1%	55.6%	63.9%	675.60	252.80
207900	59.0%	63.6%	58.5%	676.14	253.14	511200	58.1%	55.6%	63.9%	675.59	252.80
208800	59.0%	63.6%	58.6%	676.14	253.14	512100	58.1%	55.6%	63.9%	675.59	252.79
209700	59.0%	63.5%	58.6%	676.14	253.14	513000	58.1%	55.5%	63.9%	675.59	252.79
210600	59.0%	63.5%	58.6%	676.13	253.14	513900	58.1%	55.5%	64.0%	675.59	252.79
211500	59.0%	63.5%	58.6%	676.13	253.14	514800	58.1%	55.5%	64.0%	675.58	252.79
212400	59.0%	63.5%	58.7%	676.13	253.13	515700	58.1%	55.5%	64.0%	675.58	252.79
213300	58.9%	63.4%	58.7%	676.12	253.13	516600	58.1%	55.5%	64.0%	675.58	252.78
214200	58.9%	63.4%	58.7%	676.12	253.13	517500	58.1%	55.4%	64.1%	675.57	252.78
215100	58.9%	63.4%	58.7%	676.12	253.13	518400	58.1%	55.4%	64.1%	675.57	252.78
216000	58.9%	63.4%	58.8%	676.11	253.13	519300	58.1%	55.4%	64.1%	675.57	252.78

Time	Sandsloot level (%)	1160 level (%)	RWD level (%)	Booster pump power (kW)	Total mass flow (l/s)	Time	Sandsloot level (%)	1160 level (%)	RWD level (%)	Booster pump power (kW)	Total mass flow (l/s)
216900	58.9%	63.3%	58.8%	676.11	253.12	520200	58.1%	55.4%	64.1%	675.56	252.78
217800	58.9%	63.3%	58.8%	676.11	253.12	521100	58.1%	55.3%	64.2%	675.56	252.77
218700	58.9%	63.3%	58.8%	676.11	253.12	522000	58.1%	55.3%	64.2%	675.56	252.77
219600	58.9%	63.3%	58.9%	676.10	253.12	522900	58.1%	55.3%	64.2%	675.55	252.77
220500	58.9%	63.2%	58.9%	676.10	253.12	523800	58.1%	55.3%	64.2%	675.55	252.77
221400	58.9%	63.2%	58.9%	676.10	253.11	524700	58.1%	55.3%	64.3%	675.55	252.77
222300	58.9%	63.2%	58.9%	676.09	253.11	525600	58.0%	55.2%	64.3%	675.54	252.76
223200	58.9%	63.2%	59.0%	676.09	253.11	526500	58.0%	55.2%	64.3%	675.54	252.76
224100	58.9%	63.1%	59.0%	676.09	253.11	527400	58.0%	55.2%	64.3%	675.54	252.76
225000	58.9%	63.1%	59.0%	676.08	253.11	528300	58.0%	55.2%	64.4%	675.54	252.76
225900	58.9%	63.1%	59.1%	676.08	253.10	529200	58.0%	55.2%	64.4%	675.53	252.76
226800	58.9%	63.1%	59.1%	676.08	253.10	530100	58.0%	55.1%	64.4%	675.53	252.75
227700	58.9%	63.0%	59.1%	676.07	253.10	531000	58.0%	55.1%	64.4%	675.53	252.75
228600	58.9%	63.0%	59.1%	676.07	253.10	531900	58.0%	55.1%	64.5%	675.52	252.75
229500	58.9%	63.0%	59.2%	676.07	253.10	532800	58.0%	55.1%	64.5%	675.52	252.75
230400	58.9%	63.0%	59.2%	676.06	253.09	533700	58.0%	55.0%	64.5%	675.52	252.75
231300	58.8%	62.9%	59.2%	676.06	253.09	534600	58.0%	55.0%	64.5%	675.51	252.74
232200	58.8%	62.9%	59.2%	676.06	253.09	535500	58.0%	55.0%	64.6%	675.51	252.74
233100	58.8%	62.9%	59.3%	676.06	253.09	536400	58.0%	55.0%	64.6%	675.51	252.74
234000	58.8%	62.9%	59.3%	676.05	253.09	537300	58.0%	54.9%	64.6%	675.50	252.74
234900	58.8%	62.9%	59.3%	0.20	0.16	538200	58.0%	54.9%	64.7%	675.50	252.74
235800	58.8%	62.8%	59.2%	-	0.21	539100	58.0%	54.9%	64.7%	675.50	252.73
236700	58.9%	62.8%	59.2%	0.00	0.00	540000	58.0%	54.9%	64.7%	675.49	252.73
237600	58.9%	62.8%	59.2%	0.00	0.00	540900	58.0%	54.9%	64.7%	675.49	252.73
238500	58.9%	62.8%	59.2%	0.00	0.00	541800	58.0%	54.8%	64.8%	675.49	252.73
239400	58.9%	62.7%	59.1%	0.00	0.00	542700	58.0%	54.8%	64.8%	675.49	252.73
240300	58.9%	62.7%	59.1%	0.00	0.00	543600	57.9%	54.8%	64.8%	675.48	252.72
241200	58.9%	62.7%	59.2%	674.01	251.80	544500	57.9%	54.8%	64.8%	675.48	252.72
242100	58.9%	62.7%	59.2%	676.06	253.09	545400	57.9%	54.7%	64.9%	675.48	252.72
243000	58.9%	62.6%	59.2%	676.07	253.10	546300	57.9%	54.7%	64.9%	675.47	252.72
243900	58.9%	62.6%	59.2%	676.07	253.10	547200	57.9%	54.7%	64.9%	675.47	252.72
244800	58.9%	62.6%	59.3%	676.07	253.09	548100	57.9%	54.7%	64.9%	675.47	252.71
245700	58.9%	62.6%	59.3%	676.06	253.09	549000	57.9%	54.6%	65.0%	675.46	252.71
246600	58.8%	62.5%	59.3%	676.06	253.09	549900	57.9%	54.6%	65.0%	675.46	252.71
247500	58.8%	62.5%	59.3%	676.06	253.09	550800	57.9%	54.6%	65.0%	675.46	252.71
248400	58.8%	62.5%	59.4%	676.05	253.09	551700	57.9%	54.6%	65.0%	675.45	252.71
249300	58.8%	62.5%	59.4%	676.05	253.08	552600	57.9%	54.5%	65.1%	675.45	252.70
250200	58.8%	62.4%	59.4%	676.05	253.08	553500	57.9%	54.5%	65.1%	675.45	252.70
251100	58.8%	62.4%	59.4%	676.04	253.08	554400	57.9%	54.5%	65.1%	675.44	252.70
252000	58.8%	62.4%	59.5%	676.04	253.08	555300	57.9%	54.5%	65.1%	675.44	252.70
252900	58.8%	62.4%	59.5%	676.04	253.08	556200	57.9%	54.4%	65.2%	675.44	252.70
253800	58.8%	62.4%	59.5%	676.03	253.07	557100	57.9%	54.4%	65.2%	675.44	252.69
254700	58.8%	62.3%	59.5%	676.03	253.07	558000	57.9%	54.4%	65.2%	675.43	252.69
255600	58.8%	62.3%	59.6%	676.03	253.07	558900	57.9%	54.4%	65.2%	675.43	252.69
256500	58.8%	62.3%	59.6%	676.03	253.07	559800	57.9%	54.3%	65.3%	675.43	252.69
257400	58.8%	62.3%	59.6%	676.02	253.07	560700	57.9%	54.3%	65.3%	675.42	252.69
258300	58.8%	62.2%	59.6%	676.02	253.07	561600	57.9%	54.3%	65.3%	675.42	252.68
259200	58.8%	62.2%	59.7%	676.02	253.06	562500	57.8%	54.3%	65.3%	675.42	252.68
260100	58.8%	62.2%	59.7%	676.01	253.06	563400	57.8%	54.2%	65.4%	675.41	252.68

Time	Sandsloot level (%)	1160 level (%)	RWD level (%)	Booster pump power (kW)	Total mass flow (l/s)	Time	Sandsloot level (%)	1160 level (%)	RWD level (%)	Booster pump power (kW)	Total mass flow (l/s)
261000	58.8%	62.2%	59.7%	676.01	253.06	564300	57.8%	54.2%	65.4%	675.41	252.68
261900	58.8%	62.2%	59.7%	676.01	253.06	565200	57.8%	54.2%	65.4%	675.41	252.68
262800	58.8%	62.1%	59.8%	676.00	253.06	566100	57.8%	54.2%	65.4%	675.40	252.67
263700	58.8%	62.1%	59.8%	676.00	253.05	567000	57.8%	54.1%	65.5%	675.40	252.67
264600	58.7%	62.1%	59.8%	676.00	253.05	567900	57.8%	54.1%	65.5%	675.40	252.67
265500	58.7%	62.1%	59.8%	675.99	253.05	568800	57.8%	54.1%	65.5%	675.39	252.67
266400	58.7%	62.1%	59.9%	675.99	253.05	569700	57.8%	54.1%	65.5%	675.39	252.67
267300	58.7%	62.0%	59.9%	675.99	253.05	570600	57.8%	54.0%	65.6%	675.39	252.66
268200	58.7%	62.0%	59.9%	675.98	253.04	571500	57.8%	54.0%	65.6%	675.39	252.66
269100	58.7%	62.0%	59.9%	675.98	253.04	572400	57.8%	54.0%	65.6%	675.38	252.66
270000	58.7%	62.0%	60.0%	675.98	253.04	573300	57.8%	54.0%	65.6%	675.38	252.66
270900	58.7%	61.9%	60.0%	675.98	253.04	574200	57.8%	53.9%	65.7%	675.38	252.66
271800	58.7%	61.9%	60.0%	675.97	253.04	575100	57.8%	53.9%	65.7%	675.37	252.65
272700	58.7%	61.9%	60.0%	675.97	253.03	576000	57.8%	53.9%	65.7%	675.37	252.65
273600	58.7%	61.9%	60.1%	675.97	253.03	576900	57.8%	53.9%	65.7%	675.37	252.65
274500	58.7%	61.9%	60.1%	675.96	253.03	577800	57.8%	53.8%	65.8%	675.36	252.65
275400	58.7%	61.8%	60.1%	675.96	253.03	578700	57.8%	53.8%	65.8%	675.36	252.65
276300	58.7%	61.8%	60.2%	675.96	253.03	579600	57.8%	53.8%	65.8%	675.36	252.64
277200	58.7%	61.8%	60.2%	675.95	253.02	580500	57.8%	53.8%	65.9%	675.35	252.64
278100	58.7%	61.8%	60.2%	675.95	253.02	581400	57.7%	53.8%	65.9%	675.35	252.64
279000	58.7%	61.7%	60.2%	675.95	253.02	582300	57.7%	53.7%	65.9%	675.35	252.64
279900	58.7%	61.7%	60.3%	675.94	253.02	583200	57.7%	53.7%	65.9%	675.34	252.64
280800	58.7%	61.7%	60.2%	0.20	0.16	584100	57.7%	53.7%	66.0%	675.34	252.63
281700	58.7%	61.7%	60.2%	-	0.21	585000	57.7%	53.7%	66.0%	675.34	252.63
282600	58.7%	61.6%	60.2%	0.00	0.00	585900	57.7%	53.6%	66.0%	675.34	252.63
283500	58.7%	61.6%	60.2%	0.00	0.00	586800	57.7%	53.6%	66.0%	675.33	252.63
284400	58.7%	61.6%	60.1%	0.00	0.00	587700	57.7%	53.6%	66.1%	675.33	252.63
285300	58.7%	61.6%	60.1%	0.00	0.00	588600	57.7%	53.6%	66.1%	675.33	252.62
286200	58.7%	61.5%	60.1%	0.00	0.00	589500	57.7%	53.5%	66.1%	675.32	252.62
287100	58.7%	61.5%	60.1%	0.00	0.00	590400	57.7%	53.5%	66.1%	675.32	252.62
288000	58.7%	61.5%	60.1%	0.00	0.00	591300	57.7%	53.5%	66.2%	675.32	252.62
288900	58.7%	61.5%	60.0%	-	0.00	592200	57.7%	53.5%	66.2%	675.31	252.62
289800	58.7%	61.4%	60.0%	-	0.00	593100	57.7%	53.4%	66.2%	675.31	252.61
290700	58.7%	61.4%	60.0%	0.00	0.00	594000	57.7%	53.4%	66.2%	675.31	252.61
291600	58.8%	61.4%	60.0%	0.00	0.00	594900	57.7%	53.4%	66.3%	675.30	252.61
292500	58.7%	61.4%	60.0%	673.93	251.75	595800	57.7%	53.4%	66.3%	675.30	252.61
293400	58.7%	61.3%	60.0%	675.98	253.04	596700	57.7%	53.3%	66.3%	675.30	252.61
294300	58.7%	61.3%	60.0%	675.99	253.05	597600	57.7%	53.3%	66.3%	675.29	252.60
295200	58.7%	61.3%	60.1%	675.99	253.04	598500	57.7%	53.3%	66.4%	675.29	252.60
296100	58.7%	61.3%	60.1%	675.98	253.04	599400	57.6%	53.3%	66.4%	675.29	252.60
297000	58.7%	61.3%	60.1%	675.98	253.04	600300	57.6%	53.2%	66.4%	675.29	252.60
297900	58.7%	61.2%	60.1%	675.98	253.04	601200	57.6%	53.2%	66.4%	675.28	252.60
298800	58.7%	61.2%	60.2%	675.97	253.04	602100	57.6%	53.2%	66.5%	675.28	252.59
299700	58.7%	61.2%	60.2%	675.97	253.03	603000	57.6%	53.2%	66.5%	675.28	252.59
300600	58.7%	61.2%	60.2%	675.97	253.03	603900	57.6%	53.2%	66.5%	675.27	252.59
301500	58.7%	61.1%	60.2%	675.96	253.03	604800	57.6%	53.1%	66.5%	675.27	252.59
302400	58.7%	61.1%	60.3%	675.96	253.03						