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REPORT

Surface Water Impact Assessment Report for the Belfast Expansion Project and Mine Residue Facility Expansion Water Use Licence Application Process

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Distribution List

1 electronic copy to Exxaro Coal Mpumalanga (Pty) Ltd.

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1.0 INTRODUCTION

The Exxaro mining department was tasked with evaluating the Belfast Resource for potential scenarios to add additional export tonnages from the Belfast Resource to the Exxaro portfolio. Currently the Belfast Implementation Project (BIP) has an existing approved Water Use License (WUL) number 05/X11D/ABCFGIJ/2613. Exxaro intends to expand the current mining operation under the Exxaro Belfast Expansion Project (BEP). This process will require a new water use licence application (WULA).

Exxaro has requested Golder Associates Africa (Pty) Ltd. (Golder) to provide assistance with the Integrated Water Use License Application (IWULA), Integrated Water and Waste management Plan (IWWMP) and associated specialist studies for the Exxaro Belfast Expansion Project operation. This report forms the surface water specialist study for the BEP and new Mine Residue Facility (MRF).

The key objectives of the specialist study are to:

- Collect hydrology data to describe the baseline hydrology;
- Assess and analyse climate data;
- Develop an integrated water management plan of the BEP. The water management plan includes a stormwater assessment and integrated water balance modelling;
- Develop a proposed monitoring programme / plan for BEP; and
- Conduct a surface water impact assessment for the project.

2.0 SITE LOCALITY AND LAND USE

Exxaro Coal Mpumalanga (Pty) (Ltd) a subsidiary of Exxaro Coal (Pty) Ltd and owned by Exxaro Resources Limited. It manages a number of coal mining operations operated by various legal entities, which also includes the Matla and Belfast operation. The Exxaro Belfast Mining Right (Ref. No. MP 30/5/1/2/2/431 MR) is situated in the Mpumalanga Province and is located south of the town of Belfast along the N4 national highway, 10km southeast of eMakhazeni on the farms Leeuwbank, Zoekop and Blyvooruitzicht. Refer to Figure 1 for the site locality and the red boundary on Figure 2 for the MR area. The MR area is approximately 5819 ha in extent and mostly comprises of undeveloped agricultural land and semi-natural and natural grassland.

2.1 Pre-mining conditions

According to GCS, 2020b and Marsh, 2011, the predominant pre-mining land use consisted of:

- Arable land (59%).
- Wetlands (large areas along the Leeubank spruit and the Klein Komati River and their tributaries – 25%).
- Grazing land (16%).

2.2 Desired post-mining land use

According to the BIP EMPr, the desired end land use of the site includes:

- Zone 1 – Areas least affected by mining to be used for arable agriculture.
- Zone 1a – Western riparian zone to be used for eco-tourism or recreation.
- Zone 2 – Plant and associated infrastructure to be used for grazing or wilderness.
- Zone 3 – Areas heavily affected by mining to be used for grazing or recreation.
- Zone 3a – Central riparian zone within mining area to be used for eco-tourism and recreation.

- Zone 3b – Area close to the N4 to be used for commercial and light industry.

The post mining land capability must sustain the above uses.

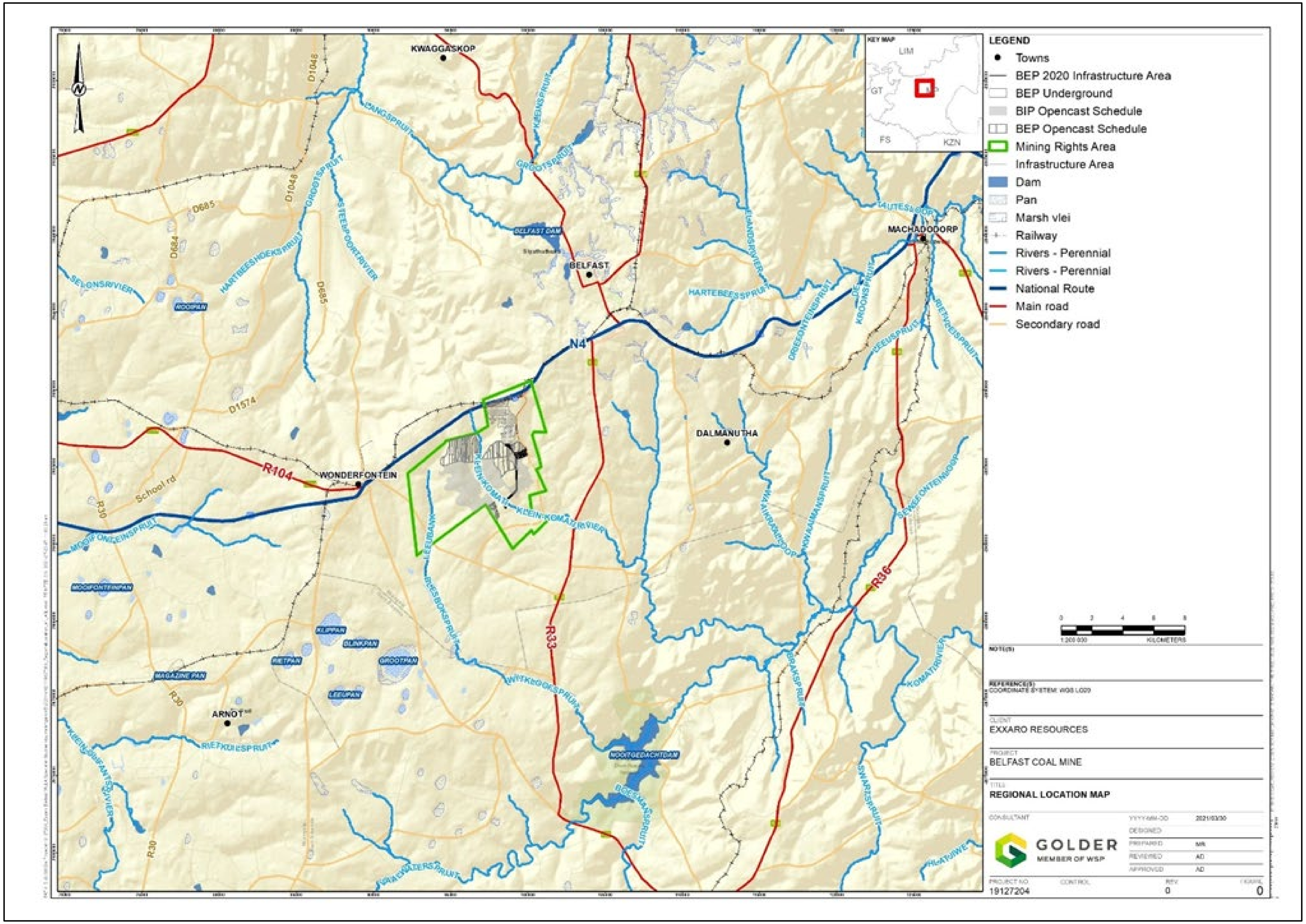

Figure 1: Regional locality for the project area

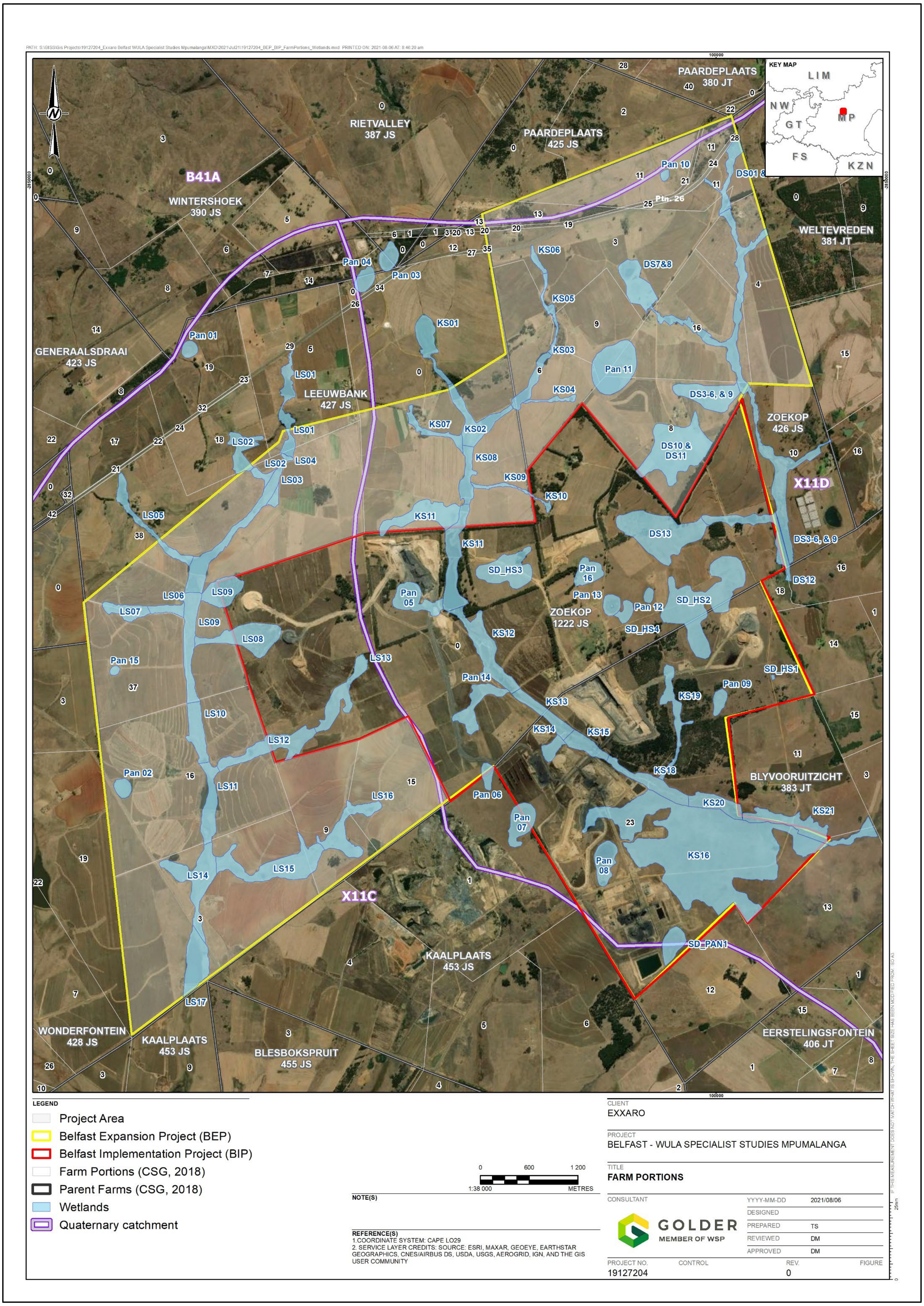

Figure 2: Belfast Mine boundary, farm portions and quaternary catchments

3.0 PROJECT BACKGROUND AND SCOPE

Exxaro is currently mining coal reserves via open cast mining methods at the Belfast Implementation Project (BIP). BIP commenced mining activities in 2018 with the construction of the associated plant and infrastructure in October / November 2017 to process 3 Mtpa of Run of Mine (RoM) with a Life of Mine (LoM) of 17 years. The first coal was produced in the processing plant during September 2019 (Exxaro, 2021).

The BEP area falls within the MR area as shown in Figure 2 and subsequently forms part of the resource pertaining to Belfast. The project area will be an extension of the BIP mining rights area to the north. A desktop study was done to evaluate the potential of both open cast and underground operation within the Belfast MR area to access high quality coal for export. The exploitation analysis of the Belfast Resource outside the current BIP layout area revealed that there is a potential for a 5 200 kcal/kg open cast and underground mining scenario as well as a 5 800 kcal/kg underground mining scenario. A potential of 39.7 Mt of RoM can be additionally mined at a yield of 69% resulting in 27.4 Mt of product, (Exxaro, 2021).

The scope of BEP therefore includes the additional open cast and underground mining area as shown in Figure 4. Figure 4 represents the LoM plan for all pits and the associated areas are listed in Table 1.

Table 1: LoM areas

Year	BIP East [ha]	BIP West [ha]	BEP East [ha]	BEP West [ha]	BEP UG [ha]
2020	13.43	5.14	0	0	0
2021	44.52	37.83	0	0	0
2022	49.4	41.5	0	0	0
2023	53.76	40.78	0	0	0
2024	63.95	34.35	0	0	0
2025	68.33	38.6	0	0	0
2026	61.67	27.48	0	0	0
2027	30.36	71.18	0	0	0
2028	10.38	79.54	0	0	0
2029	0	85.01	0	0	0
2030	0	100.9	0	0	0
2031	0	36.65	27.71	60.81	0
2032	0	0	31.47	54.05	0
2033	0	0	27.85	52.26	0
2034	0	0	26.3	39.5	0
2035	0	0	22.41	34.46	0
2036	0	0	26.65	36.93	0
2037	0	0	49.75	17.34	58.5
2038	0	0	48.03	15.91	72.22
2039	0	0	55.33	16.54	68.5
2040	0	0	0	0	54.78
2041	0	0	0	0	48.94
2042	0	0	0	0	12.36

3.1 BEP open cast mining

The new opencast BEP mining area is envisaged to be a continuation of the existing open cast mine. Therefore, minimal additional resources will be required. For the BEP future open cast mining the following assumptions are made in the model:

- Box-cut stripping will start six months prior to coal mining.
- No prestripping is planned.
- Workings will be exposed during the year as shown in the LoM plan in Figure 4.
- Mining will expose approximately 5 – 6 cuts at a time (250 – 300 m long).

3.2 BEP underground mining

Figure 6 shows the BEP underground infrastructure. The underground workings will be accessed via a ramp area. The ramp will contain a Flood Protection Dam at the foot of the ramp area to contain any stormwater runoff that reports down the lower area. This dam will also contain the water from the dewatering of the underground mine operation. RoM mined via the traditional board and pillar mining method, will be transferred up the incline via conveyor belts to the temporary and emergency ROM stockpile area. The footprint of the area is 33 408 m^2 and is designed to contain 25 000 tonnes of RoM and 5 000 tonnes of emergency RoM. Dirty water from the RoM stockpile area is routed via stormwater channels to a RoM stormwater sump. The water goes first through a silt trap. The underground ramp area contains:

- Vehicle berms.
- Vehicle brake test ramps.
- Parking.
- Tyre change and top-up area.
- Maintenance and OEM parking.
- Contractors storage.
- Diesel storage.
- Lubricant storage.
- Nitrogen and compressed air storage.
- Equipment parking.
- Workshop area with oil/silt trap.
- Dirty water sump.
- Ablutions facilities.
- Stores
- Administration buildings.
- Refuel bay.
- Water filling point.

- Water treatment plant (RO unit).
- Wastewater treatment plant.
- A Waste Water Treatment (WWT) sump to contain the final sewage effluent.
- A BEP Pollution Control Dam to contain dirty stormwater runoff from the areas as listed above.

The underground ramp area also consists of :

- Mining Caucus area.
- Mine vehicle parking.
- Change house.
- Laundry.
- Admin and ablution.
- Admin parking.
- Open storage area.
- Supply chain stores.
- Contractor construction laydown area.
- Guardhouse and security access point.
- Facilities at access area.

All the above areas are considered clean catchment areas.

As mentioned already, dust suppression requirement for the RoM stockpile area and the haul roads is sourced from the Flood Protection Dam. All internal ramp roads will be dust treated.

3.3 RoM conveyance route options

Various options will be possible to reclaim from the RoM stockpile to transfer the RoM material to the existing processing plant. The options are depicted in Figure 8 and discussed below.

- Conveyor routes A – C (situated on existing opencast pit).
- Conveyor route D (preferred option - situated partially on existing opencast pit).

In addition, option 1 and option 2 are provided for the BEP decline shaft area location as discussed below:

- Decline infrastructure Option 1 (situated on existing opencast pit).
- Decline infrastructure Option 2 (preferred option - situated partially on existing opencast pit).

3.4 Mine Residue Facility (MRF)

The BEP scope also includes a new Mine Residue Facility (MRF). Jones and Wagener have been appointed to undertake the design of the new mine residue facility (MRF) which has its own dedicated stormwater modelling approach. There is a current preliminary report detailing the approach (Jones and Wagener, 2021).

Currently the discard from the processing operation is being sent to the area west of Dam 2 as indicated on Figure 5. The current MRF is a lined area constructed with subsoil drainage. Stormwater from the MRF is collected by a series of toe paddocks and toe paddock cross walls intended to collect runoff from the side slopes of the MRF (Arup (Pty) Ltd., 2017).

Due to the increase in mining activity, a larger MRF will be required. Jones and Wagener has been commissioned by Exxaro to conduct the design of the new MRF. Figure 32 shows the design layout of the MRF expansion as taken from Jones and Wagener, 2021. The discard facilitiy will be designed to accommodate a total capacity of 3.9 Mm^3 of discard and will consist of a North and South stockpile of 16.39 ha and 9.25 ha respectively. Deposition on the new MRF will commence in 2031 on the southern section and will reach full capacity in 2034 whereafter deposition will commence on the northern section until 2039 (Jones & Wagener, 2021).

Figure 3: Layout of the new MRF at the BIP area

The proposed MRF will be constructed on the footprint to pit 5, which will be open cast mined and backfilled prior to construction of the proposed MRF. The facility will not be lined, and a risk-based (source-term-path-receptor) approach will be adopted to confirm that an alternative to the Class C liner requirement will be acceptable for the design. Contaminated seepage from the MRF will report to the pit water make and will be managed as part of the current mine water management system, (Exxaro, 2021).

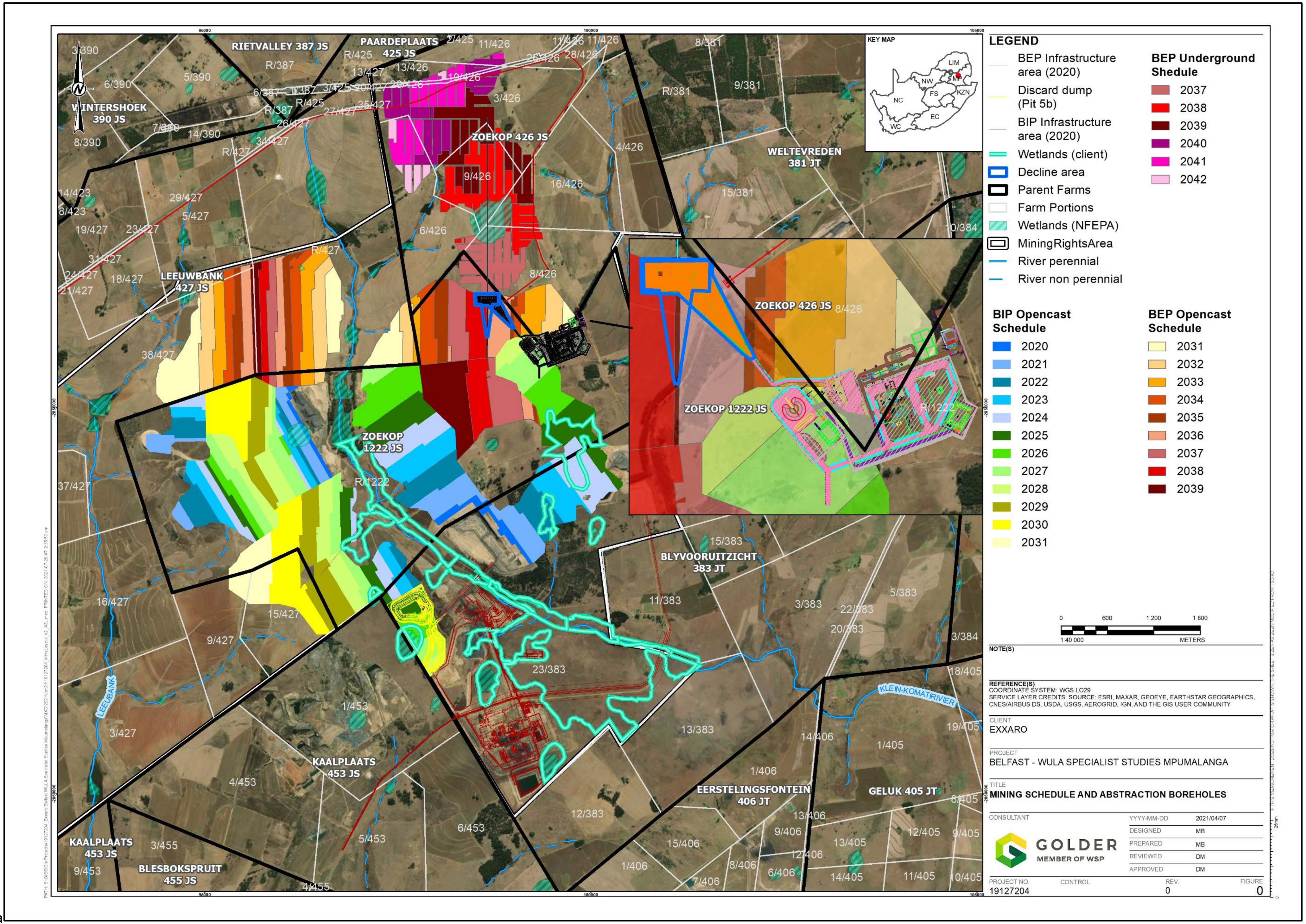

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Figure 4: LoM plan for the BIP and BEP operations

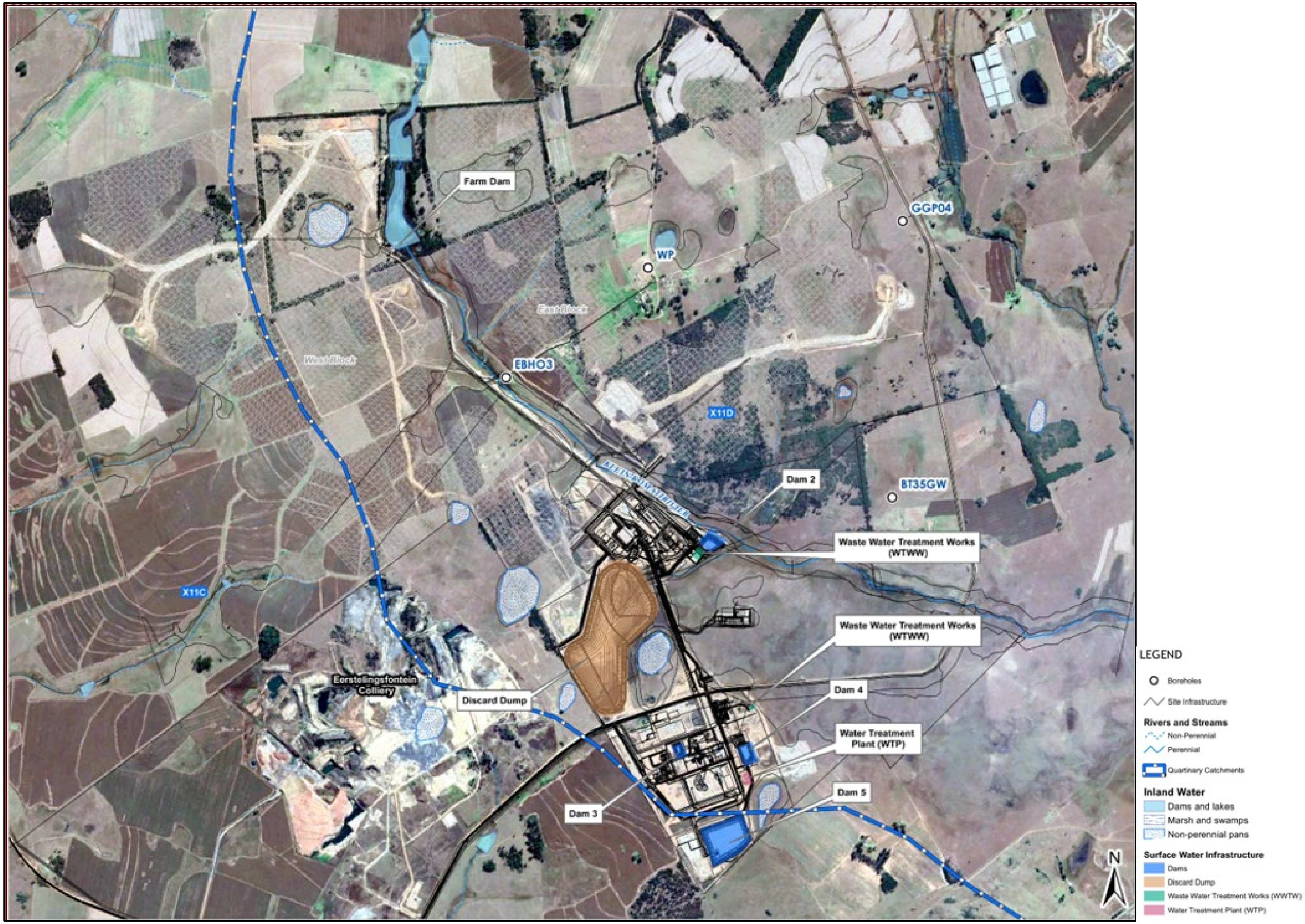


Figure 5: BIP infrastructure layout

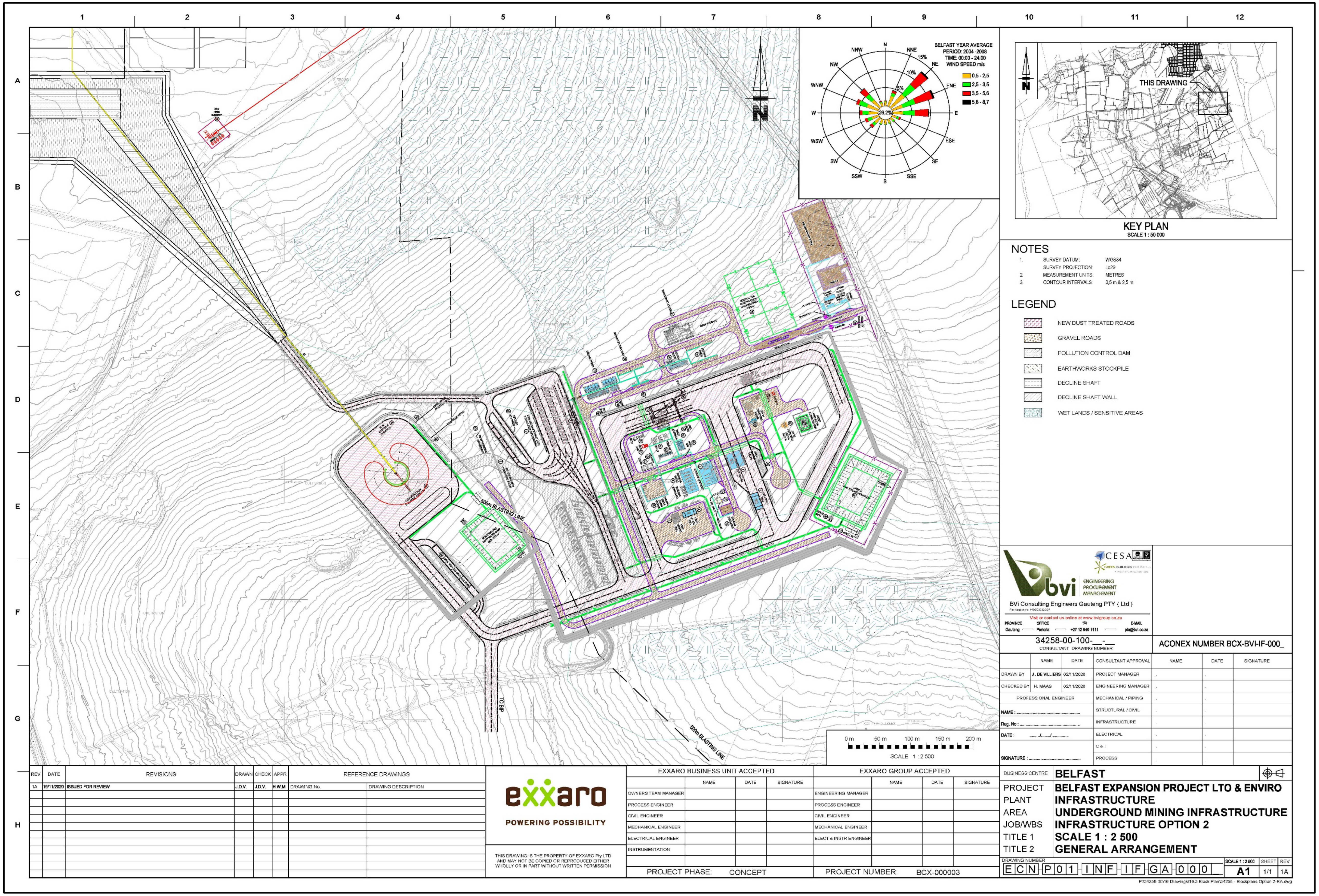


Figure 6: BEP UG Infrastructure

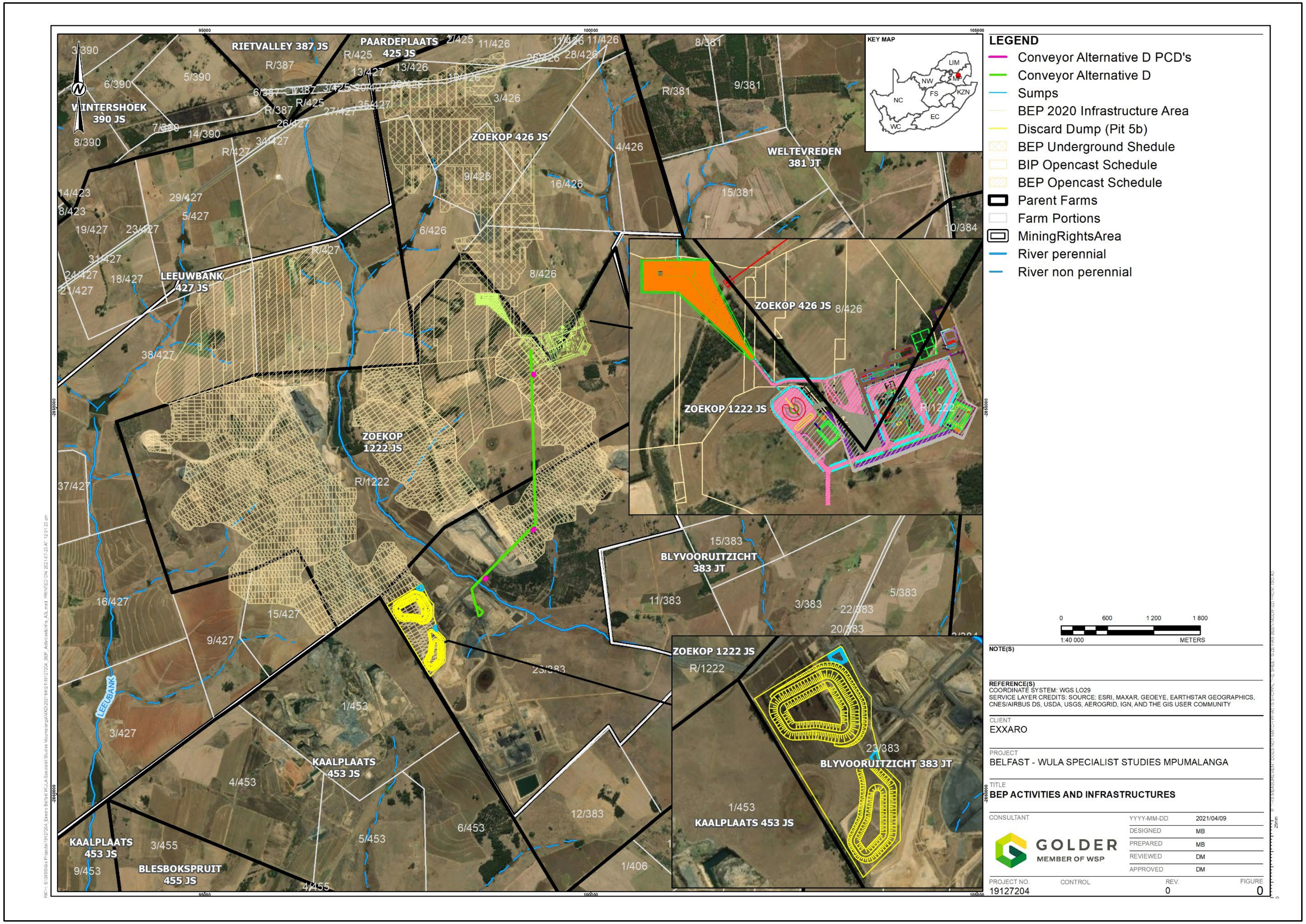


Figure 7: Figure showing the BEP scope of operations

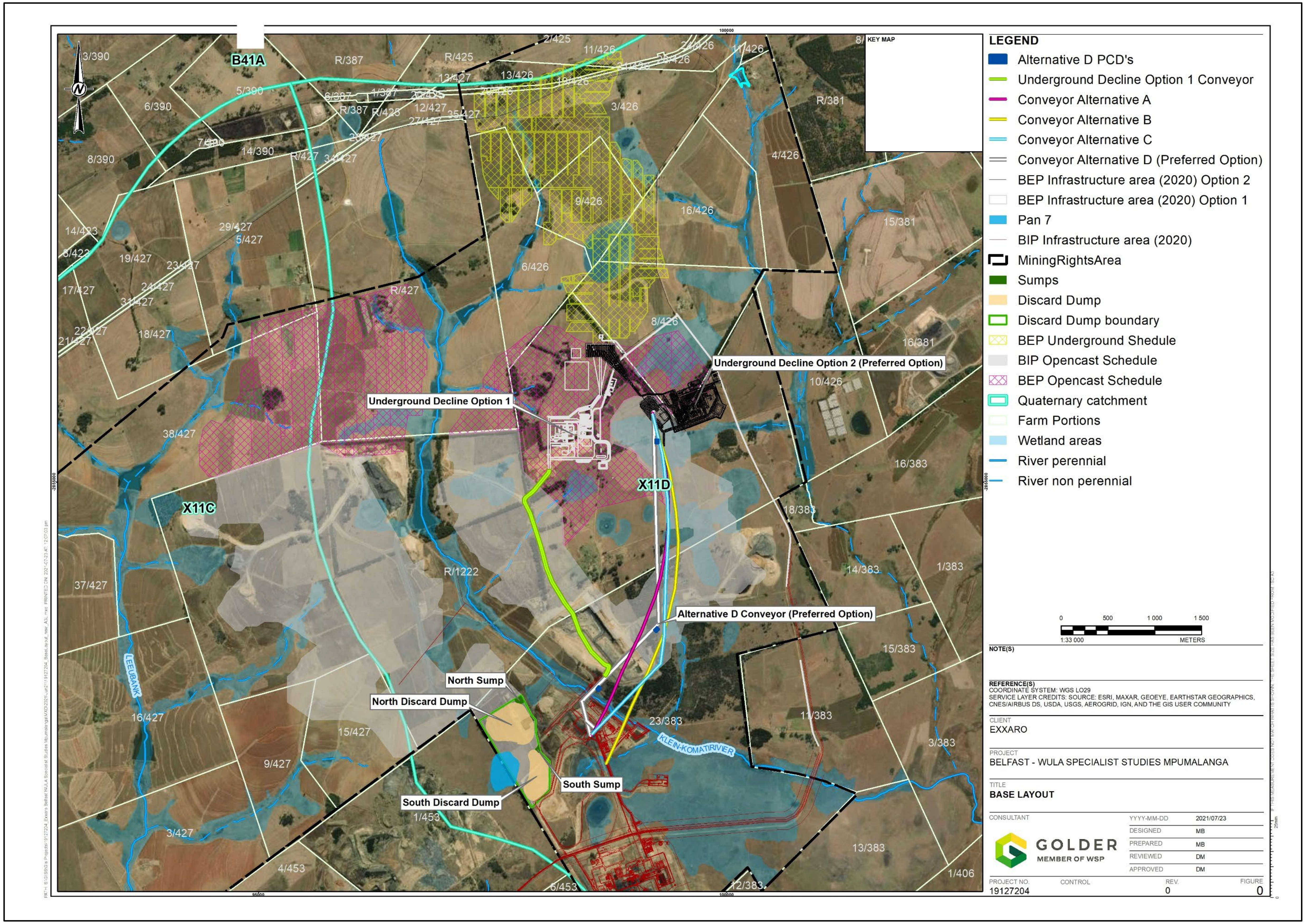


Figure 8: BEP underground and conveyor route options

4.0 CLIMATE ANALYSIS

The climate is typical of the Middelveld to Highveld and representative of the temperate, warm climatic zone. The area receives the majority of rainfall over the summer period, from October to March (Golder, 2011).

Regionally the area is located in the Komati River catchment of Drainage Region X. Locally the area falls over the X11C and the X11D quaternary catchment. The Belfast site is located on the south-western edge of the X11D catchment area, southward of the Klein-Komati River. The X11C quaternary catchment covers an area of 31 942 hectares while the X11D catchment areas has an area of 59 152 ha. The mean annual runoff (MAR) for the X11C and X11D catchments are 45 and 88 mm respectively.

4.1 Rainfall data

4.1.1 Historic rainfall record

Rainfall data for the study area was sourced through the Daily Rainfall Data Extraction Utility (Kunz, 2004). Metadata for the climate stations closest to the study area and with reliable data are provided in Table 2.

Record from Roodepoort rain gauge (No. 0516554), located 18 km away from the mine site, as given in the Computer Centre for Water Resources daily rainfall record database was used. This station was chosen because of its long record and the quality of the record. The daily rainfall record covered the period January 1905 to September 2000. A cumulative plot of the daily record shown in Figure 2 was used to check the record for any anomalies. The plot does not highlight any inconsistencies in the record.

The Mean Annual Precipitation (MAP) in the vicinity of the mine is about 693 mm. About 85% of the yearly rainfall falls in summer (October – March), in the form of showers and thunderstorms, with the maximum precipitation falling in January. The average number of rain days is 55 per year.

Table 2: Properties of the rainfall stations

Station Name	Station No	Distance to site	Latitude	Longitude	Record			Patched Data	Reliability	MAP	Altitude
		km	Degrees	Degrees	Years	From	To	%	%	mm	mamsl
Roodepoort	0516554	17.6	25.734	29.817	97	1905	2000	9.3	79.4	693	1711
Bospoort	0516701 W	16.2			97	1949	1999		43.6	690	1613
Wonderfontein (SKL)	0516708	6.90	25.801	29.901	97	1904	1980	25.8	62.8	679	1794

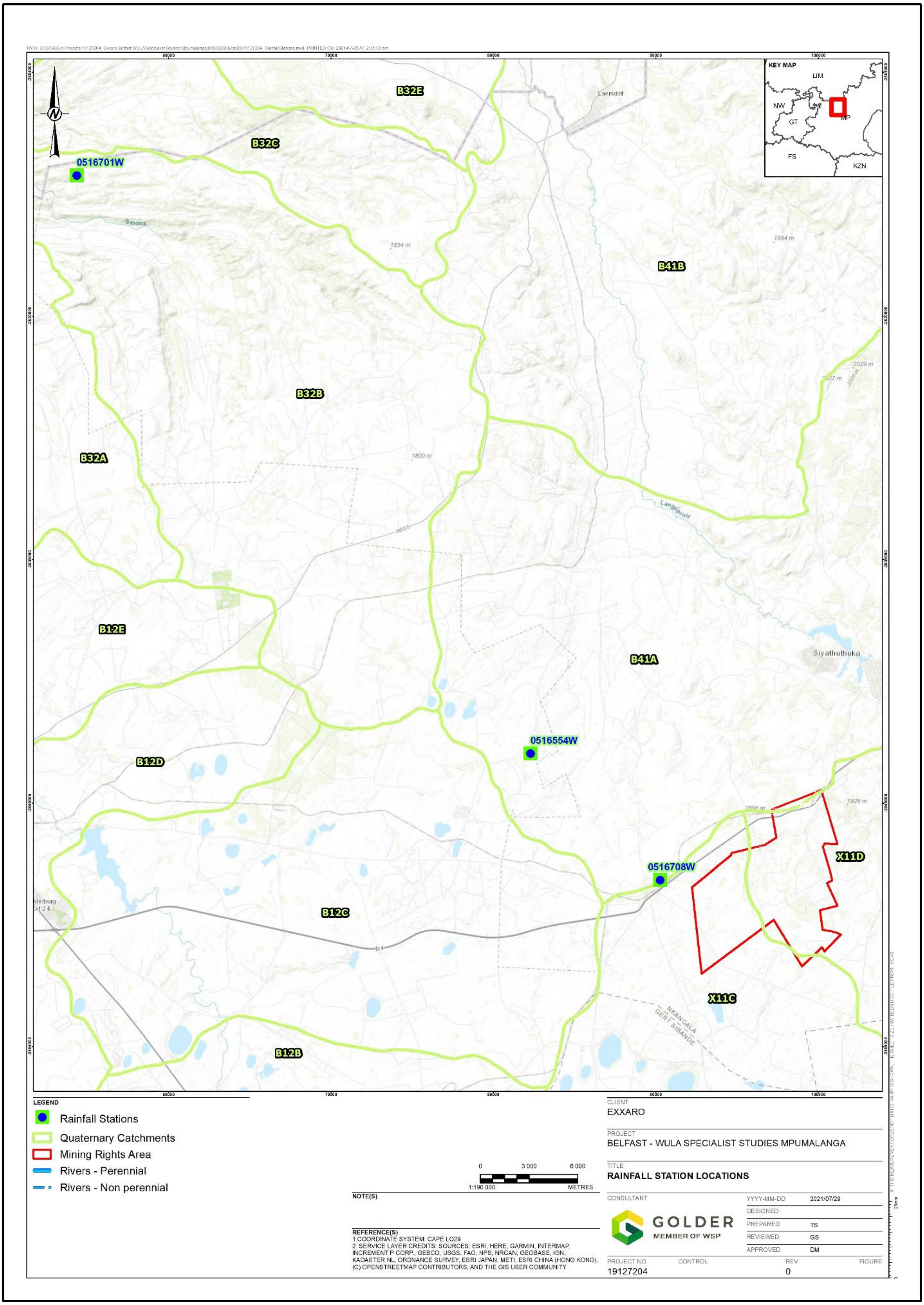
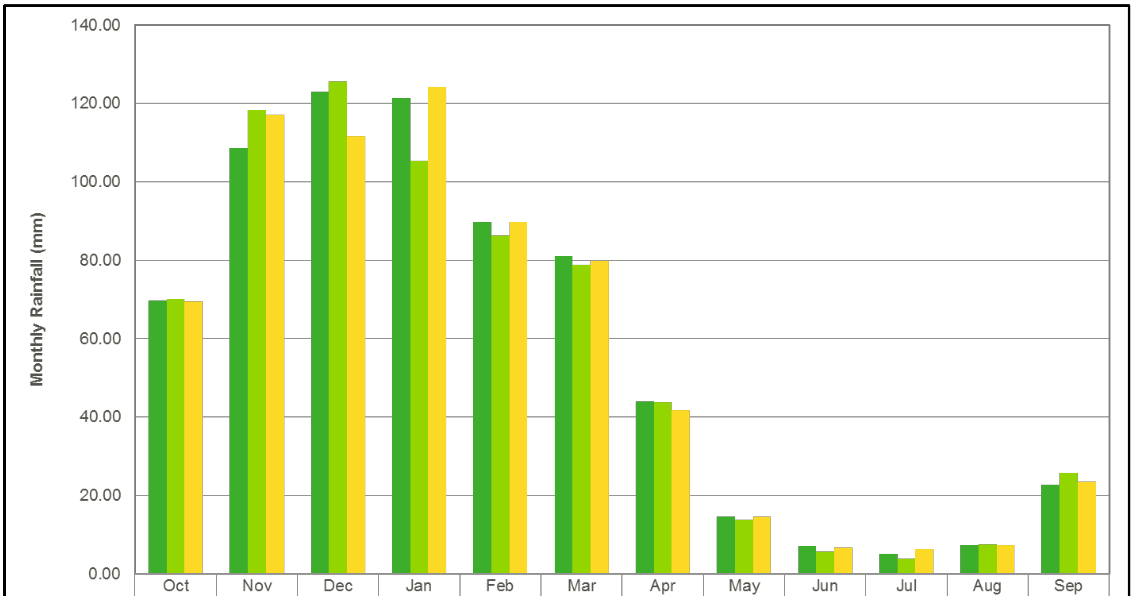


Figure 9: Rainfall stations in the vicinity of the Exxaro Belfast Mine

The data associated with station 0516554 W (Roodepoort) was chosen to be used in the study for the following reasons:

- The rainfall record is over a long duration;
- The station is located close to the site (under 20 km); and
- Data from the Roodepoort station has the least patched data.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0516554W	69.76	108.65	122.97	121.24	89.63	80.96	43.92	14.60	7.04	5.08	7.23	22.77
0516701W	70.02	118.32	125.51	105.30	86.26	78.81	43.77	13.69	5.63	3.89	7.42	25.77
0516708W	69.40	117.07	111.61	124.10	89.72	79.72	41.74	14.60	6.59	6.18	7.28	23.48

Figure 10: Monthly rainfall for the rainfall stations in the vicinity of the Belfast site

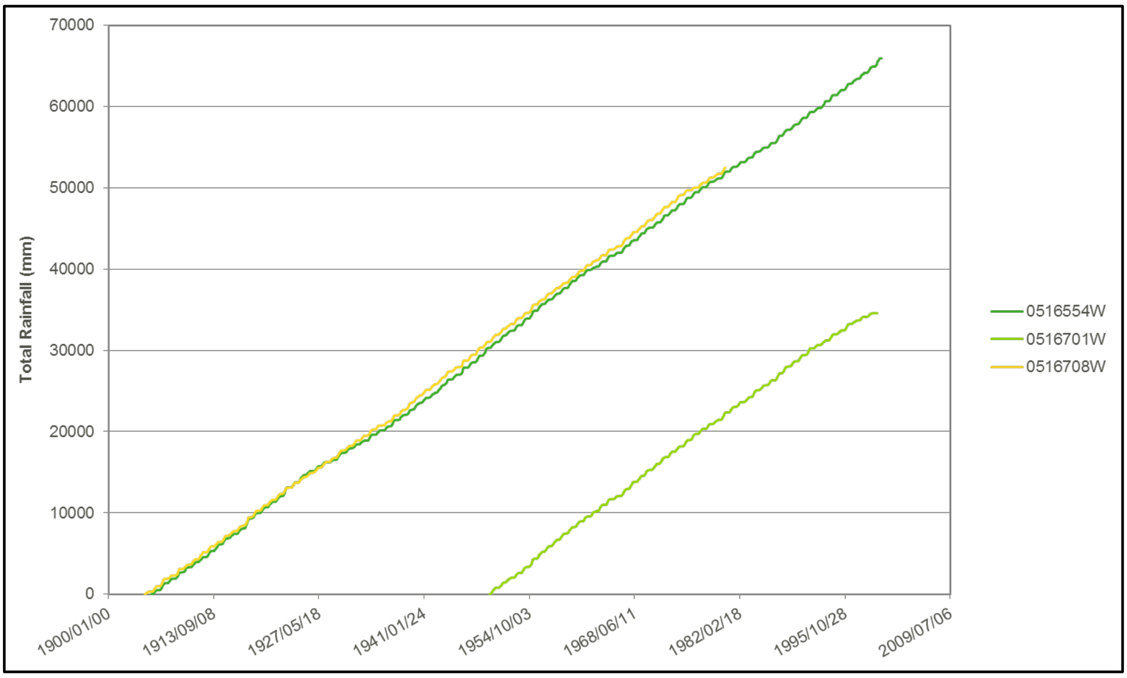


Figure 11: Cumulative rainfall distribution for rainfall stations in the vicinity of the Belfast site

Figure 12, Figure 13, Figure 14, and Figure 15 indicate the daily rainfall record, annual rainfall record, monthly boxplot, and probability of non-exceedance respectively, for the 0516554 W (Roodepoort) rainfall station.

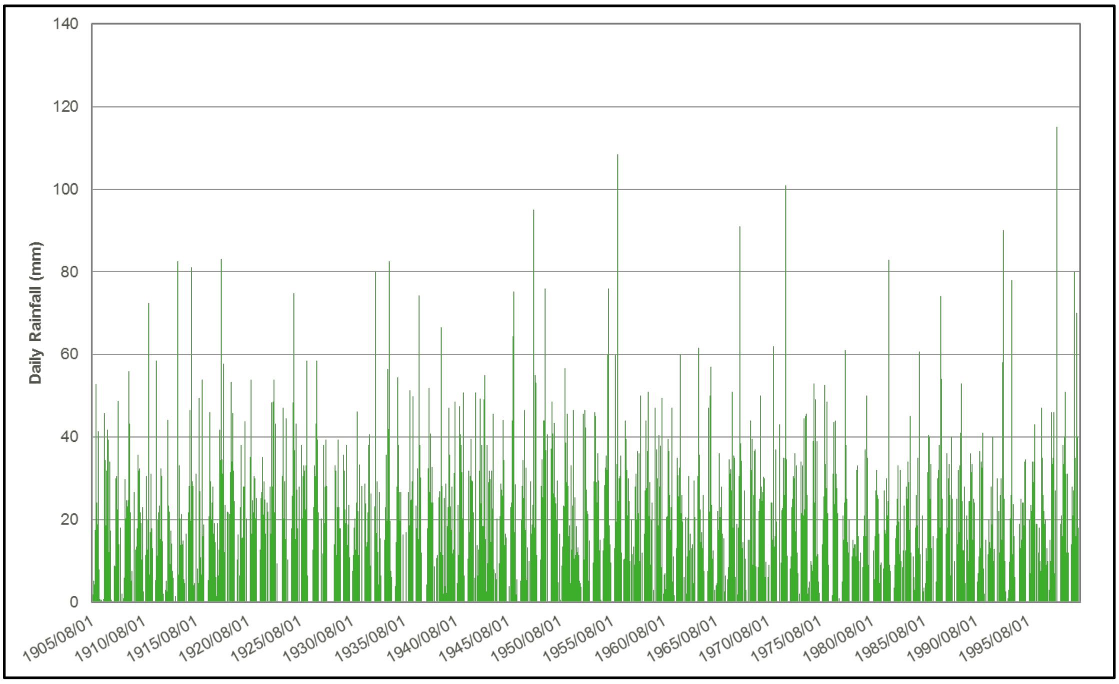


Figure 12: Daily rainfall record for the 0516554 W (Roodepoort) weather station

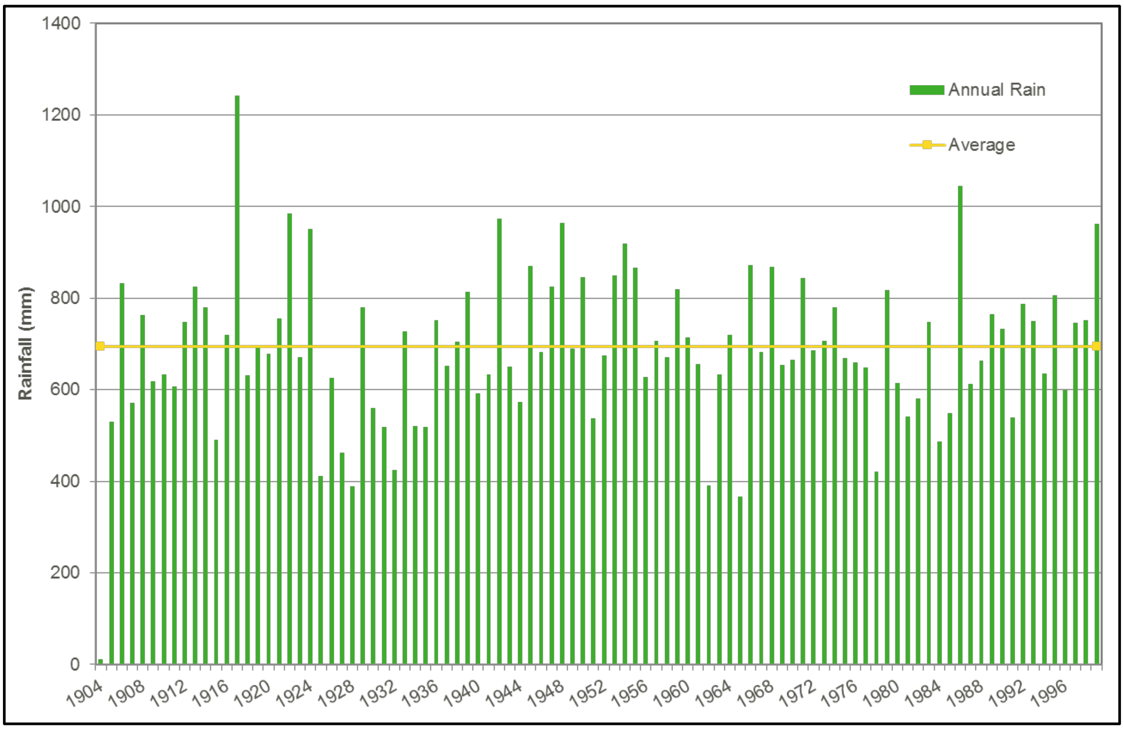


Figure 13: Annual rainfall and Mean Annual Precipitation (MAP) for the 0516554 W (Roodepoort) station

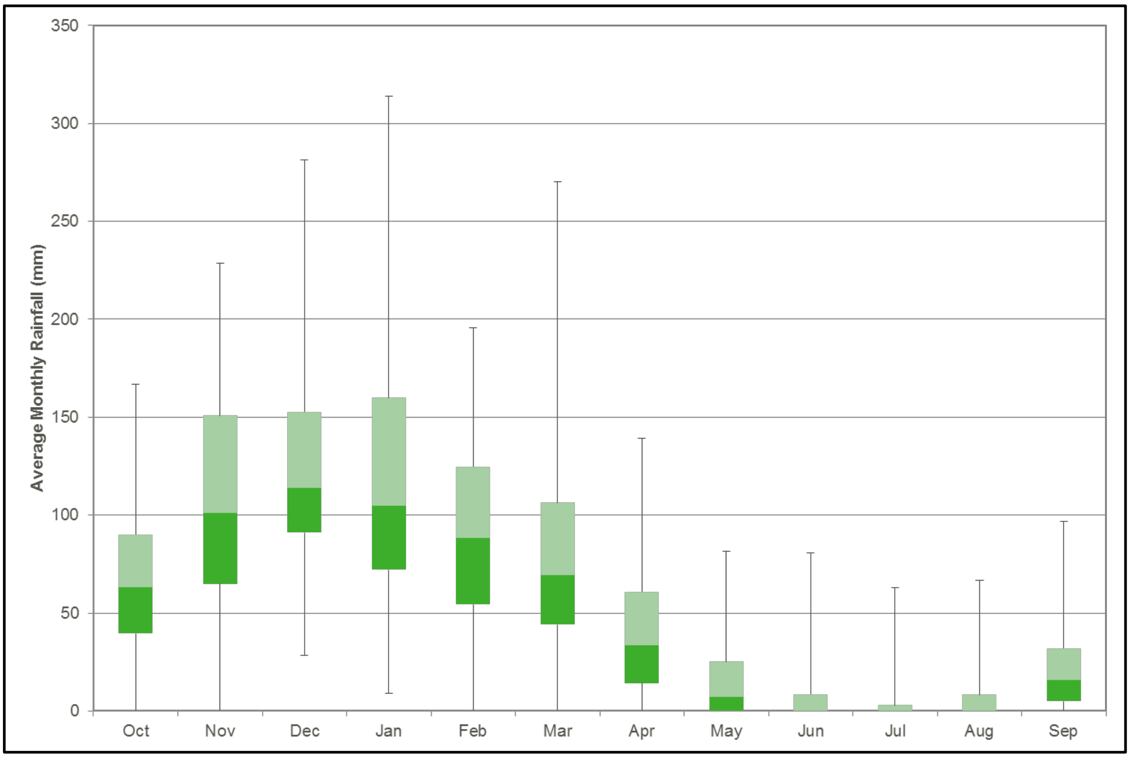


Figure 14: Monthly box plot averages for the 0516554 W (Roodepoort) station

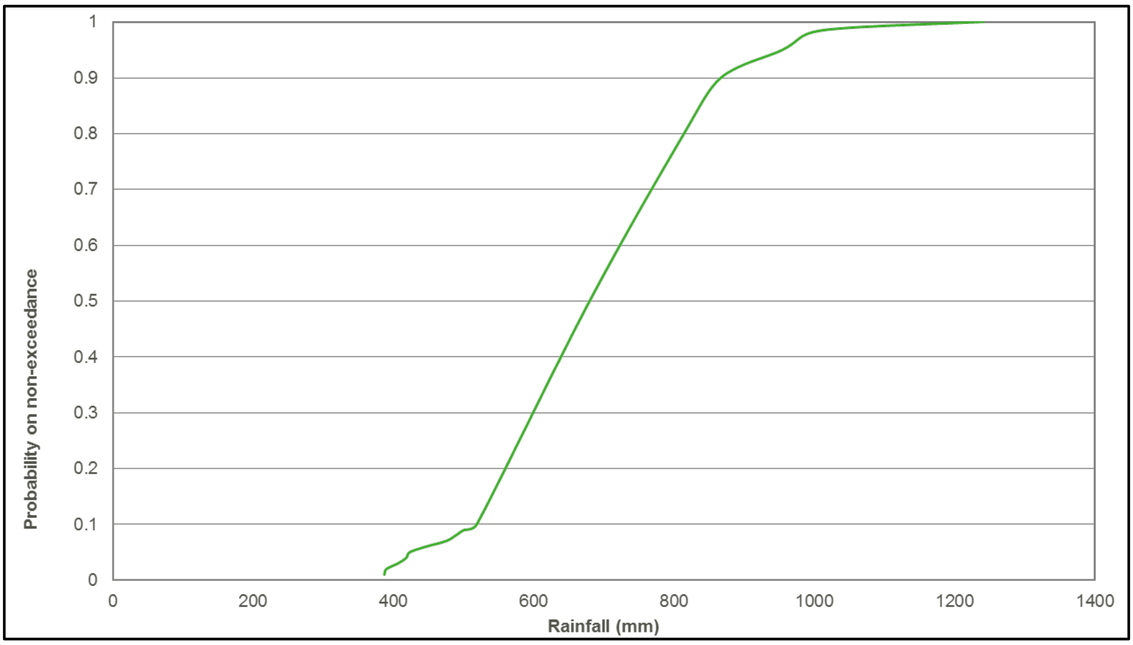


Figure 15: Probability of non-exceedance for the 0516554 W (Roodepoort) station

The highest rainfall year on record was in 1917 with 1241 mm of rain in that year. The average Mean Annual Precipitation (MAP) for the 0516554 W weather station is 693 mm.

The 5, 50 and 95 percentiles of the annual rainfall totals for the rainfall station are presented in Table 3.

Table 3: 5, 50, and 95 percentiles of the annual rainfall totals

Station Number	Station name	5th percentile	50th percentile	95th percentile
0516554 W	Roodepoort	423	680	955

Based on the information in Table 3, the following occurrences can be noted:

- There is a 95% chance that the station will experience an annual rainfall of 423 mm or more;
- There is a 50% chance that the station will experience an annual rainfall of 680 mm or more; and
- There is a 5% chance that the station will experience an annual rainfall of 955 mm or more.

4.1.2 Site Rainfall Record

Site data has been provided by the Exxaro from 25/10/2018 to 16/07/2021. The site rainfall record will be used to calibrate the model. Figure 16 shows the daily site rainfall record and Figure 17 shows the annual assessment.

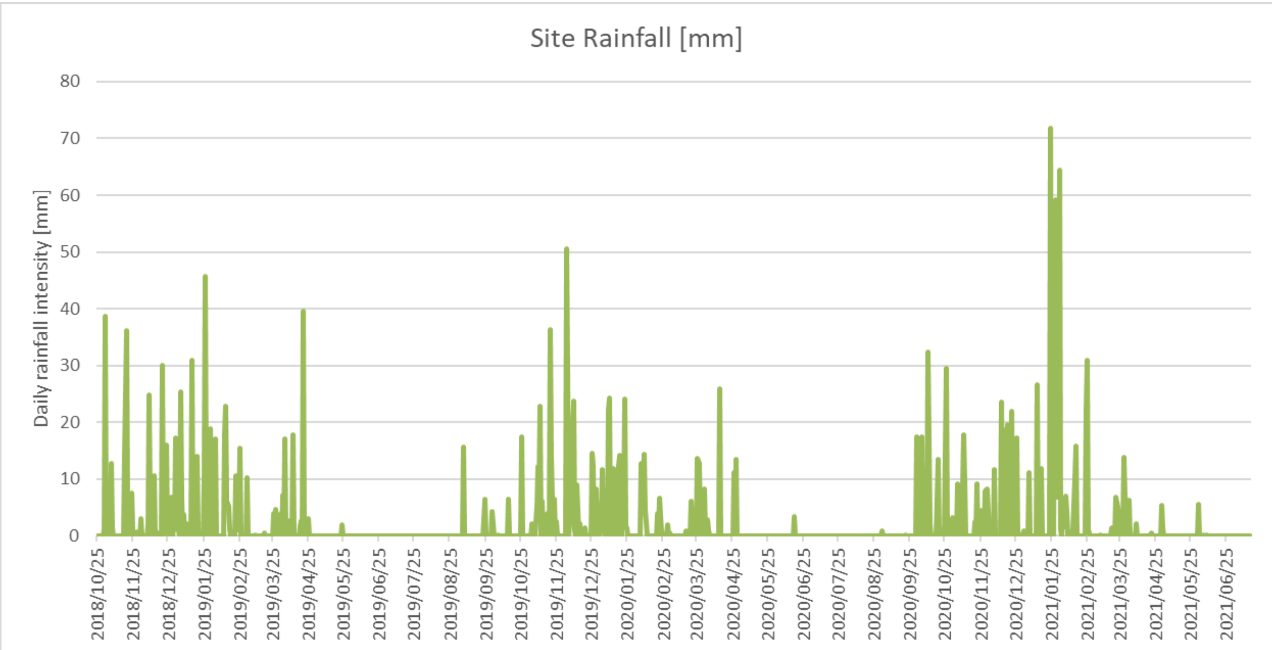


Figure 16: Site rainfall record from 25/10/2018 to 16/07/2021

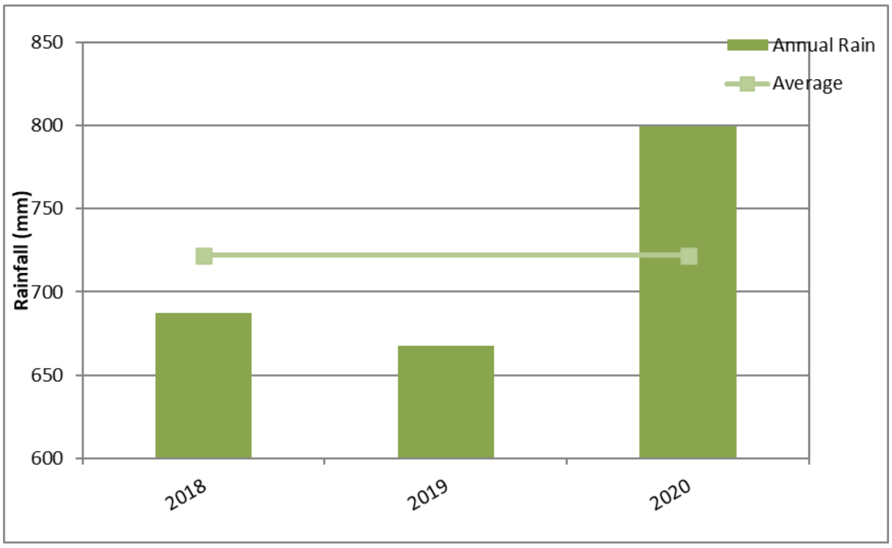


Figure 17: Annual rainfall assessment of site rainfall

4.2 Evaporation

The nearest weather station with a reliable evaporation dataset near the Belfast site is Station X1E003, located at the Nooitgedacht Dam. The station is 16.6 km away from the Belfast Mine. The station's Mean Annual Evaporation (MAE) is 1812 mm per annum (S-Pan). The length of record is from 1961 to 1980 (19 years). The average monthly evaporation for X1E003 is presented in Figure 17. Figure 17 also includes the average monthly rainfall from station 0516554 W.

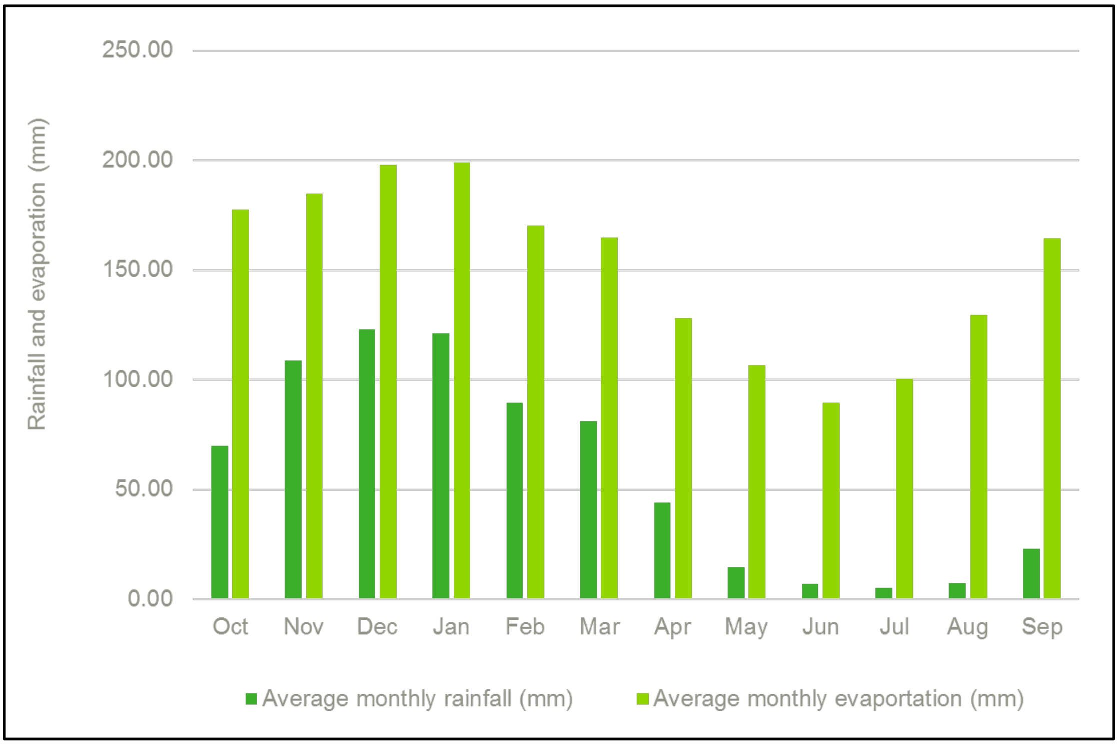


Figure 18: Comparison between the average monthly rainfall (Station 0516554 W) and evaporation (Station X2E002) in the area

4.3 Storm Events Recurrence Intervals

The 24-hour rainfall depths for the 1 in 2, 1 in 5, 1 in 10, 1 in 20, 1 in 50, 1 in 100 and 1 in 200 recurrence interval storms at the 0516554W rain station were calculated from the data available. The maximum 24-hour rainfall depth for each year was selected and plotted using various statistical distributions in order to determine the different recurrence interval daily rainfall depths. The best fit was found to be the Log Pearson Type III distribution which resulted in the storm rainfall depths summarized in Table 4.

Table 4: Recurrence intervals for 0516554W Rain Station

Recurrence Interval (years)	1:2	1:5	1:10	1:20	1:25	1:50	1:100	1:200	1:500	1:1000
Rainfall depth (mm)	52	67	79	90	94	106	118	132	151	166

4.4 Stochastic climate modelling

The mine water management system needs to be assessed under different rainfall sequences. A stochastic rainfall generator allows different sequences of daily rainfall to be generated within the model to determine the probability of spill and failure of supply for a particular water management strategy.

The stochastic rainfall generator should be able to reproduce key statistical characteristics of historic records at not only a daily level but also monthly and annual levels. A daily time step stochastic rainfall generator (Boughton, 1999) was included in the model. The parameters of the stochastic model are determined by fitting the model to a measured daily rainfall record considered to be representative of the area.

The stochastic rainfall generator is based on historical rainfall data and does not take the effects of climate change into account. The total annual precipitation probability of exceedance curves for the actual recorded data as well as the simulated sequences are provided in Figure 18 below. This graph indicates a good fit and thus a good calibration of the simulator.

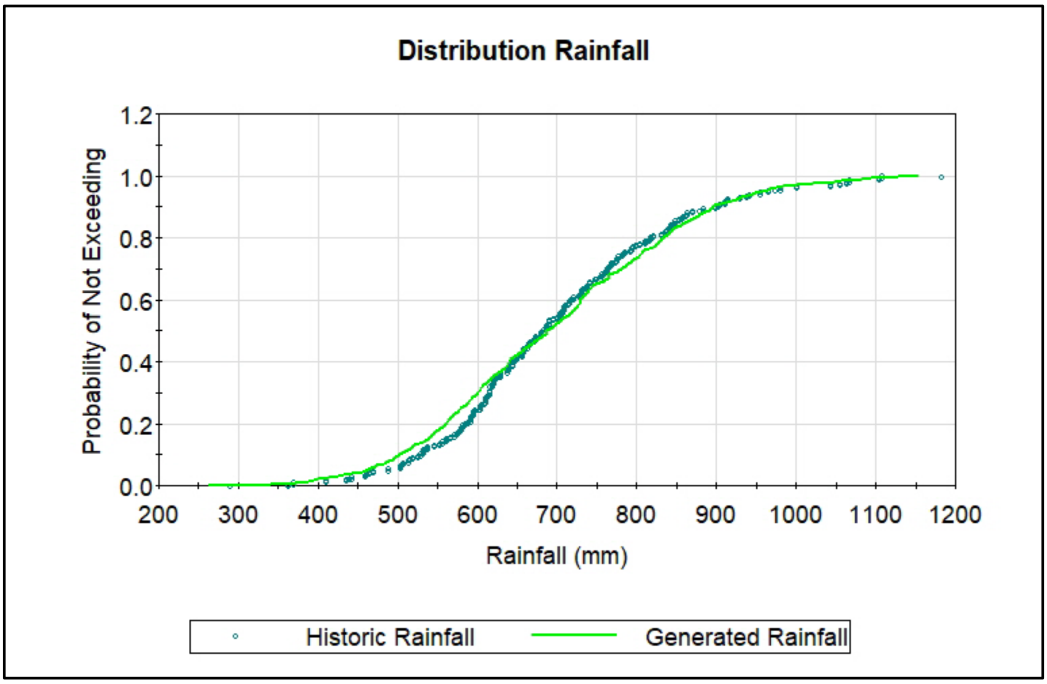


Figure 19: Annual Rainfall - Probability of Exceedance (Recorded vs. Simulated)

Long-term rainfall projections

In order to conduct post closure assessment, the water balance model will need to be run into the future scenarios. Sometimes decant management is required more than 50 years post-closure, therefore the stochastic rainfall model was run for 150 years into the future (2019 to 2170) to ensure that the stochastic climate module within GoldSim will be able to accurately simulate rainfall conditions into the future.

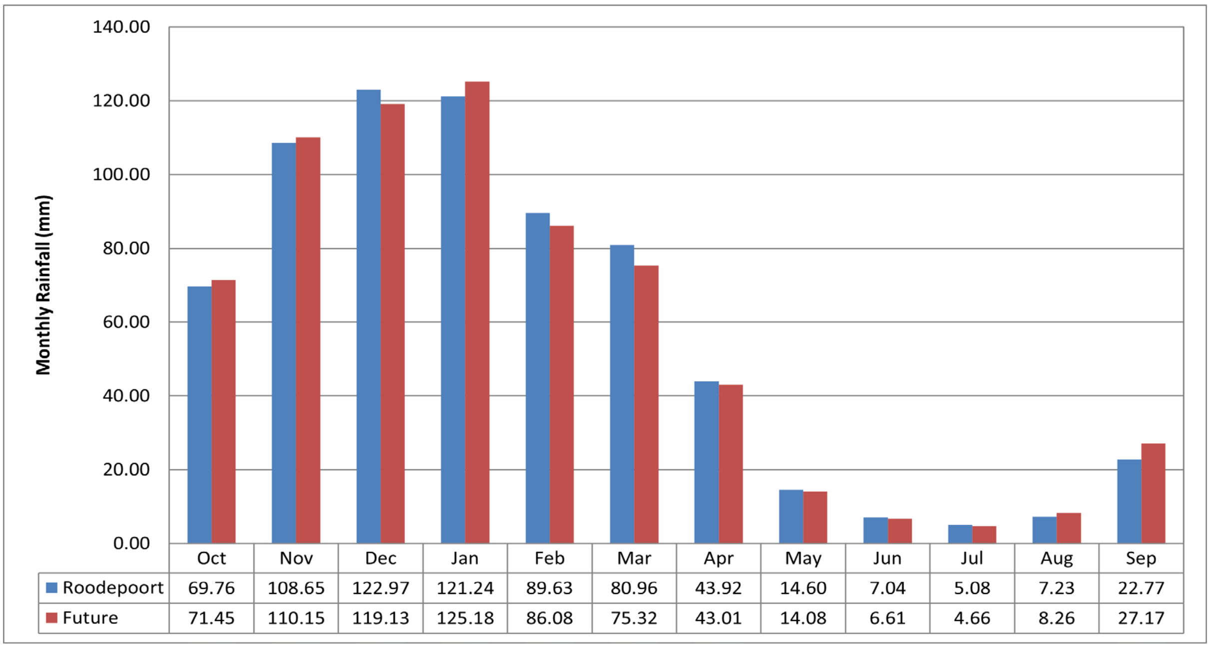


Figure 20: Monthly rainfall comparison between historical rainfall data and project rainfall data

The model allows the user to apply specific types of rainfall sequences to determine the system response during, for example, a wet year. These rainfall year types have been classified according to the percentile groups provided in Table 5.

Table 5: Annual Rainfall Percentiles

Rainfall Year Description	Percentile Ranges	Annual Rainfall Range (mm)	Annual Projected Rainfall Range (mm)
Very Wet	>90th	> 867	> 863
Fairly Wet	70th – 90th	753 - 867	767 - 863
Average Wet	50th – 70th	680 - 753	685 - 767
Average	40th – 60th	654 - 718	646 - 734
Average Dry	30th – 50th	627 - 680	609 - 685
Fairly Dry	10th – 30th	519 - 627	517 - 609
Very Dry	<10th	<519	<517

4.5 Southern Oscillation Index (SOI)

The Southern Oscillation Index (SOI) is the measure of the intensity of strength of the Walker Circulation. The Walker Circulation is one of the key atmospheric indices for gauging the strength of El Niño and La Niña events and their potential impact.

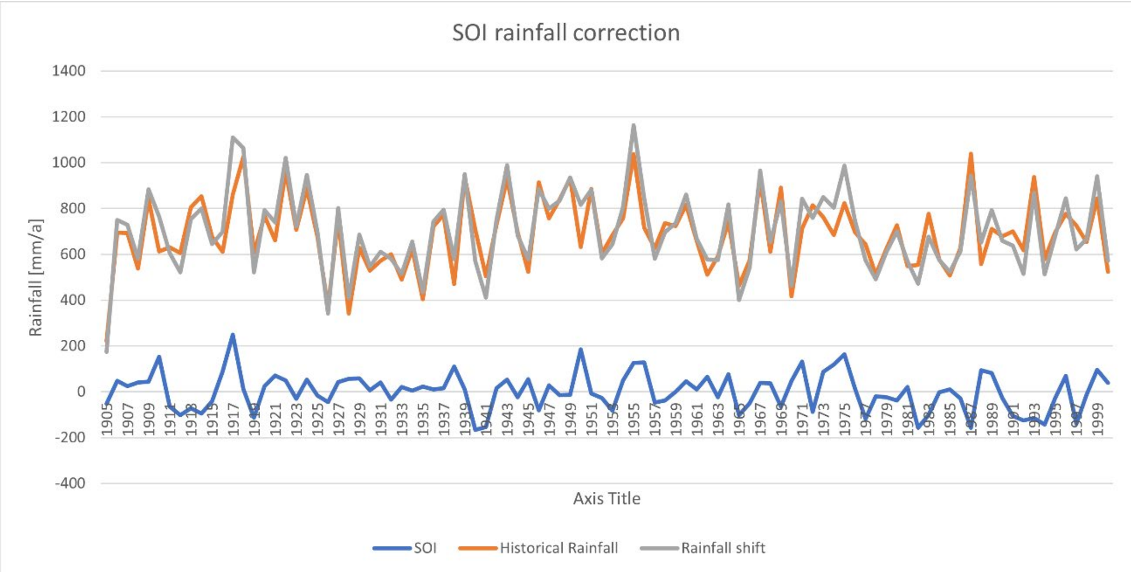


Figure 21: Graph showing the correction of the historical rainfall for SOI factors

The model conducts scenarios to evaluate the impact on the SOI effect on relevant facilities.

4.6 Climate change

Climate change is an important consideration for mining operations worldwide. The impact on water resources and water management facilities due to climate change must be assessed in order to manage and mitigate future and latent risks. Climate change will therefore be included in the water balance modelling for the BIP and BEP operation as a separate scenario to understand potential risks to future water supply as well as to help with the management and design of water infrastructure on site.

4.6.1 Greenhouse gas scenarios

The future of anthropogenic greenhouse gas and aerosol emissions is highly uncertain, encompassing substantial unknowns in population and economic growth, technological developments and transfer, and political and social changes.

The climate modelling community has developed Representative Concentration Pathways (RCPs) to explore possible future options. Climate change projections are derived from climate models driven by the RCPs (www.climatechangeinaustralia.gov.au).

Figure 22 show emissions and concentrations of carbon dioxide associated with various RCPs. These provide a range of options for decision making. RCPs are prescribed pathways for greenhouse gas and aerosol concentrations, together with land use change, that are consistent with a set of broad climate outcomes used defined by the climate modelling community. No RCP is deemed more likely than the others, however, some require major and rapid change to emissions to be achieved.

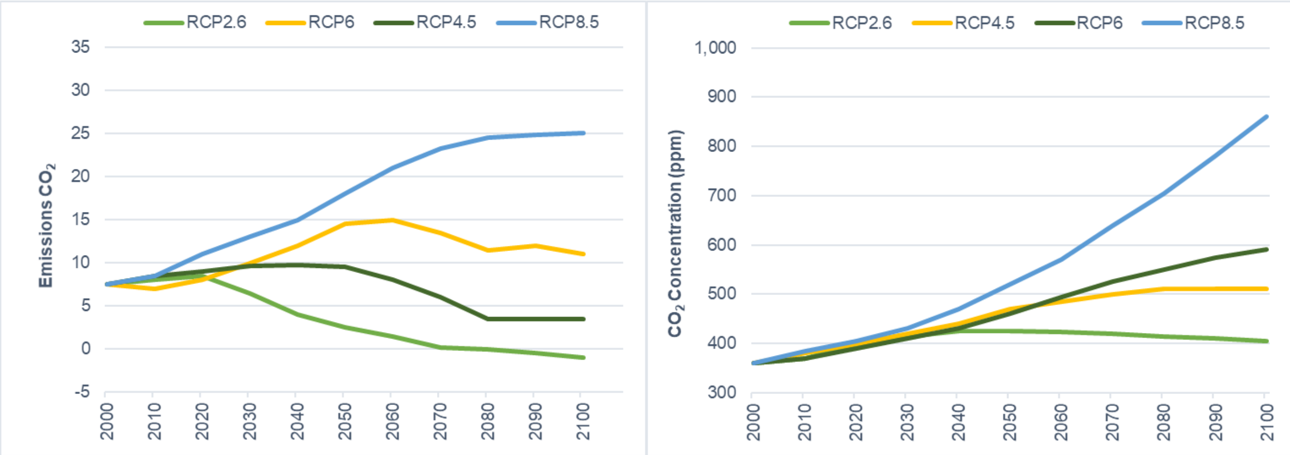


Figure 22: Emissions of CO_2 across the RCPs (left), and trends in concentrations of carbon dioxide (right). Source: van Vuuren et. al. (The representative concentration pathways: an overview. , 2011).

Four RCPs are defined as follows:

- RCP8.5 - a future with little curbing of emissions, with a CO_2 concentration continuing to rapidly rise, reaching 940 ppm by 2100.
- RCP6.0 – lower emissions, achieved by application of some mitigation strategies and technologies. CO_2 concentration rising less rapidly (than RCP8.5), but still reaching 660 ppm by 2100.
- RCP4.5 - CO_2 concentrations are slightly above those of RCP6.0 until after mid-century, but emissions peak earlier (around 2040), and the CO_2 concentration reaches 540 ppm by 2100.
- RCP2.6 - the most ambitious mitigation scenario, with emissions peaking early in the century (around 2020), then rapidly declining. Such a pathway would require early participation from all emitters, including developing countries, as well as the application of technologies for actively removing carbon dioxide from the atmosphere.

4.6.2 CSIR Climate Change study

A study has been conducted by the CSIR that investigates the future projection of Climate Change over the North Easter South Africa (CSIR, 2017). This section will therefore discuss the basis of the study and the results from the study. The region under discussion in this study includes the Exxaro operations and therefore is applicable to the BIP and BEP operation.

Climate change has a high risk for South African due to the low mitigation futures and the lack of planning. Climate change impact is projected to result in rapid rise in temperatures to 1.5 to 2 times the global rate of temperature increase. In South Africa specifically, as high as 2 to 3° C per century rise has been recorded over the period from 1961 until 2010 (CSIR, 2017).

CSIR, 2017, utilised the most recent down scalings of global circulation model (GMC) projects of the Coupled Model Intercomparison Project Phase 5 (CMIP5) and Assessment Report Fie (AR5) of the Intergovernmental on Climate Change (IPCC). The downscaling was conducted for the period from 1961 to 2100 and follows the experimental design recommended by the \\coordinated Downscaling Experiment (CORDEX) and has been developed for both the low and high mitigation scenarios.

The downscaling was conducted for the RCP4.5 and RCP8.5 emission scenarios first to a 50 km resolution and then to an 8 km resolution for a domain covering about 2 000 x 2 000 km^2.

Summary of study results

Temperature

The study showed that the coolest conditions occur over the Mpumalanga escarpment in the south-eastern part of the domain with low temperatures also over the Waterberg, north of Gauteng. The hottest regions are the Limpopo River basin and the Lowveld of Limpopo and Mpumalanga. The following are relevant in terms of projected temperature:

- Rapid temperature rises to the annual average near surface temperatures are projected to occur over Southern Africa during the 21st century with temperature over the South African interior projected to rise at about 1.5 to 2 times the global rate of temperature increase.
- For the period 2021 – 2050 as compared to the period 1961 – 1990, temperature increases of 2°C to 3°C are plausible over the north-eastern South Africa with larger temperature increases of up to 3°C expected over the western parts. This is under the low mitigation scenario.
- Under the modest high mitigation scenario, temperature increase over South Africa will be less but could reach 3°C over the western parts of north-eastern South Africa.
- For the period 2071 – 2100 as compared to the period 1961 – 1990, temperature increases of 4°C are likely across north-eastern South Africa and could exceed 6°C over the western parts. This is under the low mitigation scenario. For the high mitigation scenario, temperature increases may be significantly reduced to less than 3°C even over the interior.

Rainfall

The study results show a pronounced south-north rainfall gradient over the region with maximum rainfall projected to occur in the southeast over the Mpumalanga escarpment and in the northeast over the Soutpansberg region. A dry area stretches from Botswana into the Limpopo River basin. The following are relevant in terms of projected temperature:

- A general decrease in rainfall is plausible over Southern Africa under enhanced anthropogenic forcing.
- For the period 2021 – 2050 as compared to the period 1971 – 2000, rainfall is projected to decrease for the north-eastern South Africa with increases projected over the far south western parts. This is for the low mitigation scenario.
- Under the modes-high mitigation scenario, the rainfall projection patterns are similar to that of the low mitigation scenario. General reductions in rainfall are projected except over the western parts of the regions, where increases in rainfall are projected to be more likely than for the case of low mitigation.
- For the period 2071 – 2100 as compared to the period 1961 – 1990, a decrease in rainfall is projected across the north-eastern South Africa. This is for the low mitigation scenario.
- For the high mitigation scenario, the projection indicates wetting of the western parts of the regions with prediction of a minority of the modelling showing extension of this wetting over the eastern parts

The rainfall projections display more uncertainty than the temperature projections. Therefore, it is imperative to consider the plausibility of a range of scenarios. Infact, extreme rainfall scenarios must be evaluated.

4.6.3 Climate Change Projection Data

Golder has acquired 64-years (2006 – 2070) of daily climate change projection data (namely precipitation and evaporation) from the ESGF (2020) website. In order to attain the highest resolution data possible, data from the Coordinated Regional Climate Downscaling Experiment (CORDEX) was used. CORDEX provides Regional Climate Model (RCM) data which has already been downscaled from a coarser resolution Global

Circulation Model (GCM). CORDEX data was also chosen as it uses forcing data from the 5th Coupled Model Intercomparison Project (CMIP5) (CORDEX, 2020). This means that it accounts for a range of models, which significantly reduces model error.

IPCC (2014) have adopted four possible future climate change scenarios called 'Resolution Concentration Pathways (RCPs)', these are RCP2.6, RCP4.5, RCP6.0, and RCP8.5. Each scenario describes a different climate future depending on greenhouse gas (GHG) emissions and land use. Due to the unlikelihood associated with RCP2.6 and RCP8.5 scenarios (IPCC, 2014; Carbon Brief, 2019; Hausfather and Peters, 2020), Golder decided to use an intermediate RCP scenario. As data for RCP6.0 was unavailable, data for RCP4.5 was sourced. The dataset considered is for CORDEX's Africa domain, which covers the whole of the African Continent. The data has a spatial resolution of approximately 50 km, and data for the grid in which the Site is located was downloaded. The bottom left corner of the grid is located at -25.92°N 29.92°E.

The 2006 – 2070 climate change projection data acquired was split into a 'control' period (2006 – 2020) and a 'future' period (2020 – 2070). Mean precipitation and evaporation data for the two periods are presented in Table 6 and Table 7, and in Table 8 and Table 9, respectively. These data indicate small changes in mean monthly and annual totals for both precipitation and evaporation.

Table 6: Climate Change Projection Data - Mean Precipitation (mm)

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Control	196.3	163.4	156.8	113.0	50.4	7.6	9.5	14.1	17.2	94.8	175.9	195.6	1189
Future	201.3	165.0	149.9	101.0	70.0	22.1	7.1	12.1	26.6	116.1	176.9	208.8	1253

Table 7: Climate Change Projection Data - Mean Number of Days with Precipitation

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Control	26	23	25	22	16	7	5	7	9	20	25	26	211
Future	26	22	24	24	15	9	6	9	9	21	24	26	215

Table 8: Climate Change Projection Data - Mean Evaporation (mm)

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Control	118.8	100.0	92.5	69.6	55.9	40.3	40.9	45.6	43.0	72.6	100.7	114.1	895.2
Future	120.0	104.2	93.4	72.0	56.0	41.7	41.6	49.4	48.9	81.9	103.5	117.4	927.5

Table 9: Climate Change Projection Data - Mean Number of Days with Evaporation > 2 mm

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Control	28	26	26	21	9	1	0	4	7	19	26	27	195
Future	28	26	26	22	11	1	1	7	9	22	26	28	207

Quantile plots of daily precipitation and evaporation for these periods are presented in Figure 23 and Figure 24, respectively. As seen for both parameters, the differences in the quantile plots for the control and future period data are small indicating that the cumulative frequency distribution remains relatively constant over time.

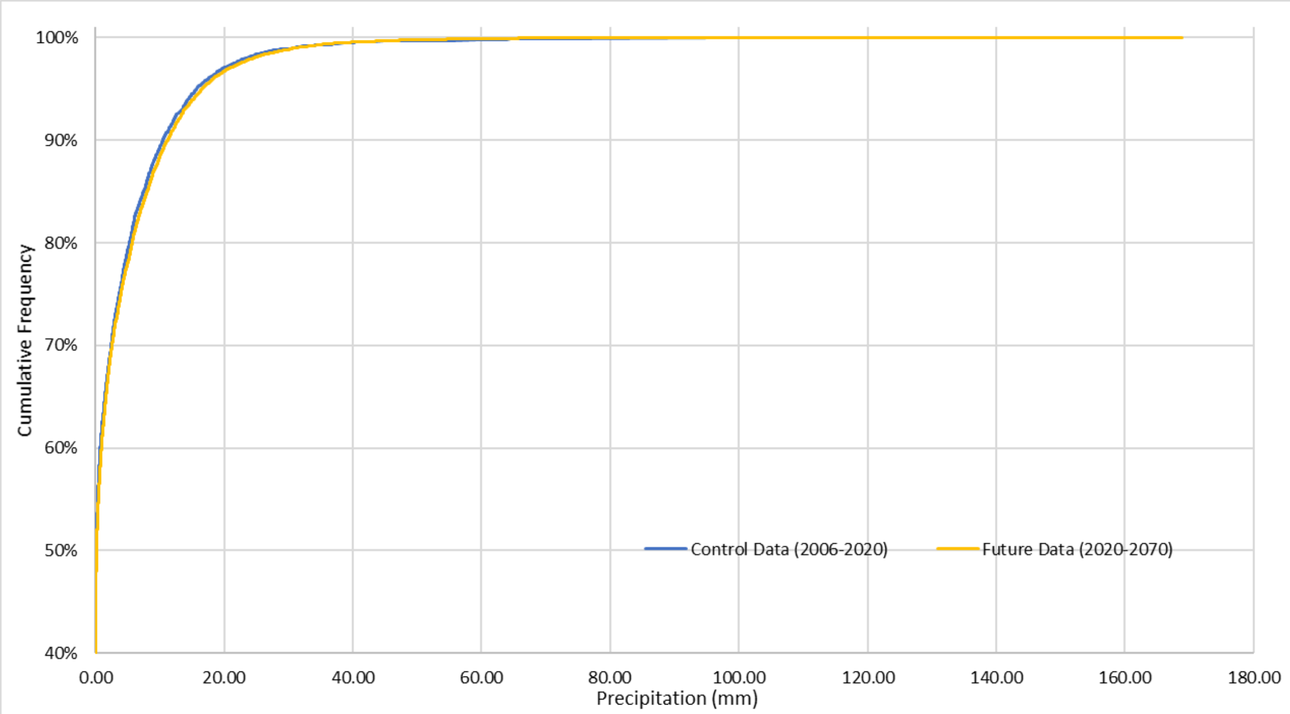


Figure 23: Quantile Plot of Control Period and Future Precipitation

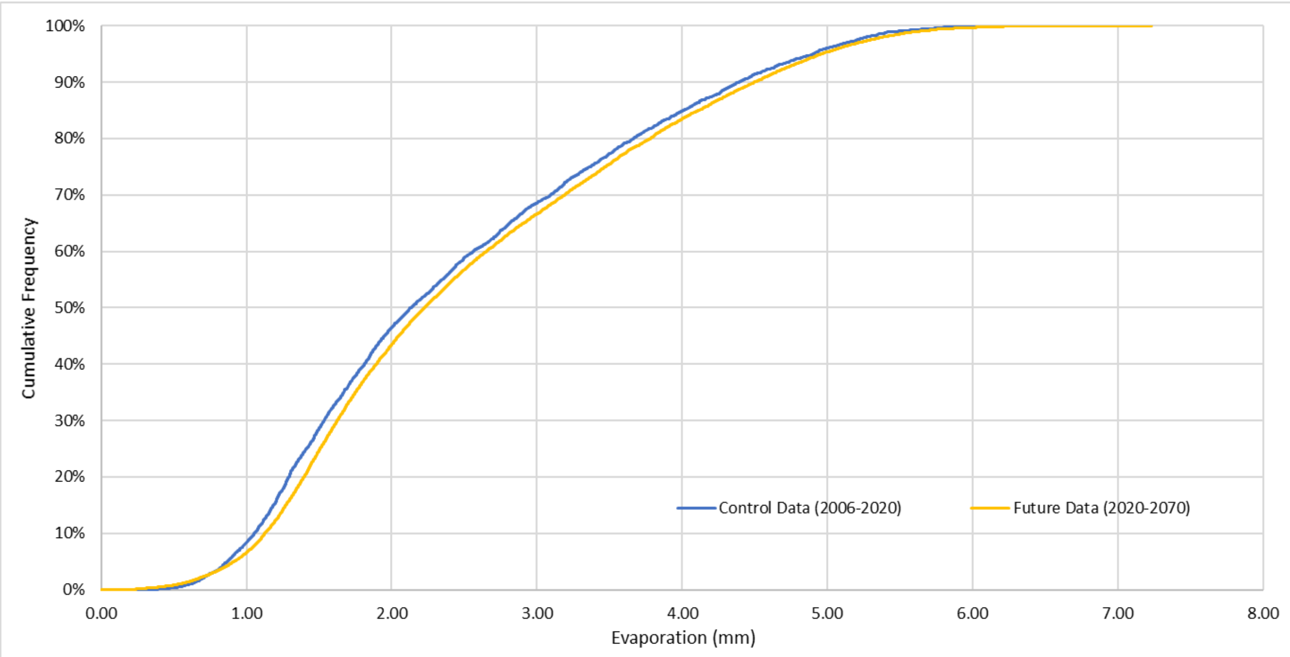


Figure 24: Quantile Plot of Control Period and Future Evaporation

Corrected Climate Change Projection Data

Control Period, 2006 to 2020

Comparison of the mean historic climate data) to the 2006 - 2020 mean uncorrected climate change projection data (Table 6 through Table 9) indicates significant differences in precipitation and evaporation. Quantile plots of the historic climate data and the uncorrected control climate change projection data are compared in Figure 25 (precipitation) and Figure 26 (evaporation) and show similar differences.

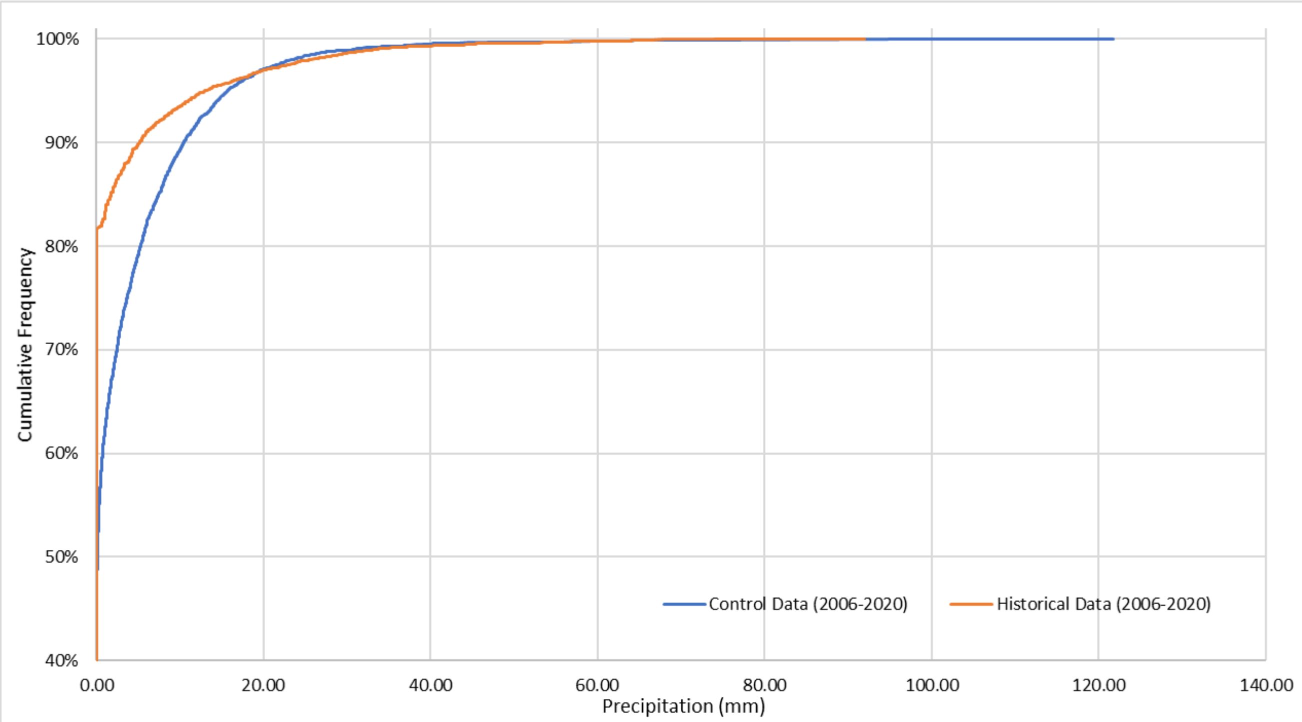


Figure 25: Quantile Plot of Uncorrected Control Period and Historic Precipitation

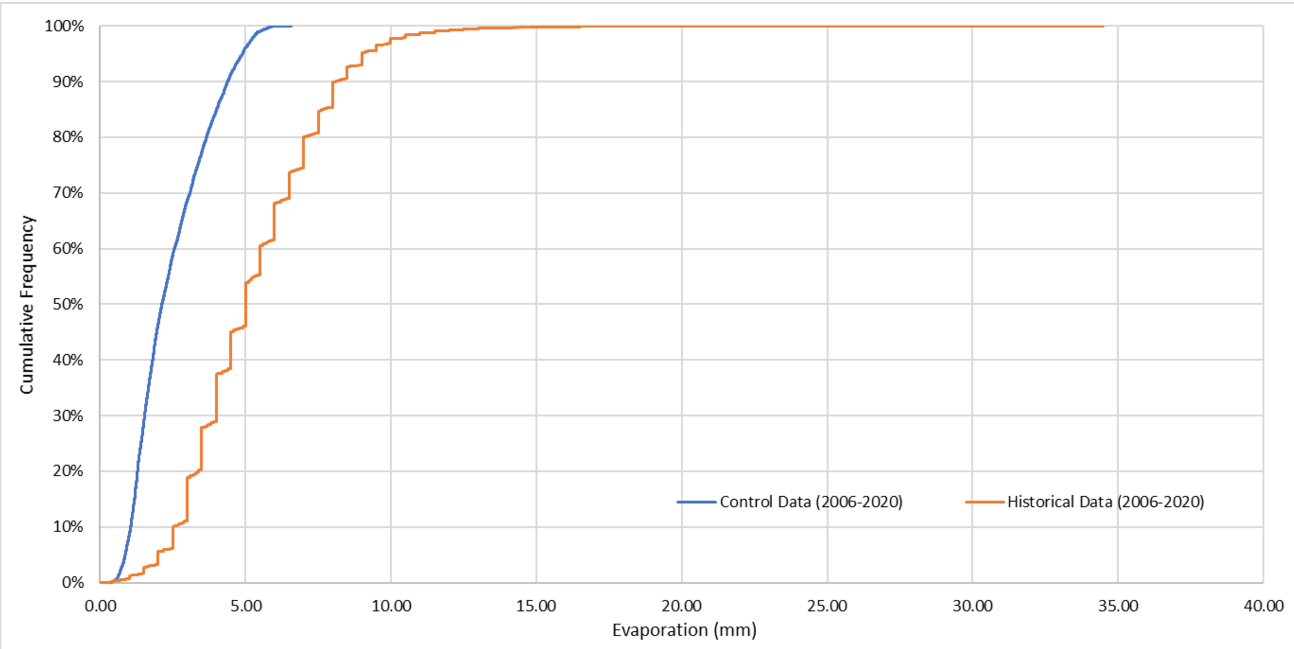


Figure 26: Quantile Plot of Uncorrected Control Period and Historic Evaporation

A common issue with future climate precipitation data is the overprediction of light precipitation (Terai *et al*., 2016). The historic climate data shows that no precipitation was recorded for 81.7% of days between 2006 and 2020. However, the uncorrected control climate change projection data estimates that only 42.2% of days were dry (Table 7).

The uncorrected climate change projection data was bias corrected against the historical climate data and a range of percentiles for different datasets are presented in Table 10 (precipitation) and Table 11 (evaporation). As can be seen in the tables, percentiles for the corrected control climate change projection data match values for the historic climate data. Correcting the control climate change projection data also results in a similar number of days with precipitation and days with evaporation greater than 2 mm as occurs in the historic climate dataset.

Table 10: Control Climate Change Projection Data - Precipitation Percentile Values (mm)

Percentile	Historic Data	Uncorrected Control Data	Corrected Control Data
5.00%	0.0	0.0	0.0
25.0%	0.0	0.0	0.0
50.0%	0.0	0.2	0.0
75.0%	0.0	3.7	0.0
90.0%	5.2	10.5	5.2
95.0%	13.1	15.7	13.1
99.0%	33.4	30.8	33.4
99.9%	64.8	68.1	64.8

Table 11: Control Climate Change Projection Data - Evaporation Percentile Values (mm)

Percentile	Historic Data	Uncorrected Control Data	Corrected Control Data
5.0%	2.0	0.9	2.0
25.0%	3.5	1.4	3.5
50.0%	5.0	2.2	5.0
75.0%	7.0	3.4	7.0
90%	8.1	4.4	8.1
95.0%	9.0	4.9	9.0
99.0%	11.5	5.5	11.5
99.9%	23.3	5.9	23.3

Future Period, 2020 to 2070

Quantile plots of the corrected control period and the uncorrected future climate change projection data are presented in Figure 27 and Figure 28 for precipitation and evaporation, respectively.

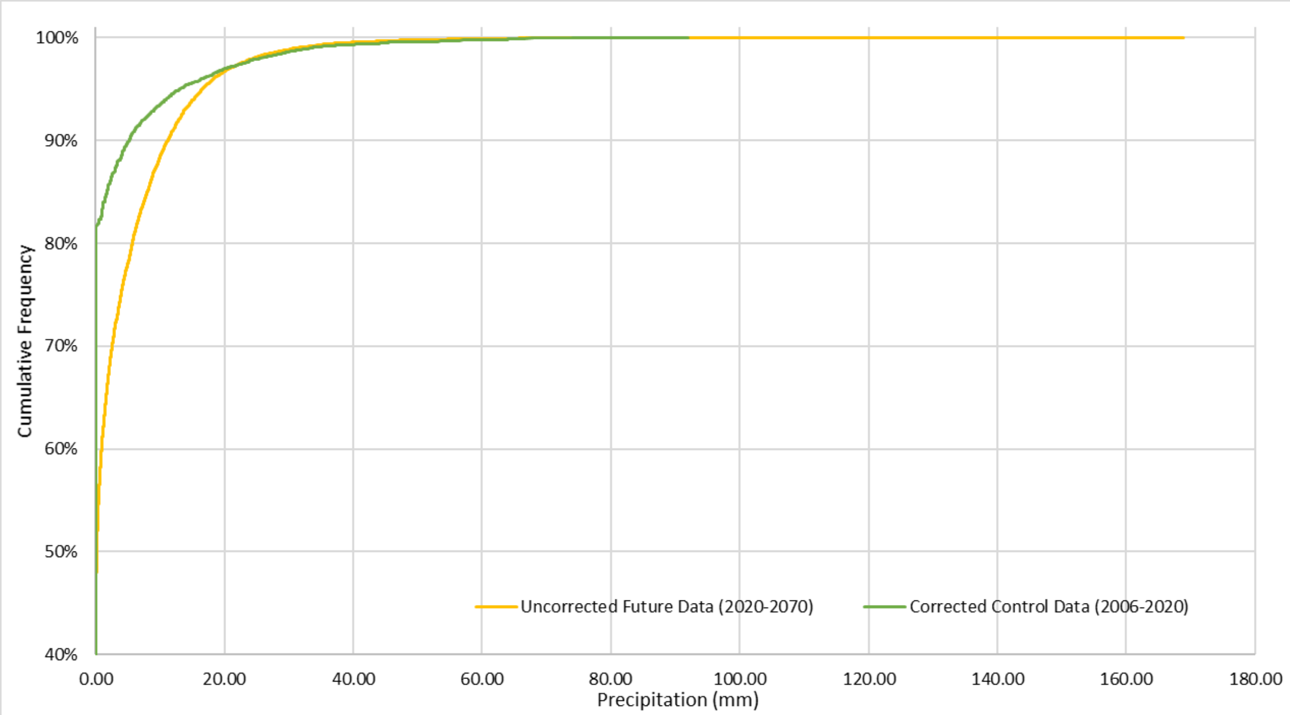


Figure 27: Quantile Plot of Corrected Control Period and Uncorrected Future Precipitation

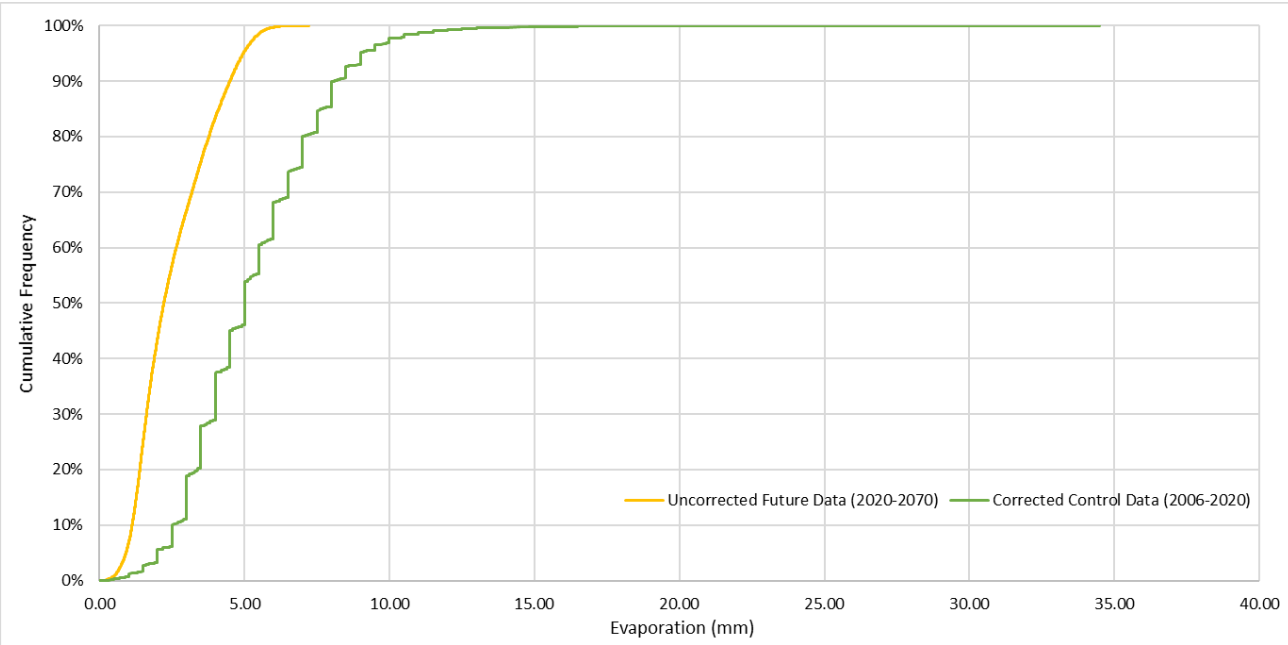


Figure 28: Quantile Plot of Corrected Control Period and Uncorrected Future Evaporation

The future climate change projection data were corrected based on the biases calculated from the uncorrected control climate change projection and historic climate data. A range of percentiles for the different datasets are compared in Table 12 (precipitation) and Table 13 (evaporation). Percentiles for the corrected future climate data are closer to values for the corrected control climate data.

Table 12: Future Climate Change Projection Data - Precipitation Percentile Values (mm)

Percentile	Corrected Control Period Data	Uncorrected Future Climate Data	Corrected Future Climate Data
5.0%	2.0	0.9	2.1
25.0%	3.5	1.5	3.7
50.0%	5.0	2.2	5.2
75.0%	7.0	3.5	7.2
90%	8.1	4.5	8.3
95.0%	9.0	5.0	9.1
99.0%	11.5	5.6	11.8
99.9%	23.3	6.4	25.2

Table 13: Future Climate Change Projection Data - Evaporation Percentile Values (mm)

Percentile	Corrected Control Data	Uncorrected Future Data	Corrected Future Data
5.0%	2.0	0.9	2.1
25.0%	3.5	1.5	3.7
50.0%	5.0	2.2	5.2
75.0%	7.0	3.5	7.2
90%	8.1	4.5	8.3
95.0%	9.0	5.0	9.1
99.0%	11.5	5.6	11.8
99.9%	23.3	6.4	25.2

Mean precipitation and evaporation data computed from the downscaled future climate change projection data are provided in Table 14. The annual total numbers of rainy days and days with evaporation greater than 2 mm are similar to those for historic climate dataset, however, the annual total amounts of precipitation and evaporation have each increased by 24 mm and 75 mm, respectively.

Table 14: Mean Downscaled Future Precipitation and Evaporation Data

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Precipitation (mm)	132.4	104.0	92.2	51.1	35.8	8.8	1.2	2.4	6.7	57.9	111.4	131.9	736.0
Number of days with precipitation	11	9	8	6	4	1	0	0	1	6	9	11	67
Evaporation (mm)	244.1	209.5	194.9	160.2	134.3	103.8	103.4	119.2	114.6	175.3	210.0	240.6	2010
Number of days with evaporation > 2 mm	31	28	31	30	30	29	29	28	26	30	30	31	353

Climate Change modelling

The methodology for adjusting a daily historical data set to provide an adjusted climate change daily data for rainfall and evaporation are adopted from Golder, 2020 and described in the sections below.

Rainfall adjustment

Rainfall is adjusted to the projected climate change for average annual climate change projection for rainfall while preserving adjusted large event rainfall. The Log-Pearson Type III distribution was adopted for fitting a frequency distribution for the maximum annual 24-hour observed rainfall. The standard deviation associated with this observed 24-hour rainfall distribution was adjusted to fit a distribution that aligns to the projected climate change 5 % AEP rainfall (climate change aligned rainfall distribution). Observed daily rainfall greater than the observed 24-hour rainfall distribution are adjusted when the climate change aligned rainfall distribution is greater than the rainfall of the observed 24-hour rainfall distribution (large event rainfall).

The following relationship are used to apply change in monthly and annual rainfall while preserving large event rainfall with the 5 % AEP climate change aligned rainfall frequency distribution.

$$Adjusted\ Daily\ Rainfall = AR_D \times \frac{Total\ Adjusted\ Rainfall - Total\ Large\ Event\ Rainfall}{Total\ Frequent\ Rainfall}$$

$$AR_D = (OR_D - OD_x) \times \frac{AW_{x+1} - AW_x}{HW_{x+1} - HW_x} + AD_x\ \ for\ (OR_D > OW_x)\ and\ (AW_x > OW_x)$$

$$AR_D = OR_D\ \ for\ (OR_D < OW_x)\ and\ (AW_x > OW_x)$$

$$Total\ Adjusted\ Rainfall = \sum OR_D \times Monthly\ Adjustement\ Factor$$

Seasonal average change in rainfall is applied while preserving the annual climate change projection for rainfall as follows:

$$Monthly\ Adjustment\ Factor = \frac{Adjusted\ Monthly\ Average\ Rainfall}{Observed\ Monthly\ Average\ Rainfall} \times \frac{Adjusted\ Annual\ Average\ Rainfall}{\sum Adjusted\ Monthly\ Average\ Rainfall}$$

$$Adjusted\ Monthly\ Average\ Rainfall = Observed\ Monthly\ Average\ Rainfall \times Seasonal\ Rainfall\ Change\ Factor$$

$$Adjusted\ Annual\ Average\ Rainfall = Observed\ Annual\ Average\ Rainfall \times Annual\ Rainfall\ Change\ Factor$$

$$Total\ Large\ Event\ Rainfall = \sum AR_D\ \ for(OR_D > HW_x)\ and\ (AW_x > OW_x)$$

$$Total\ Frequent\ Rainfall = \sum AR_D\ \ for\ \ (OR_D \leq OW_x)\ and\ (AW_x > OW_x)$$

Where

OR_D is the observed daily rainfall

AR_D is the daily large event adjusted rainfall

OW_x is the 24-hour rainfall associated with AEP, x

AW_x is the 24-hour rainfall associated with AEP, x

Evaporation Adjustment

The bulk formula for evaporation, E, has been found from field experiments is presented by Katsaros (Evaporation And Humidity, 2010) as follows:

$$E = \rho \times C_E \times \overline{U} \times (\overline{q_s} - \overline{q})$$

Where

ρ is the air density;

C_E is the exchange coefficient;

$\overline{U}$ is the mean wind speed;

$\overline{q}$ is the time averaged mean specific humidity;

$\overline{q}$ is the saturation specific humidity.

Relative humidity, RH is the ratio of the vapor pressure to saturation vapor pressure or $^{\omega}/_{\omega_s}$, the ratio of mass mixing ratios of water vapor at actual and saturation values. q is defined as:

$$q = \frac{m_v}{m_v + m_d} = \frac{\omega}{\omega + 1} \approx \omega$$

$$RH \approx \frac{q}{q_s}$$

$$E = \bar{\rho} \times C_{E_D} \times \overline{U} \times \overline{q_s}(1 - RH)$$

Rearranging gives a relationship with observed daily data for OE_D and RH as follows:

$$\bar{\rho} \times C_{E_D} \times \overline{U} \times \overline{q_s} = \frac{OE_D}{(1 - RH)}$$

Assuming the left side of the above equation is valid for the climate change adjusted evaporation, AE_D, and substituting with the bulk formula allows the application of climate change adjustment factors for wind, F_U, and relative humidity, F_{RH}, as follows:

$$AE_D = OE_D \times F_U \times \frac{(1 - F_{RH} \times RH)}{(1 - RH)}$$

The climate change adjustment module was added to GoldSim to create the required projections Figure 29 presents the comparison of the adjusted annual projected historical rainfall versus the climate change rainfall and Figure 30 shows the daily comparison.

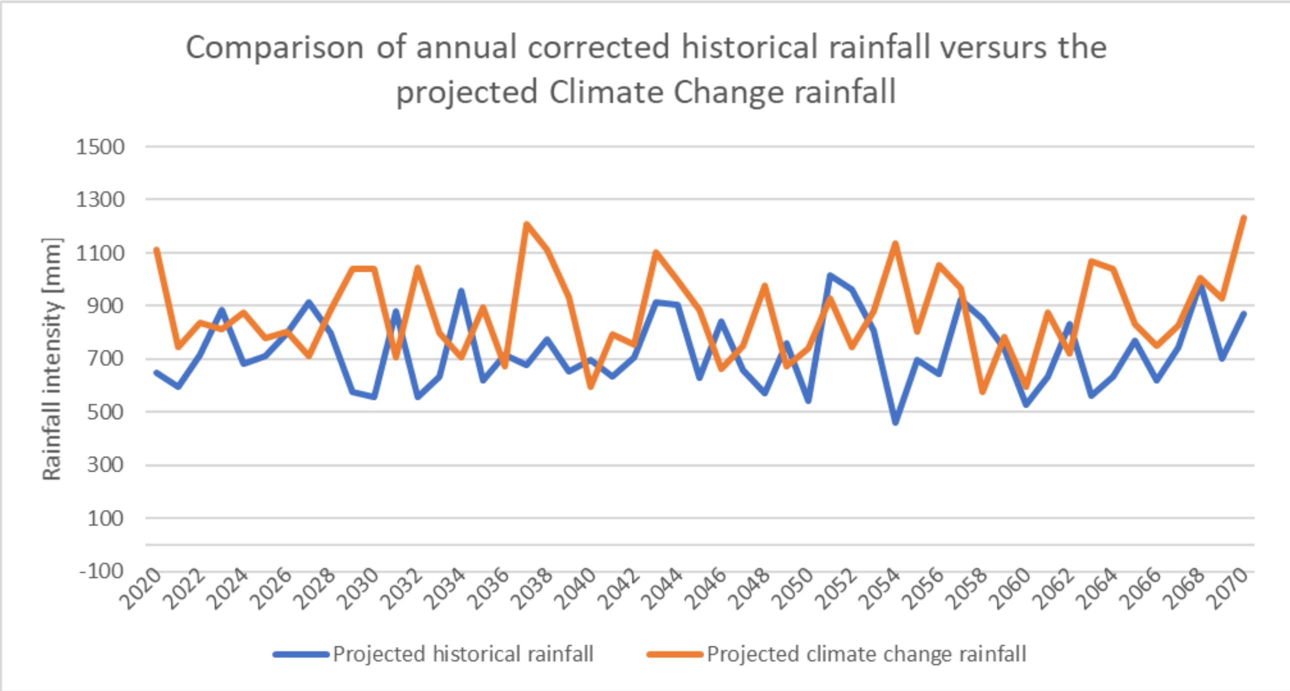


Figure 29: Comparison of corrected annual projected historical rainfall versus project climate change adjusted rainfall

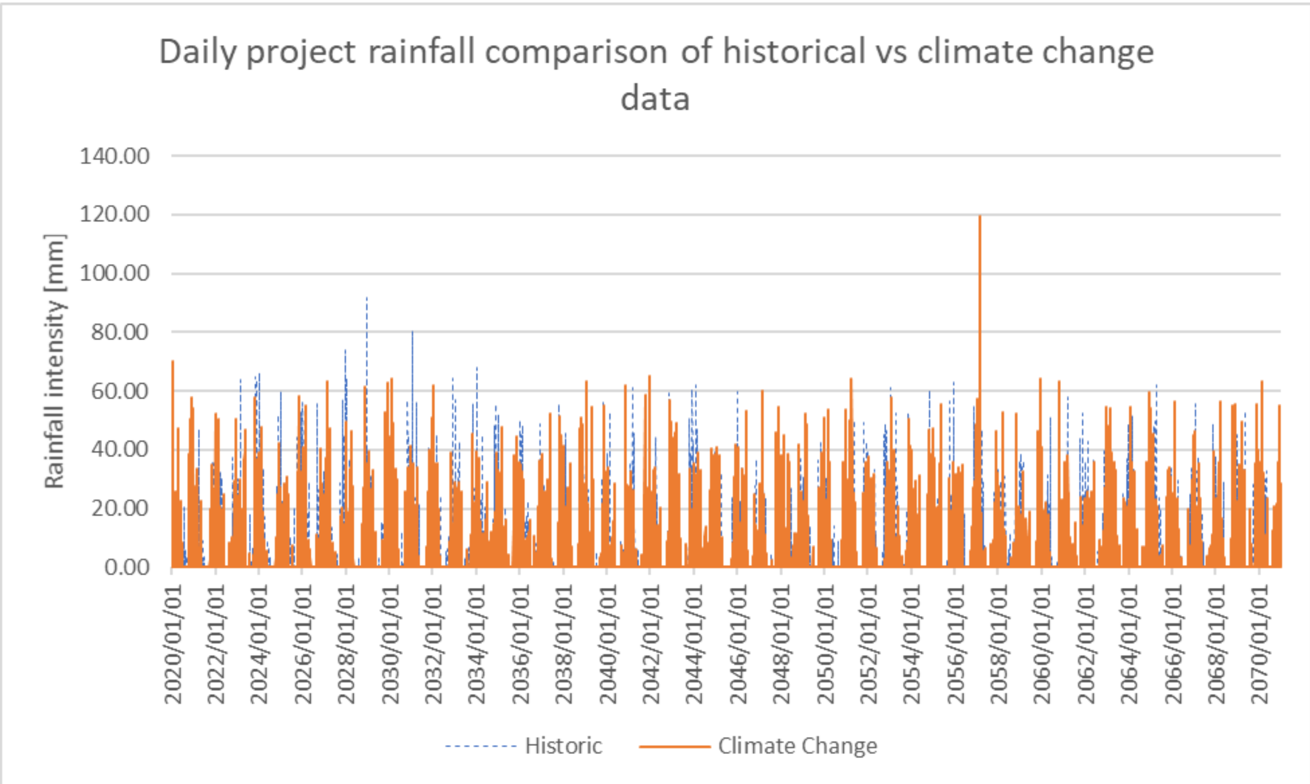


Figure 30: Comparison of corrected daily projected historical rainfall versus project climate change adjusted rainfall

5.0 PRESENT ECOLOGICAL STATE AND ECOLOGICAL IMPORTANCE AND SENSITIVITY

The Present Ecological State (PES) is defined as the current state or condition of a water resource in terms of its biophysical components (drivers) such as hydrology, geomorphology and water quality and biological responses viz. fish, invertebrates, and riparian vegetation. The degree to which ecological conditions of an area have been modified from the natural condition and the Ecological Importance and Ecological Sensitivity (EI/ ES) relate to the presence, representativeness, and diversity of species of biota and habitat. Ecological Sensitivity relates to the vulnerability of the habitat and biota to modifications that may occur in flows, water levels and physico-chemical conditions.

Data for the Witkloofspruit and Klein Komati River, the two main rivers that would be impacted by the project are set out in Table 1. The tributaries are unnamed tributaries that drain to the Klein Olifants River.

Table 15: PES, EI/ ES and EC of the Witkloofspruit and Klein Komati River (DWA, 2013)

	Witkloofspruit	Klein-Komati River
Quaternary catchment	X11C	X11D
Present Ecological State	C	C
Ecological Importance	Moderate	Moderate
Ecological Sensitivity	High	Very High
Ecological Category	B	A

All of the above inform the classification and Resource Quality Objectives (RQO) set for a catchment, and ultimately the limits that would be set for any discharge, as well as measures put in place, such as lining and stormwater management, for resource protection. Refer to Figure 23 and Figure 24 for a graphical representation of the PES and EIS categories for the project area and surrounding.

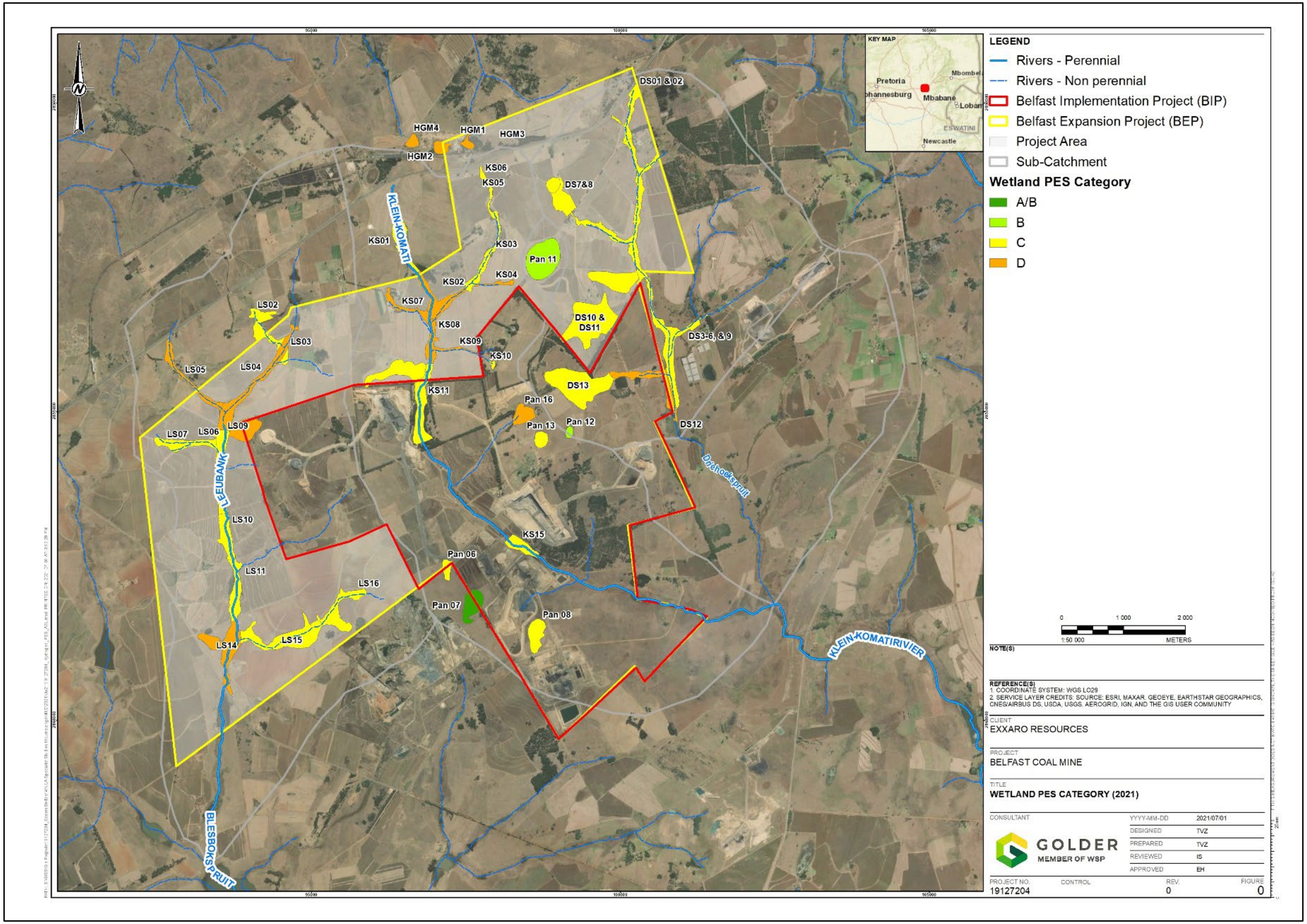


Figure 31: PES category delineations

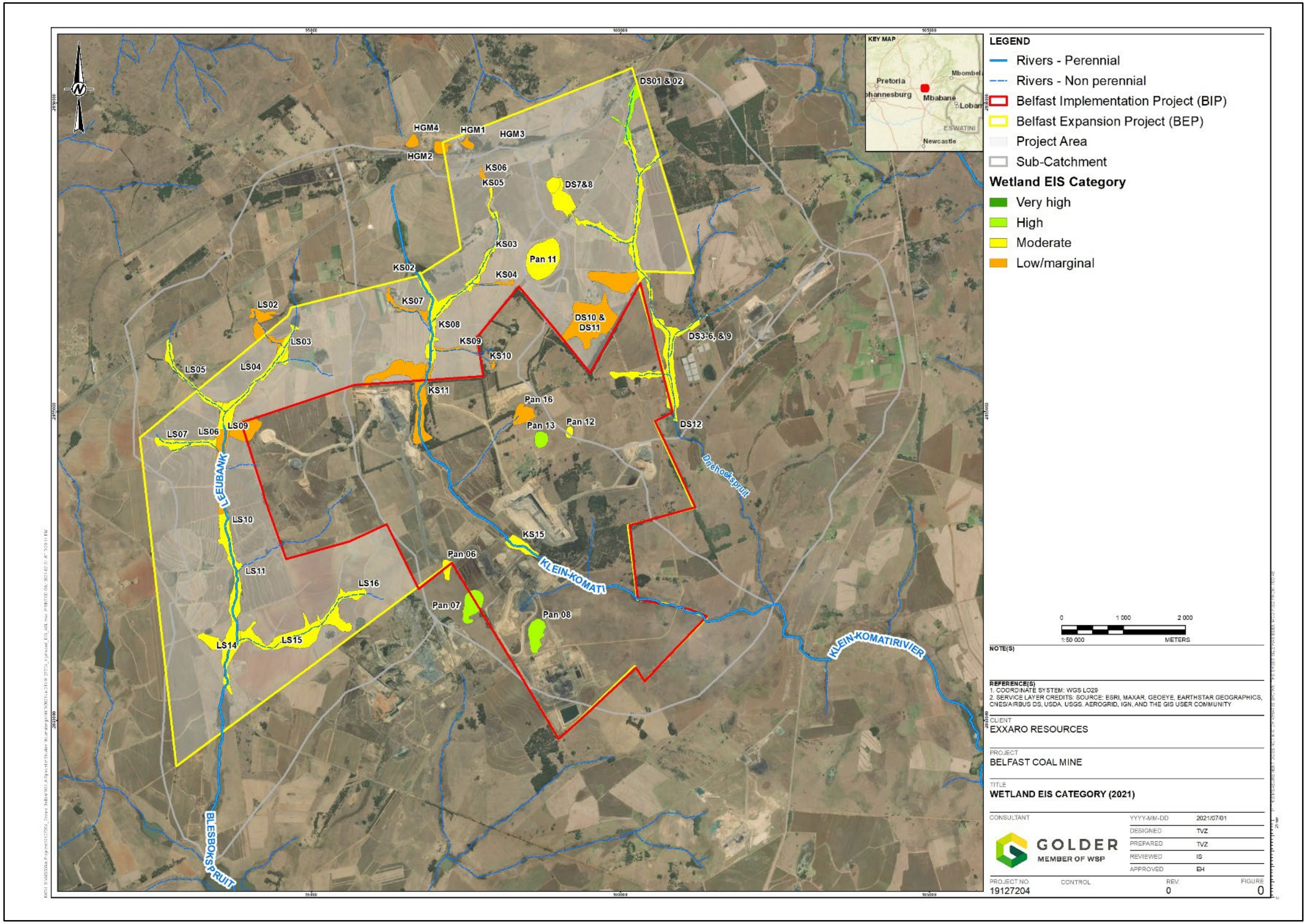


Figure 32: Surface water EIS

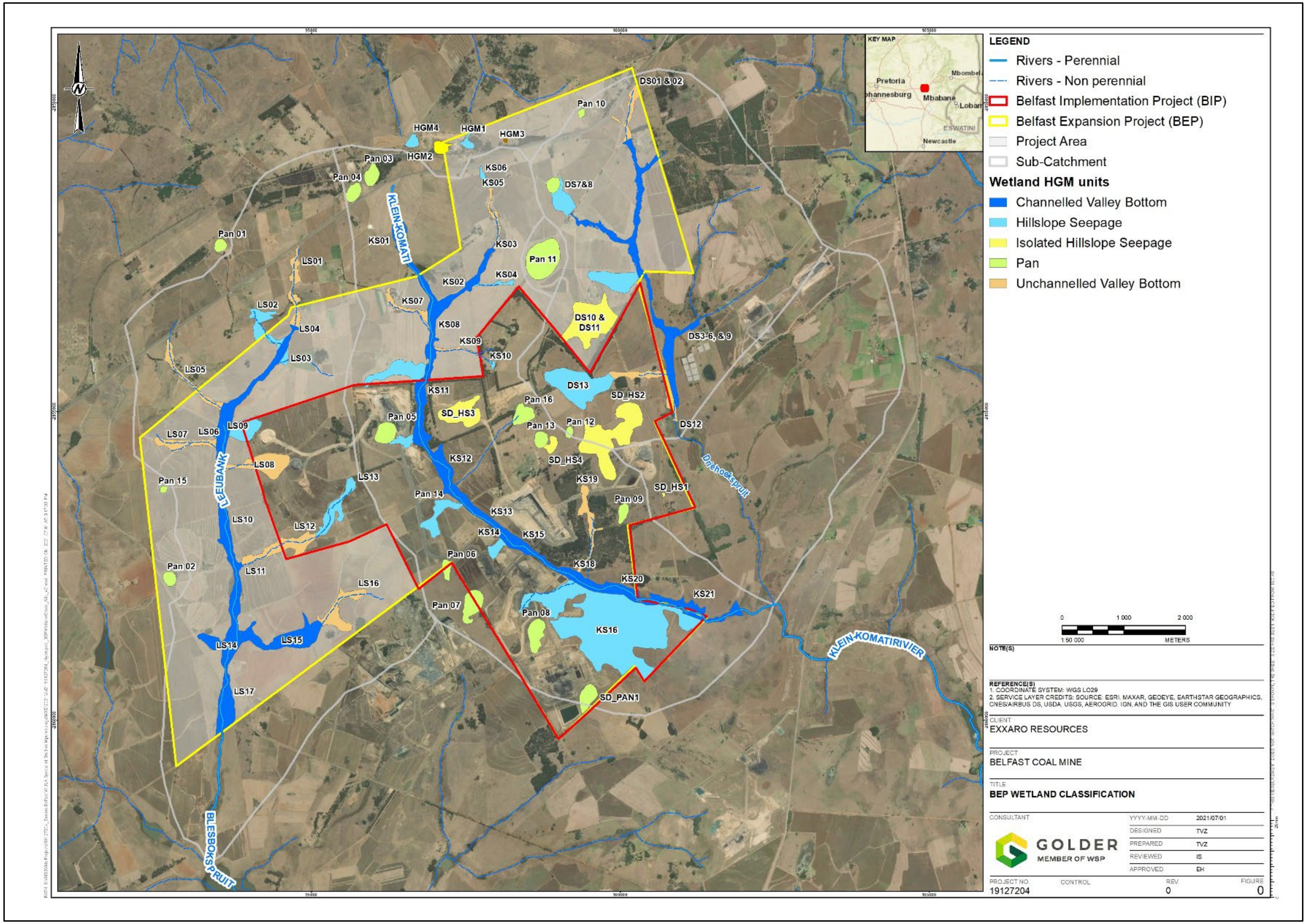


Figure 33: Wetland classification (HGM units) within Belfast MRA

6.0 SURFACE HYDROLOGY

6.1 Regional Hydrology

The proposed project and current development area are in the headwaters of the Komati River catchment. The area is divided into three catchments with three streams running southward, namely the Leeubankspruit (Quaternary Drainage Region X11C) (which flows into a southerly direction and becomes the Blesbokspruit which becomes the Witkloofspruit before flowing into the Nooitgedacht Dam on the Komati River), Klein Komati River and Driehoekspruit (Quaternary Drainage Region X11D) which confluence with the Komati River approximately 12km downstream of the Nooitgedacht Dam. The Komati River falls within the X1 Primary Drainage Region within the Inkomati-Usuthu Water Management Area (WMA) of South Africa and has a catchment area of about 11 200 km^2. The river is bordered by towns including Carolina, Eerstehoek, Machadodorp, Waterval Boven, Ekulindeni, Mbojane, Barberton, Emangweni, Sibayeni and Komatipoort. The river is a shared watercourse, and crosses the South African border into Swaziland, and back into South Africa, to the north of Swaziland, and eventually flows into Mozambique. Elevations vary between 1 870 mamsl in the upper reaches of the catchments and 1 740 mamsl in the south of the catchments. The three catchments are characterised by moderately undulating plains and pans, with grassland vegetation and no industrial/urban areas. There are various small capacity dams along the course of the rivers (Golder, 2014).

The major water requirements in the catchment are power generation demands in the Olifants Water Management Area (WMA) met by water transferred from the Komati, irrigation, afforestation, industrial activities and an increasing domestic water demand (AfriDev, 2006).

Currently the major stresses facing the Inkomati-Usuthu WMA are the high water demands for Eskom, irrigation, afforestation and industry, and rapidly increasing domestic water demands. The water shortages experienced in the area have led to competition for the available water resources among user sectors. A substantial portion of the population in the catchment does not have access to a basic level of services and a number of planned expansions to water uses have been put on hold. Furthermore, the major dams in the study area change the flow regime and impact on the water quality.

The Komati River Catchment study detailed in a report by AfriDev Consultants (AfriDev, 2006) revealed that the water in the headwaters of the Komati River was generally of good quality with no major water quality problems being experienced. Some water quality impact is experienced in terms of dry land farming and forestry in the Upper Komati River between Nooitgedacht and Vygeboom Dams, however the catchment is in good ecological condition (AfriDev, 2006). The two main dams in the Upper Komati catchment are operated to ensure the maximum yield. The volumes of water abstracted are based on the water available through the inter-basin transfers from the Vaal-Eastern Sub-system. The water is abstracted by Eskom for power generation. Eskom power stations receiving water from the Komati catchment were designed for use of this high quality (low sulphate) water. The continued supply of good quality water to Eskom is of strategic national importance and a key factor for the management of the catchment water resources. Due to the abstraction and rigid operating rules, the low flows of the Komati River between the dams have been impacted upon. This has resulted in an increase of nutrients in this reach of the river due to trout dams and tourism activities (AfriDev, 2006). The low flow reduction coupled with trout dams, agricultural and tourism activities has resulted in increased nutrient concentrations in the river.

Water management in the Upper Komati region is therefore very sensitive and attention has to be given to changes in flow and water quality.

Wetlands as well as several pans and dams are common in the area. Much of the catchment supports cattle grazing and crop cultivation activities and some coal mining operations. The natural vegetation is dominated by grasslands.

The tributaries that are likely to be impacted are unnamed tributaries that drain to the Klein Olifants River. These tributaries originate within 300 m of the X11C watershed.

6.2 Reserve, Classification of the Resources and Resource Quality Objectives

The protection of water resources is governed by Chapter 3 of the National Water Act (2018), Act 36 of 2018, (NWA), and Chapter 5 of the National Water Resources Strategy 2 (NWRS2) (DWA, 2013) which prescribe the protection of the water resources through resource directed measures (RDM) and the classification of water resources. These are measures which, together, are intended to ensure the protection of water resources, as well as being measured for pollution prevention and remedying the effects of pollution while balancing the need to use of water as a factor of production to enable socio-economic growth and development.

In order to give effect to the concept of sustainability, an understanding of the nature and requirements of aquatic ecosystems under present conditions is needed. In addition, the pressures being placed upon resources, how the resources are being used, the water resources management intent, and finally the objectives which provide a statement (in terms of biota, habitat, flow and water quality) of the conditions that need to be met are also factors that must be considered.

The Reserve, classification of the resources and RQOs have been promulgated for the catchments of the Inkomati River which forms part of the Inkomati-Usuthu Water Management Area in which the Belfast Expansion Project is located (X11C and X11D).

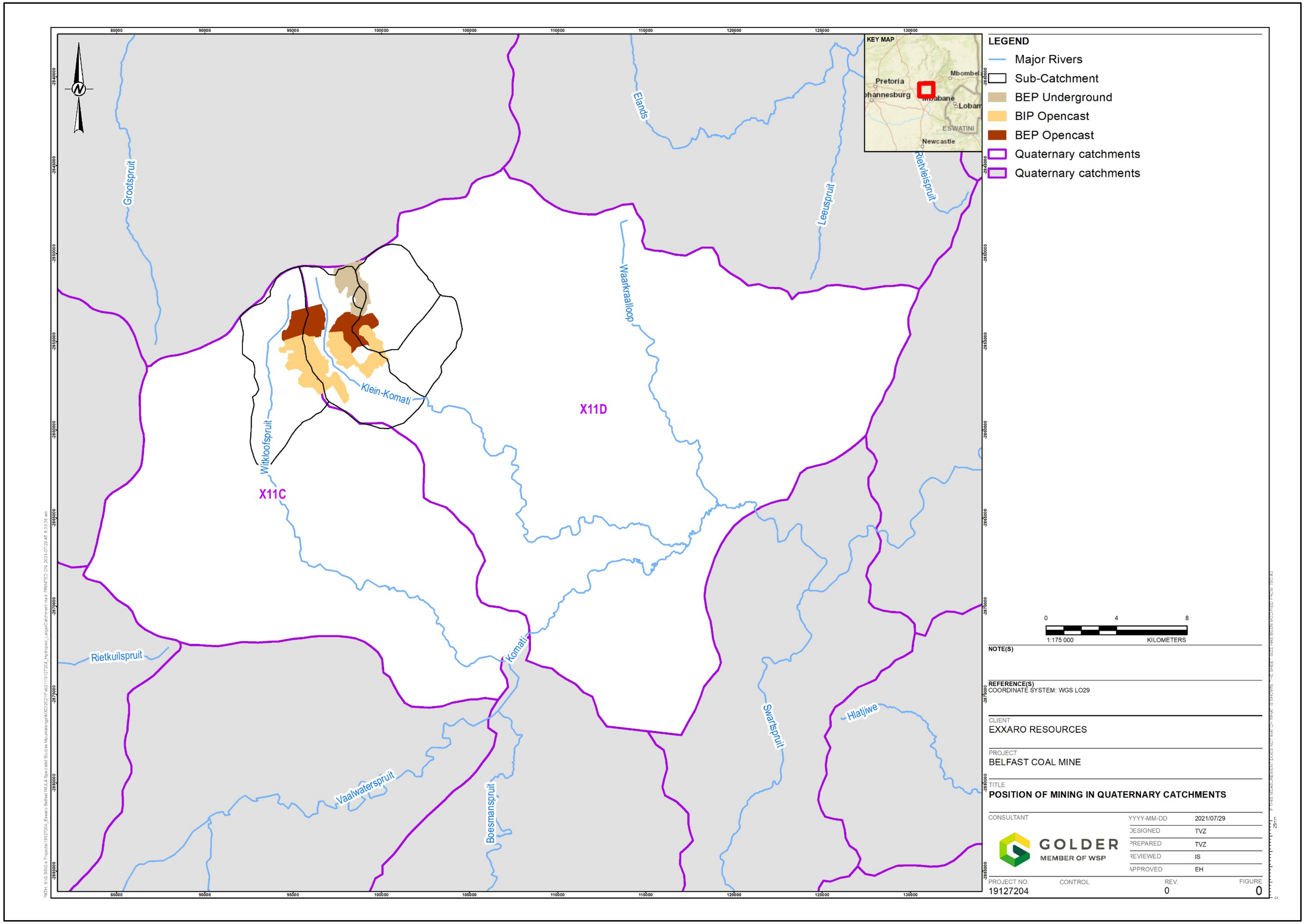


Figure 34: Quaternary catchments relevant to the project area

6.3 Classification

The Water Resource Classification Study (WRCS) places the following principles at the forefront of implementation:

1) Maximising economic returns from the use of water resources;

2) Allocating and distributing the costs and benefits of utilising the water resource fairly; and

3) Promoting the sustainable use of water resources to meet social and economic goals without detrimentally impacting on the ecological integrity of the water resource.

The classes are described below.

Class I	**Minimally used** Water resource is one which is minimally used, and the overall condition of that water resource is minimally altered from its pre-development condition
Class II	**Moderately used** Water resource is one which is moderately used, and the overall condition of that water resource is moderately altered from its pre-development condition
Class III	**Heavily used** Water resource is one which is heavily used, and the overall condition of that water resource is significantly altered from its pre-development condition

The X11C and X11B quaternaries of the Inkomati Catchment have been classified as Class II rivers in Government Gazette No 40531, 30 December 2016, Notice No 1616, National Water Act, 1998 (Act No.36 of 1998) Classes of Water Resources and Resource Quality Objectives for the catchments of the Inkomati (DWS, 2016). This means that the water resources are those which are moderately used, and the overall condition of that water resource is moderately altered from its pre-development condition.

The Upper Olifants River catchment has been classified as a Class III River in Government Gazette No 39943, 22 April 2016, Notice No 466, National Water Act, 1998 (Act No.36 of 1998) Classes and Resource Quality Objectives of Water Resources for the Olifants Catchment (DWS, 2016b). This means that the water resources are those which are heavily used, and the overall condition of that water resource is significantly altered from its pre-development condition.

6.4 The Reserve

The Reserve specifies the quantity, quality, habitat and biotic integrity requirements necessary for the protection of the resource, has priority over other water uses, and will vary according to the class of the resource. The Reserve is a protection measure that comprises two components:

- Basic human needs (BHN), ensuring that the essential needs of individuals served by the water resource in question are provided for; and
- The ecological Reserve which is not intended to protect the aquatic ecosystem *per se*, but to maintain aquatic ecosystems in such a way that their integrity remains intact, and they can continue to provide the goods and services to society and is specified for groundwater, wetlands, rivers and estuaries.

The Reserve for the Olifants Water Management Area has been finalised, however that for the Inkomati-Usutu Water Management Area has not been completed.

6.5 Resource Quality Objectives

Resource Quality Objectives have been set for quaternary catchment X11C and X11D. Table 2 sets out the water quality component of the Resource Quality Objectives.

Table 16: Resource Quality Objectives relevant to X11C and X11D

Sub-component	Narrative RQO	Numerical RQO
Electrical conductivity (salts)	Ideal	95th percentile of the data must be less than or equal to 30 mS/m (aquatic ecosystems: driver)
Toxics*	Ideal	95th percentile of the data must be within the TWQR for toxics (DWAF, 19960F0F[1]) or the upper limit of the A category in DWAF (2008)1F1F[2].
Sulphate	Acceptable	95th percentile of the data must be less than 30 mg/L (industrial cat 3: driver).
pH	Acceptable	5th percentile of 5.9-6.5; 95th percentile of 8.0-8.8 (aquatic ecosystems: driver).

*Toxics include: Aluminium, ammonia, arsenic, atrazine, cadmium, chlorine (free), chromium (III and VI), copper, cyanide, endosulfan, fluoride, lead, mercury and phenol.

There are no gazetted flows relevant to the quaternary catchments. The quantity component of the RQOs is set at a point on the Komati River (EWR K1). The monthly flow requirements are shown in Table 3.

Table 17: Hydrological RQOs at EWR K1 on the Komati River

River	Target Ecological Category	nMAR1 (MCM)	Low flows (% nMAR)2	Total flows (% nMAR)3	Months	RQO (m^3/s)	
						90%	60%
Komati	C	158.6	16.1	27.5	Oct	0.25	0.49
					Nov	0.34	0.6
					Dec	0.45	0.72
					Jan	0.54	0.86
					Feb	0.62	0.89
					Mar	0.6	1.06
					Apr	0.61	0.98
					May	0.49	0.85
					Jun	0.37	0.68
					Jul	0.32	0.5
					Aug	0.26	0.4
					Sep	0.23	0.38

1 nMAR is the natural Mean Annual Runoff in million cubic meters per annum.
2 %nMAR is flow required at the nodes expressed as a percentage of the natural Mean Annual Runoff, Low flows and Total flows.
3 Percentage points on the monthly low flow frequency distribution continuum at the nodes, expressed as the percentage of the months (90% and 60%) that the flow should equal or exceed the indicated minimum values.

[1] DWAF (1996) South African Water Quality Guidelines for Domestic Use

[2] DWAF (2008) Methods for Determining the Water Quality Component of the Ecological Reserve

RQOs have been gazetted for the Upper Olifants River catchment (DWS, 2016b). There are no specific water quality and quantity limits set for these tributaries, however the following must be taken into consideration.

- Instream habitat must be in a largely modified or better condition to support the ecosystem and for ecotourism users.
- Instream biota must be in a largely modified or better conditions and at sustainable levels.
- Low and high flows must be suitable to maintain the river habitat for ecosystem condition and ecotourism.
- Nutrient concentrations must be improved to prevent nuisance conditions for ecotourism, and
- Salt concentrations must be maintained at levels where they do not render the ecosystem unsustainable.

6.6 Water Quality Limits

Water quality limits are included in the current integrated water use licence number: 05/X11D/ABCFGIJ/2613 in order to assess the impact on the Leeubankspruit, Klein Komati and Driehoekspruit (Table 4). However, Exxaro has made an application to amend sone of the limits. These are included in Table 18 although the amendments have not yet been approved.

Table 18: Surface water quality requirements as stipulated in the IWUL (number 05/X11D/ABCFGIJ/2613) with proposed limit amendments

Parameter	Units	Existing IWUL limits	Proposed IWUL Limit Change	
			Streams & Rivers	Pans/ *dams
Section for 21(c and i) Watercourse diversion or alteration)				
Aluminium	mg/l	<0.7	<0.7	<0.7
Boron	mg/l	<0.15	<0.15	<0.15
Iron	mg/l	<2	<2	<6.8
Manganese	mg/l	<0.5	<0.5	<2.0
Sodium	mg/l	<20	<20	<350
Sulphate	mg/l	<150	<150	<305
Chloride	mg/l	<55	<55	<700
Nitrate	mg/l	<2	<2	<10
Nitrite	mg/l	<2	<2	<2
Orthophosphate	mg/l	<0.05	<0.1	<0.05
Ammoniacal Nitrogen	mg/l	<0.007	<1.6	<5.2
Ammonium	mg/l	<1	<1.7	<5.5
Total Alkalinity	mg/l	<120	<120	<154
Dissolved Oxygen	mg/l	>6	>6	>1

Parameter	Units	Existing IWUL limits	Proposed IWUL Limit Change	
			Streams & Rivers	Pans/ *dams
Electrical Conductivity	mS/m	<40	<40	<280
pH	s.u	6.5-7.8	6.5-7.8	
Total Dissolved Solids	mg/l	<450	<450	<1,800
Total Suspended Solids	mg/l	<25	<120	<7,500
Turbidity	NTU	<5	<150	<130
Faecal Coliforms	CFU /100 ml	0	<1400	<1400
Section 21g (waste disposal affecting resource) & b (water storage)				
Magnesium	mg/l	<30	<30	<30*
Sodium	mg/l	<70	<70	<70*
Fluoride	mg/l	<1	<1	<1*
Sulphate	mg/l	<200	<200	<200*
Chloride	mg/l	<100	<100	<121*
Nitrate as NO_3-	mg/l	<6	<6	<6*
Electrical Conductivity	mS/m	<40	<40	<40*
pH	mg/l	6.5-8.5	6.5-8.5	6.5-8.5*
Total Dissolved Solids	mg/l	<450	<450	<450*
Dissolved Oxygen	mg/l	>6	>6	>6*
Faecal Coliforms	Colonies/100 ml	0	<1400	<1300*

7.0 SURFACE WATER QUALITY ASSESSMENT

Golder is currently conducting routine water quality sampling and analysis for the BIP. The water quality monitoring is done on a weekly and monthly basis for the surface water sites relevant to the BIP to ensure compliance to their approved IWUL limits as shown in Table 4. The data and information represented in this section (Section 7.0), is taken from the BIP monitoring reports, Golder, 2020a and Golder, 2020b.

Wetlands as well as several pans and dams are common in the area. Much of the catchment supports cattle grazing and crop cultivation activities and some coal mining operations. The natural vegetation is dominated by grasslands. Monitoring data is submitted to Exxaro monthly by Golder in Equis™ format. Surface water quality samples are taken from thirty-three (33) surface water sites (river/streams and dams) over the period 20 July 2015 – March 2020. Refer to Figure 26 for the location of the surface water quality monitoring points which is listed in Table 19. A summary of the surface water quality monitoring and analysis for the 2019 monitoring year and Q1 2020 is provided in the sections that follow and tables showing water quality results are shown in **Tables A1** to **A12.**

Table 19: Surface water sampling points

Type	Site Name	Y Co-ordinates	X Co-ordinates
River/ Stream	BWQ2	-25.798896	30.005524
	BWQ4	-25.828062	30.006357
	BWQ5	-25.81334	29.972468
	BWQ9	-25.840007	29.93358
	DS11	-25.786027	29.995499
	DS12	-25.793887	29.998238
	DS13	-25.794267	29.992808
	DS14	-25.803127	30.007338
	KS08	-25.786837	29.966778
	KS09	-25.790667	29.974258
	KS10	-25.792347	29.976968
	KS11	-25.794407	29.965438
	KS12	-25.808247	29.969948
	KS13	-25.815137	29.976788
	KS14	-25.819537	29.977168
	KS15	-25.819727	29.983018
	KS16	-25.826017	29.983338
	KS18	-25.822317	29.991198
	KS19	-25.816787	29.993148
	KS20	-25.824397	29.998118
	KS22	-25.833757	30.026618
	LS03	-25.792277	29.943228
	LS04	-25.79551	29.93813
	LS08	-25.807347	29.938078
	LS12	-25.817277	29.948338

Type	Site Name	Y Co-ordinates	X Co-ordinates
	LS13	-25.812377	29.951338
	LS16	-25.826177	29.955488
Dams	BWQ1	-25.759729	29.998024
	BWQ6	-25.77584	29.961913
	BWQ7	-25.78084	29.944413
	BWQ8	-25.800562	29.933857
	FD (Farm Dam)	-25.79592	29.96373
	KPFD (Koos Pretorius farm dam)	-25.80432	29.96413
Pans	Pan05	-25.8024	29.95976845
	Pan06	-25.821	29.97035845
	Pan07	-25.8278	29.97356844
	Pan08	-25.8314	29.98382844
	Pan09	-25.8138	29.99805845
	Pan12	-25.8026	29.98898845
	Pan13	-25.8036	29.98450845

Latex gloves were worn when collecting samples at each site. Field measurements were done for temperature, pH, EC, TDS, salinity and DO. Three bottles were filled at each surface water sampling site:

- A 50-ml bottle with nitric acid for analysis of dissolved metals;
- A 50-ml bottle with sulphuric acid for analysis of nitrogen species; and
- A 250-ml bottle for analysis of pH, TDS, EC, alkalinity and anions.

An additional sample was collected in a sterile glass bottle at selected stream sites for bacteriological analysis. All the samples were kept in a cooler box with ice packs prior to delivery to the laboratory.

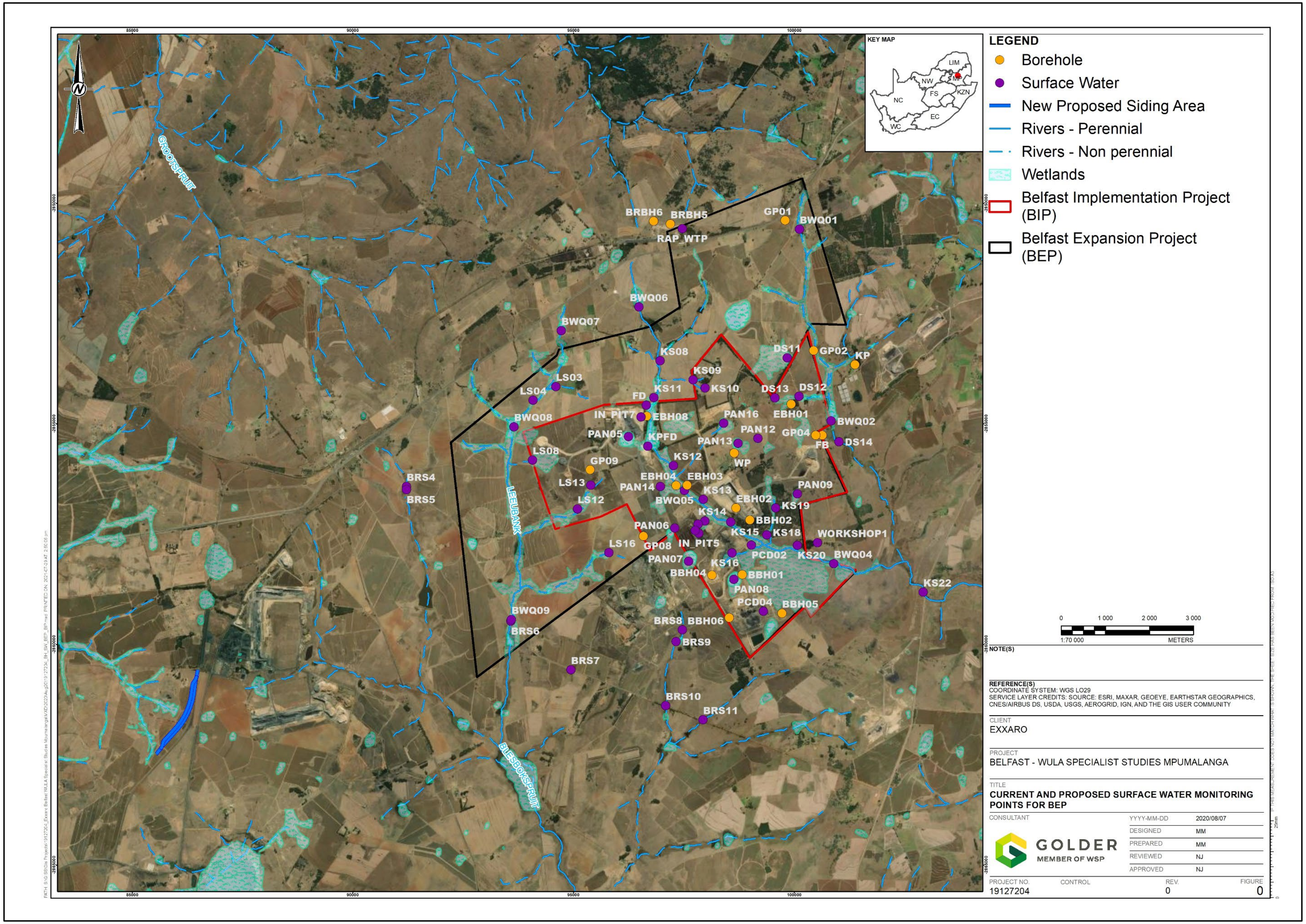


Figure 35: Current surface water monitoring sites for BEP

7.1 BIP baseline surface water quality results

Table 20 shows the temporal trends for selected parameters following the baseline water quality results in Quarter 3 2019 (Golder, 2019) focussing mainly on those that are indicative of mine-affected water. Mining in the BIP area began in May 2019 hence the water quality results up to Q3 2019 were considered the baseline condition. Note that the pan baseline water quality was generally non-compliant with IWUL, reflecting the evaporative behaviour of pan hydrochemistry, as different from flowing fresh water.

Table 20: Temporal changes, Belfast surface water

Parameter	Streams	Dams	Pans
pH	5.0 to 6.0 during baseline (mildly acidic values non-compliant)	More acidic than WUL during baseline	Generally, circum-neutral to mildly acidic (all pans) during baseline
Dissolved oxygen	1 to 9 mg/L during the baseline	4.5 to 7.5 mg/L, except for BWQ07, where substantially lower levels during baseline.	Low (< 5 mg/L) during baseline (all pans)
Sulphate	< 10 mg/L during the baseline.	< 25 mg/L during the baseline.	Generally low to moderate (< 200 mg/L) at Pan 8 and moderate to high (< 550 mg/L) at Pan 5, 7, 9, 13 during baseline.
Chloride	<10 mg/L (Driehoekspruit) < 30 mg/L (Leeubankspruit & Klein Komatispruit) during the baseline. All sites were compliant during baseline, except KS12. LS04, KS08, KS11 had moderate, compliant values.	KPFD on average and BWQ7, FD at times exceeded the WUL limits during baseline. BWQ6, BWQ8 compliant.	Moderate (< 250 mg/L) at Pan 8, high (550 mg/L) at Pan 5, 7 and very high (< 1200 mg/L) at Pan 9, 13 during baseline.
Nitrate	Exceeded the WUL limits at times during baseline	< 5 mg/L during the baseline.	Much lower High (< 55 mg/L) during baseline (all pans).
Sodium	All sites were compliant during April-June 2019, except KS11 and KS12.	Compliant during baseline, but BWQ1, FD and KPFD occasionally non-compliant	Low during (< 150 mg/L) at Pan 8, high (100 to 600 mg/L) at Pan 5, 7, 9, 13 during baseline.
Aluminium	Driehoekspruit and Leeuwbankspruit catchments at times exceeded the WUL limits during baseline, Leeuwbankspruit and Klein Komatispruit.	0.01 to 1.7 mg/L during baseline.	Compliant during baseline and construction (all pans)
Manganese	Klein Komatispruit catchment exceeded the WUL limits during baseline. KS14, BWQ4 and BWQ5 (near or downstream of plant area) were non-compliant.	up to 0.5 mg/L, except KPFD: average 5.7 mg/L during baseline.	Low (< 0.5 mg/L) at all pans except Pan 12 (1 mg/L) during baseline.

7.2 Stream water quality samples

The results for the stream water samples for the 2019 year and the 2020 Quarter 1 is presented below.

7.2.1 2019 Water Quality results

The results for the stream water samples for the December 2018 to November 2019 period are reported as minimum, maximum and mean values in **Tables A1** to **A12** with exceedances of the IWUL limits highlighted. The number (n) of months analysed for the monitoring period are indicated. The stream samples exceeded the stipulated IWUL limits for all constituents at some point, except for sulphate and nitrite.

The following were observed from the stream water sites' data:

- All sites had continuous exceedance of the limits for ammoniacal nitrogen (NH_3), and over half the sites showed frequent exceedance of ammoniacal nitrogen as NH_4^+, turbidity, orthophosphate and suspended solids limits – these parameters are likely to be related to the impact of agricultural activities on the catchments.
- The maximum turbidity was reported for site LS12 (888 NTU). The highest suspended solids value was reported for site LS04 (881 mg/l). This is likely related to the low flows and agricultural activities in the area;
- The maximum nitrate concentrations reported throughout the monitoring period was at site KS15 (3.87 mg/l);
- Maximum sodium concentrations were reported for site LS12 (52 mg/l);
- There were several cases of non-compliance to the dissolved oxygen limit, however the minimum value of 0.5 mg/l was recorded at most monitoring sites;
- Non-compliant maximum manganese concentrations were recorded at site KS14 (1.9 mg/l); and
- Faecal coliforms for the stream sites BWQ9 and KS22 were non-compliant with maximum counts of 31 000 CFU/100ml and 59 CFU/100ml respectively. These are both downstream points indicating potential impacts from livestock activities in the area.

7.2.2 2020 Quarter 1 results

The results for the stream water samples for the December 2019 to February 2020 period are reported for the different sample sites presented in **Tables A1** to **A12**, with exceedances of the IWUL limits highlighted.

The results indicate that some water quality constituents of stream samples exceeded the stipulated IWUL limits at some point, except for sulphate, nitrate, nitrite, boron and aluminium, which were below laboratory detection limits for most of the monitoring period.

The following were observed from the stream water sites' data:

- All sites had continuous exceedance of the limits for ammoniacal nitrogen (NH_3), and over half the sites showed frequent exceedance of ammoniacal nitrogen as NH_4^+, turbidity, orthophosphate and suspended solids limits – these parameters are likely to be related to the impact of agricultural activities on the catchments.
- However, the maximum turbidity was reported for site LS08 (196 NTU) and the highest suspended solids value was reported for RAP WTP (287 mg/l) which is likely related to the agricultural activities in the area;
- Nitrate concentrations are below the IWUL limit with the exception of LSO8 which reported 9.8 mg/l for nitrate and pH falling outside the monitoring range of 6.5 - 7.8;

- Sodium (93.5 mg/l), TDS (516 mg/l), EC (91.8 mS/cm), alkalinity (270 mg/l) and chloride (65.9 mg/l) limits were exceeded at RAP WTP for the quarter one monitoring period;
- There were several cases of non-compliance to the dissolved oxygen limit. Dissolved oxygen reported below 6 mg/l at sites: BWQ5, BWQ9, DS12, DS13, LS03, LS04, KS13, LS13, KS11, KS09, KS08, RAP WTP and Workshop;
- Non-compliant manganese concentrations of 4.18 mg/l were recorded at Workshop;
- Non-compliant iron concentrations were recorded at LS04, LS13, KS11, KS08 and Workshop with the highest iron concentration reported at KS08 (10.2 mg/l);
- Faecal coliforms for the stream sites BWQ9 and KS22 were non-compliant.

7.2.3 2021 Results (January to May 2021)

The results for the stream water samples for the period January to May 2021 indicate that some water quality constituents of stream samples exceeded the stipulated IWUL limits at some point, except for sulphate, nitrate, nitrite, boron and aluminium, which were below laboratory detection limits for most of the monitoring period. The data are included in Appendix A **Table A13**.

The following were observed from the stream water sites' data:

- All sites had continuous exceedance of the limits for ammoniacal nitrogen (NH_3) with respect to the strict aquatic ecosystems guidelines of 0.007 mg/L, however the results are well below the proposed limit of 1.6 mg/L. Due to the agricultural land use in the upstream catchment it is unlikely that the in-stream quality will be able to achieve a value of < 0.007 mg/L.
- The turbidity and suspended solids levels also constantly exceed the WUL limit value of < 5 NTU and <25 mg/L respectively. However, the majority of the samples, except for KS10 with a maximum level of 348 mg/L suspended solids measured, and turbidity of 195 NTU, are well within the proposed limit values of 120 mg/L and 150NTU. It is likely the high turbidity is due to low flowing rivers and agricultural activities in the upstream catchment.
- Site LS08, on the nonperennial unnamed tributary west of the three stockpile areas shows that there is some non-point source contamination occurring during rainfall events, with elevated Total Dissolved Solids (2.264 mg/L) and sulphate (1,538 mg/L) measured in January 2021.
- Site KS10 showed elevated sodium and chloride, with maximum values of 34.1 mg/L and 99.8 mg/L respectively.
- pH for the majority of samples was within the limits of 6.5 to 7.8, with the lowest pH of pH 5.8 measured at KS20.

7.3 Dam water samples

The results of dam water quality samples and the PCD water quality samples are presented for the 2019 year and 2020 Quarter 1 below.

7.3.1 2019 Water Quality results

The results of the dam's samples taken from December 2018 to November 2019 period are shown in **Tables A1** to **A7**. The exceedances against the IWUL limits are highlighted. All the water quality constituents for dam water samples exceeded limits throughout the annual monitoring period except for sulphate and nitrite. Maximum turbidity exceeding the IWUL was reported at In Pit 5 (2 918 mg/l). Maximum non-compliant constituents were reported for RAP-WTP: EC (1 083 mS/m), Na (165 g/l), Cl (176 mg/l) and TDS (702 mg/l).

BWQ6 reported the maximum non-compliant suspended solids (2 681 mg/l) in the November 2018 to December 2019 monitoring period.

7.3.2 2020 Quarter 1 results

The results of the dam's samples taken throughout quarter one (December 2019 – February 2020) period are shown in **Tables A1** to **A12.** The exceedances against the IWUL limits are highlighted. The water quality constituents for dam water samples that exceeded limits are pH, turbidity, dissolved oxygen, EC and faecal coliforms. Turbidity exceeded the IWUL at over half the sites. Non-compliant dissolved oxygen was reported for BWQ6, BWQ1, BWQ7, BWQ8 and KFPD, non-compliant pH for BWQ01, non-complainant EC for BWQ6 (44mS/m) and non-compliant turbidity for BWQ1, BWQ6, BWQ8 and KFPD. Faecal Coliforms were non-complaint for the monitored dam sites: BWQ1, BWQ7 and BWQ6 reporting the highest count (470 CFU/100ml)

Pollution control dams reported exceedances in sulphate above the 200 mg/l limit for PCD 2, PCD 4 and in PIT 5. In PIT 5 reported the highest sulphate concentration (524 mg/l). Calcium, manganese and EC were non-compliant for PCD2 and In PIT5, with In Pit 5 reporting the highest of these parameters.

7.3.3 2021 Results (January to May 2021)

The results for the dam water samples for the period January to May 2021 indicate that in almost cases the water quality was within the limits set. This is likely due to the rainfall during this period. The data are included in Appendix A **Table A14**.

Iron at sites BWQ1 and Koos Pretorius Farm Dam were elevated with maximum levels of 4.5 mg/L and 3.2 mg/L respectively. The source is possibly from run-off during rainfall events from agricultural lime addition.

Elevated turbidity and suspended solids were noted in almost of the samples with the highest levels of 78 NTU and 205 mg/L respectively being recorded at BWQ1.

Elevated chloride (88 mg/L) and sodium (32 mg/L) were measured at Site BWQ7.

7.4 Pan water samples

A few pans held water throughout the monitoring period some of which are supplied by surface flow, groundwater, and springs. The results for the 2019 year and 2020 Quarter 1 are presented below.

7.4.1 2019 Water quality results

Over December 2018 to December 2019, the results of the pans samples are shown in **Table A10** and **Table A11**. The exceedances are highlighted. All pans are non-compliant with ammoniacal nitrogen limits, and most with dissolved oxygen, turbidity and suspended solids. Several pans had non-compliant low pH, high dissolved iron or both.

Pan 13 continues to have some of the highest constituents reported such as TDS (461 mg/l), EC (56 mS/m), chloride (61.9 mg/l), iron, alkalinity, sodium, and manganese. The lowest dissolved oxygen reading was also reported at PAN13. The lowest pH which fell outside the WUL limit is at PAN09 with a pH of 5.41. Turbidity was the highest at PAN05 (257 NTU).

7.4.2 2020 Quarter 1 results

The results of the pans samples over December 2019 to February 2020 are shown in **Table A12** with exceedances highlighted. All pans were non-compliant for ammoniacal nitrogen (NH3) and turbidity limits. Several pans were non-compliant for dissolved manganese, TDS, EC, sodium, chloride, dissolved oxygen, ammoniacal nitrogen (NH_{4+}) and orthophosphate (PO_4). This is expected at this time of year as the pans are still wet from the rainy season (October – April), however the chemicals have started to concentrate as the pans dry up.

Pan 13 has the most non-compliant constituents reported with some of the highest concentrations including TDS (642 mg/l), sodium (102 mg/l), EC (87.5 mS/m), chloride (145mg/l), NH_{4+} and NH_3. The lowest dissolved oxygen reading was recorded for PAN12, PAN06, PAN08, PAN12 and PAN13 at 0.5 mg/l. Manganese non-compliance was recorded at PAN08 (0.5 mg/l).

7.4.3 2021 Results (January to May 2021)

The results for the pan water samples for the period January to May 2021 indicate that in almost cases the water quality was within the limits set. The exception was for turbidity and suspended solids, with maximum levels of 191 NTU and 450 mg/L measured respectively. However, these results are well within the proposed limit values and are expected for pans in this area. Higher turbidity and suspended solids, as well as salinity, is likely during the drier periods. This is however a natural phenomenon. The data are included in Appendix A **Table A15**.

Pan 13 had the highest chloride and sodium levels of 83.2 mg/L and 44 mg/L respectively.

7.5 Water quality requirements associated with the conveyor options

The preferred conveyor route utilises the existing crossing of the Klein-Komati River so as to minimise impact to the receiving environment. The conveyor route has been designed to minimise spillages through storm water management measures, covering of conveyor over sensitive areas and specific processes that assist with sediment control at the transfer stations. No additional load is therefore envisaged to the receiving environment due to the different conveyor options. The current and proposed water quality sampling points are sufficient to cater for the different conveyor options. Pollution prevention measures are implemented in the form of erosion control and sediment traps.

8.0 STORM WATER MANAGEMENT

8.1 Rainfall

Several probability distributions were fitted to the recorded 24-hour maximum annual storm events extracted from the rainfall data for the Roodepoort rain station (No. 0475637 1). The Log Pearson III distribution (LP3) fitted the data best with a R^2 coefficient of 0.983. The Log Pearson Type 3 distribution fit is shown in Figure 28 below. Storm depths for the various specified recurrence intervals, based on this fitted distribution, are presented in Table 12.

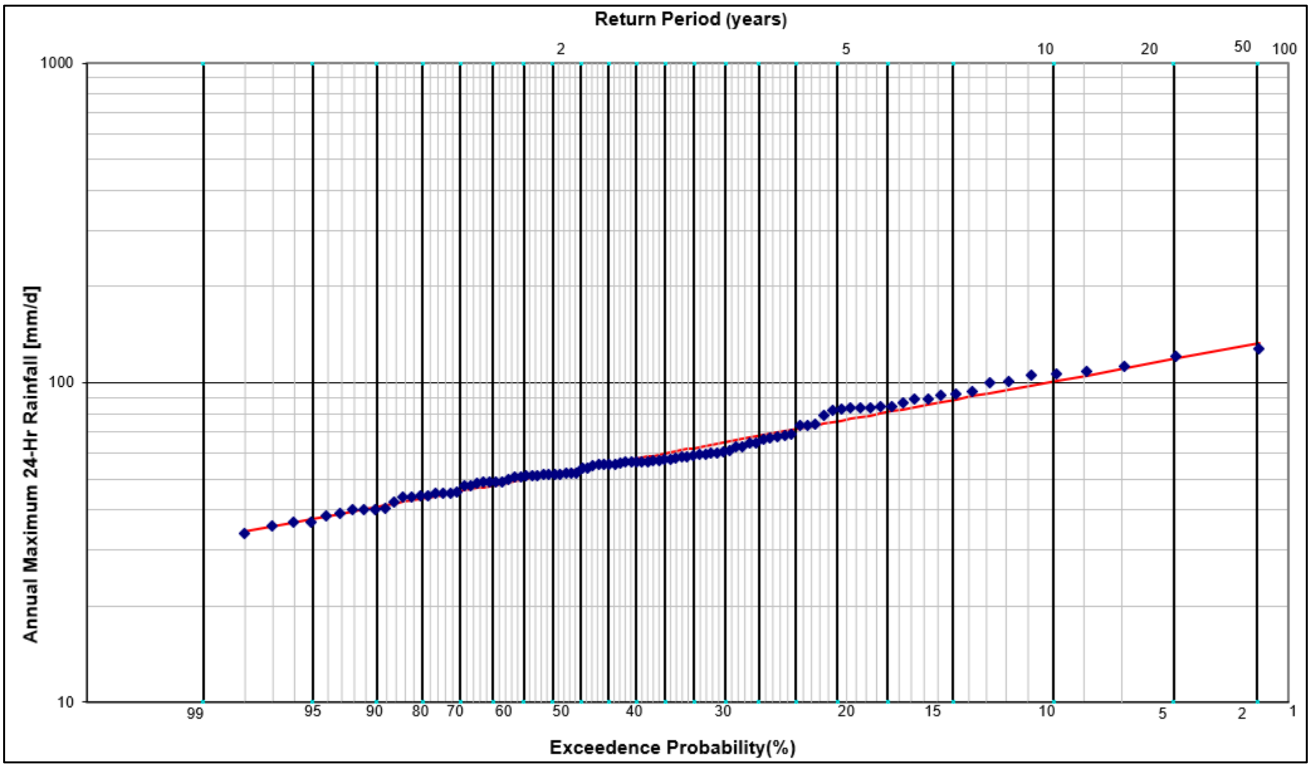


Figure 36 : Log Pearson Type III distribution fit of the rainfall dataset.

Table 21: 24-hour storm rainfall for various annual recurrence intervals

Return Period in years	2	5	10	20	50	100	200
LP3 Distribution (mm/d)	58	76	88	101	118	132	147

The 1:50-year return interval rainfall depth for the site is 118 mm, and the SCS-SA rainfall distribution is Type III. The resulting rainfall intensity distribution is shown in Figure 29.

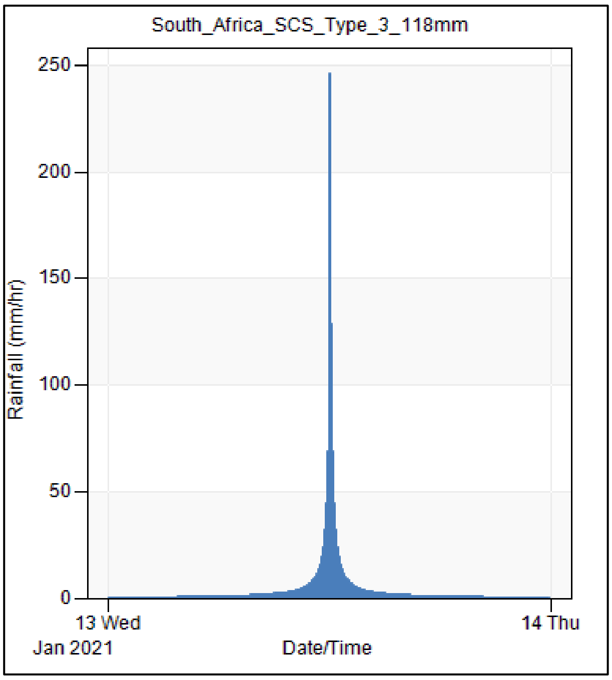


Figure 37: 1-in-50-year return interval SCS-SA Type III design rainfall intensity distribution.

8.2 Summary of current storm water management and the receiving environment

The current mining area consists of processing plants, a waste rock dump facility and open cast pits. For the pits, mining occurs uphill towards the north. The West Block mining area is flanked by the Leeuwbank Spruit on the west running to the south and the Klein Komati running on the west. The East Block mining area is flanked by the Klein Komati on the west and the Driehoek Spruit running on the west. The mine area is therefore, drained by three streams. The plant and waste rock dump location are located south of both mining areas on the north-west side of the Klein Komati.

Storm water run-off from the waste dumps located around the pits will drain into the pits and be pumped to the PCDs (together with possible dewatering water). A dirty water channel running parallel to the Klein Komati River will carry the dirty water from the Tip and Primary Crusher, Mobile Equipment yard, discards road and discards stockpile area. The dirty water channel running northeast carries dirty storm water from the MRF through a silt trap to Dam 2. The description of these reporting catchments are as follows, refer to Figure 30 for the topography of the area and Figure 31 for the general surface water flow directions.

8.2.1 Leeuwbank Spruit (X11C)

The Leeuwbank Spruit is the eastern most catchment. The stream flows in a southernly direction and joins the Blesbok Spruit to the south of the project. The name then changes to the Witkloof Spruit before flowing into the Nooitgedacht Dam. The catchment area of the portion of the river, which may be impacted upon by the mine is 31.2km2. This catchment has six (6) farm dams and four (4) pans.

8.2.2 Driehoek Spruit (X11D)

The Driehoek Spruit is on the western boundary of the identified coal outcrop. The stream flows in a southernly direction and joins the Klein Komati River 4 km after the mining area. There are eight (8) farm dams and four (4) pans in the identified catchment. The catchment area, which may be impacted upon by mining is 36.43km^2 in size.

The Klein Komati Spruit is the control catchment, which is likely to be impacted upon by the mining activities. The catchment will include open pit activities as well as possible mining infrastructure. The stream flows in a southernly direction and joins the Driehoek Spruit 5 km downstream of the project area. The catchment area is 23.40km^2 at the point where the mine activities may affect the stream.

8.2.3 MRF

The current MRF is a lined area constructed with subsoil drainage. Stormwater from the MRF is collected by a series of toe paddocks and toe paddock cross walls intended to collect runoff from the side slopes of the MRF (Arup (Pty) Ltd., 2017). This water drains to Dam 2 via storm water channels.

8.2.4 Plant infrastructure area and terraces

The plant infrastructure area houses numerous offices, beneficiation and loading facilities. The purpose of the plant infrastructure area is to facilitate loading and haulage of coal to an export rail siding for subsequent supply of coal to local Eskom power stations. The area of the plant infrastructure area is 37.8 ha. Dirty storm water is routed to Dam 4.

Terraces have been constructed to house various buildings, stockpiles, and process and distribution facilities. RoM and product stockpile areas are lined and are equipped with subsoil drainage systems.

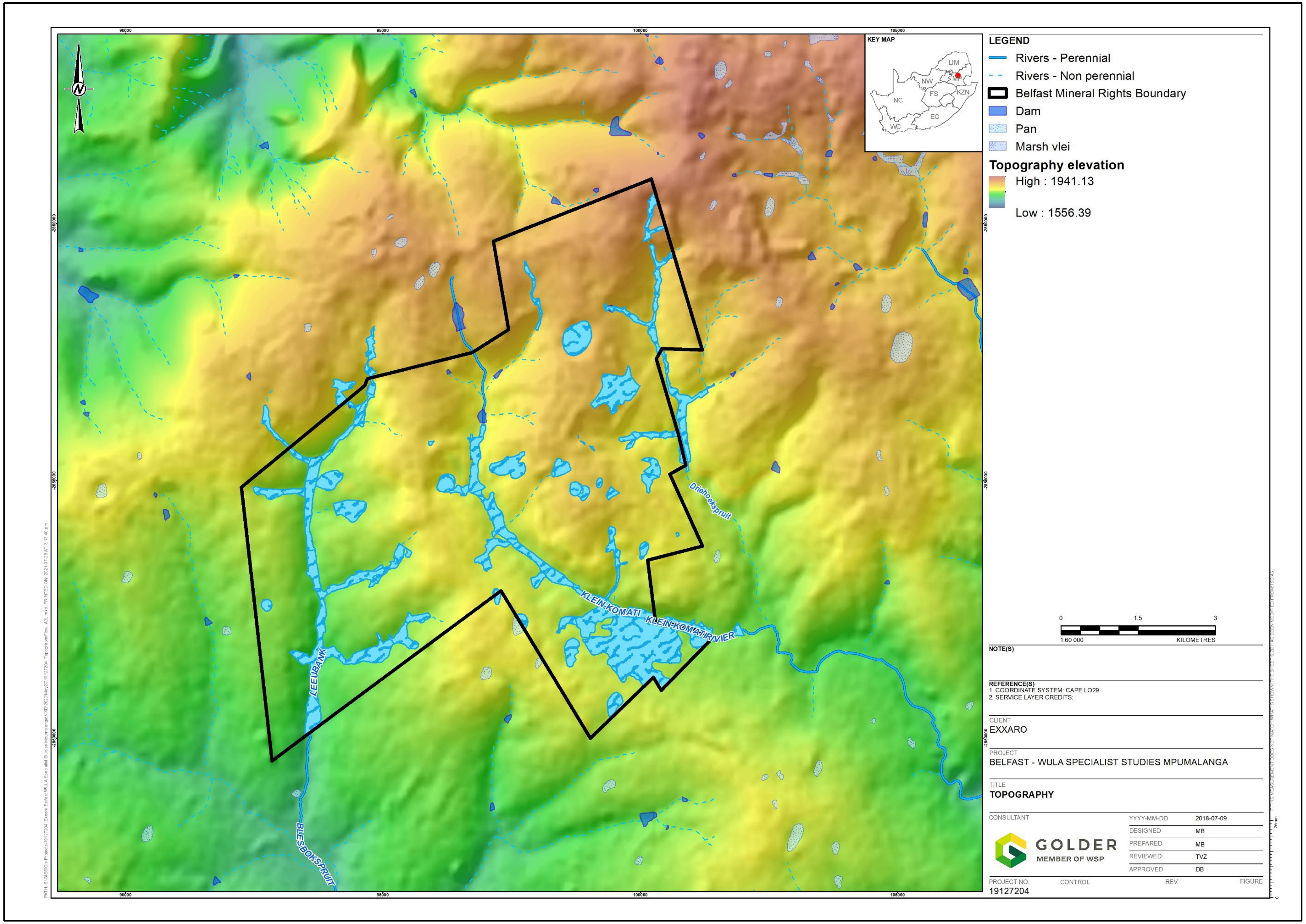


Figure 38: Topography around the project area

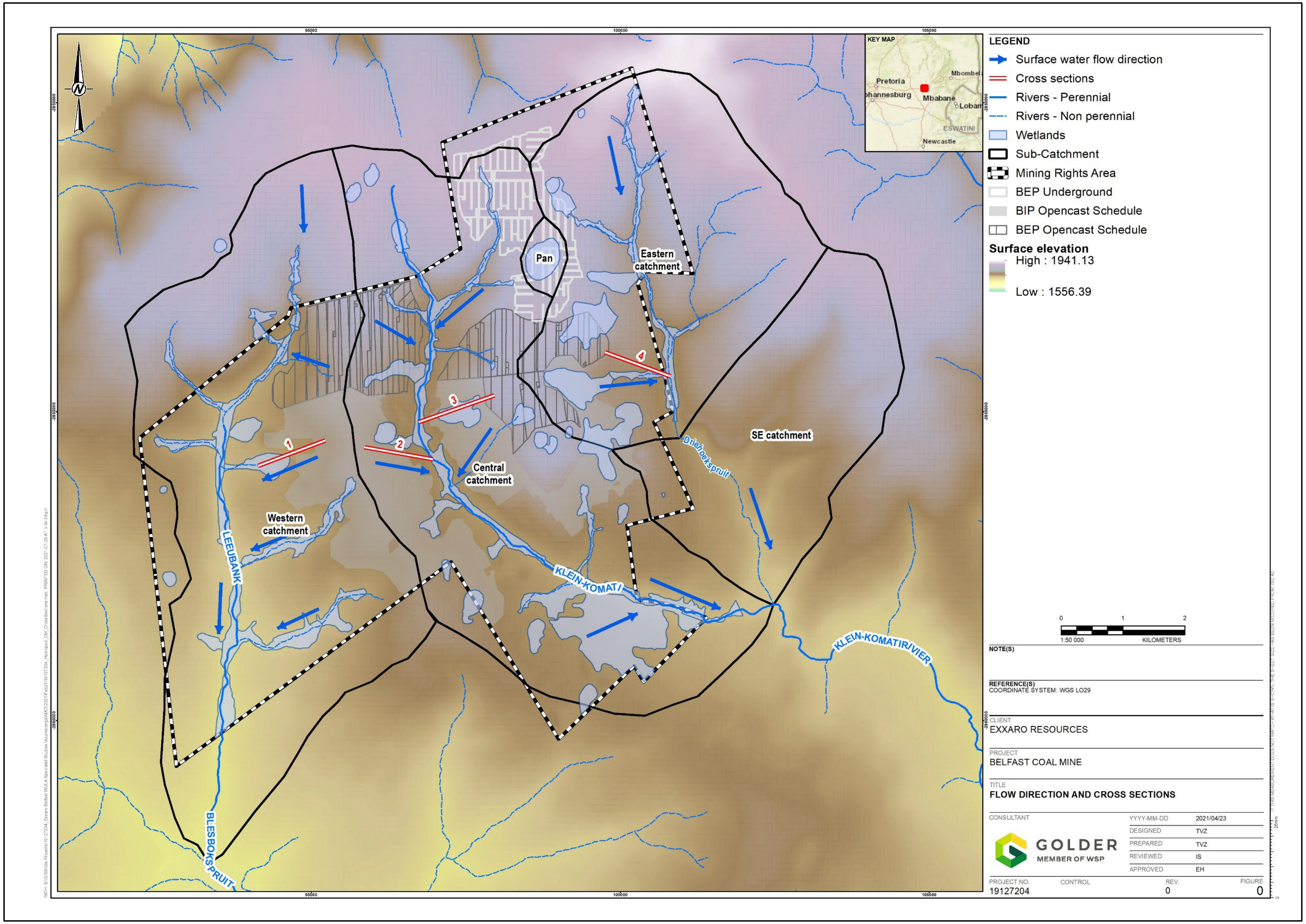


Figure 39: Surface water flow direction

8.3 Stormwater management plan around the new mine residue facility

Jones and Wagener have been appointed to undertake the design of the new mine residue facility (MRF) which has its own dedicated stormwater modelling approach. There is a current preliminary report detailing the approach (Jones and Wagener, 2021).

Currently the discard from the processing operation is being sent to the area west of Dam 2 as indicated on Figure 5. The current MRF is a lined area constructed with subsoil drainage. Stormwater from the MRF is collected by a series of toe paddocks and toe paddock cross walls intended to collect runoff from the side slopes of the MRF (Arup (Pty) Ltd., 2017).

Due to the increase in mining activity, a larger MRF will be required. Jones and Wagener has been commissioned by Exxaro to conduct the design of the new MRF. Figure 3 shows the design layout of the MRF expansion as taken from Jones and Wagener, 2021. The discard facilitiy will be designed to accommodate a total capacity of 3.9 Mm^3 of discard and will consist of a North and South stockpile of 16.39 ha and 9.25 ha respectively. Deposition on the new MRF will commence in 2031 on the southern section and will reach full capacity in 2034 whereafter deposition will commence on the northern section until 2039 (Jones & Wagener, 2021).

A storm water channel will be located along the boundary of the MRF and dirty storm water will be routed as to a sump situted at the foot of the north stockpile area. The MRF will be located within the rehabilitated pit 5 boundary area and seepage from the MRF is expected to report straight into the pit. The decant management for the western pit area will therefore include seepage from the MRF area.

8.4 Stormwater management plan for the BEP open cast mining area

The objective of this task was to develop a pragmatic stormwater management plan for collection and discharge of clean storm water approaching the opencast mining operation at the proposed BEP area. The philosophy adopted in this study follows best practice for mine storm water management. The intention is to divert clean water away from the opencast mining area to prevent this water entering the workings thereby protecting the mining operations and to reduce clean water contamination. The proposed clean water management measures would manifest in a phased layout of clean water diversion channels sized to suit governing regulations and discharging to the environment in a controlled manner. The contaminated mine water is collected within the opencast pit and handled as part of the pit water management.

The following key tasks were undertaken:

- Delineation of clean sub-catchments.
- Location of alignments / layouts of clean stormwater conveyance channels.
- Determination of cross-sections and vertical profiles of stormwater conveyance channels.
- Determination of cross-sectional dimensions of clean stormwater channels to convey stormwater runoff resulting from the design storm event as stipulated in regulations.

The guiding principles for the above work are taken from government regulation No. 704 of 4 June 1999 – Regulations on use of Water for Mining and related activities aimed at the Protection of Water Resources (National Water Act No. 36 of 1998) (Department of Water Affairs and Forestry, 4 June 1999), specifically clause 6. The regulation is commonly referred to as GN704.

The United States Environmental Protection Agency Storm Water Management Model (EPA SWMM) was used to construct the rainfall-runoff model – refer https://www.epa.gov/water-research/storm-water-management-model-swmm. The Computation Hydraulics International (CHI Water – www.chiwater.com) PCSWMM model was used as the software interface for coding and running the EPA SWMM model. The model uses the US Soil Conservation Service rainfall distributions (Type I to Type IV), adapted for South African conditions (Schimdt & Schulze, 1987a). The project falls in a region of South Africa having a Type III rainfall intensity distribution.

Available 5 m interval topographic contour data was used for the digital elevation model (DEM). Higher resolution contour data provided by the client does not cover the required area to conduct the analysis. The contour data was processed in GIS software to obtain a DEM of the study area. The hydrological model was developed in PCSWMM incorporating the DEM. This DEM was used to obtain watershed boundaries defining the local sub-catchments within the model, as well as for determining required geometric characteristics of the sub-catchments.

A phased channel layout was designed to intercept clean water runoff from the corresponding sub-catchments separately. The design rainfall analysis (Table 12) was used to develop rain gauges which were then applied to the sub-catchments. The analysis was run using the 1-in-50-year recurrence interval storm event following the GN-704 regulation. Land-use and geometric parameters, relating to the sub-catchment response to rainfall, were applied to the sub-catchments. The model was run, and necessary adjustments made in an iterative process to optimise the channel sizes to ensure that the channels do not overtop during a 1-in-50-year storm event, but also to ensure that the channels are not unduly oversized.

The SWMP has separated the LoM into four separate phases so that the construction of the stormwater infrastructure can occur in a phased approach. Each phase is determined by the year of mining planned and are listed below:

- Phase 1: mining to occur in 2031.
- Phase 2: mining to occur in 2032 -2033 – Phase 1 channels will be mined through, and the collection channels extended.
- Phase 3: mining to occur in 2034 -2035 – Phase 2 channels will be mined through, and the collection channels extended.
- Phase 4: mining to occur in 2036 to end-of life – Phase 3 channels will be mined through, and the collection channels extended.

This phased approach is presented in Figure 34 to Figure 38 below.

8.4.1 Storm water input parameters

The following paragraphs present descriptions and data used for determining input parameters required to conduct the event-based rainfall-runoff simulation:

Sub-catchment parameters

Roughness of sub-catchments and channels affect time of concentration of runoff from the sub-catchments, which in turn influences the peak flow reporting from the catchment. Roughness estimations for different land uses are estimated in studies and published in tables in literature. The data in published tables distinguish between roughness values for overland flow (sheet flow) and channelized flow (concentrated flow). (Chow, 1959) and (United States Environmental Protection Agency, May 2017) were consulted for roughness estimates for the sub-catchments and channels. Based on the predominantly agricultural land use, the impervious surface percentage is assumed to be 0% i.e., infiltration is simulated over the full extent of the sub-catchments. The “manning’s n”, a surface roughness factor for hydraulic calculations, for the natural catchment was taken as 0.03. The sub-catchment input data details are given in APPENDIX A.

Initial abstractions remove water from the runoff in the form of depression storage and infiltration. Exact determination of depression storage is not practical and is based on estimates and experiential judgements. However, the magnitude thereof is insignificant in the large design event used for these models, and therefore high-level estimates are adequate, and are taken in the order of 0.5 mm for the sub-catchment surface. The EPA-SWMM model offers a variety of infiltration models. For this model, the Modified Green-Ampt model was selected. It takes account of soil hydraulic characteristics based on soil type. The model uses three parameters:

- Suction head (mm)
- Conductivity (mm/hr)
- Initial deficit (fraction)

The soil type of the natural land is interpreted to be a sandy clay loam based on the South African soil parameters map (Water Research Commission, 2012). The parameters in Table 13 were therefore applied to the infiltration model. The soil parameters required for the estimation of infiltration within the stormwater model was obtained from the Soil, Land Use, Land Capability Assessment for Exxaro Belfast Project (Viljoen and Associates, 2009). The report states that the top-most spoil layer, Orthic A-Horizon, is characterised by a low-density structure and texture of approximately 65% sand, 20% silt and 15% clay with drainage properties in the order of 10 mm/hr. The distribution is best described as a sandy clay loam which correlates to the parameters based on the South African soil parameters map (Water Research Commission, 2012). However, the associated saturated hydraulic conductivity of 10 mm/hr given in the report does not correlate to the conductivity associated with the sandy clay loam value of 3.0 mm/hr, a preliminary estimate, given in the estimation of Green-Ampt Infiltration Parameters, in the absence of in-situ detailed studies (United States Environmental Protection Agency, May 2017). The discrepancy can be explained by differences in compaction (density) and the locally measured hydraulic conductivity should be used. Based on the value of 10 mm/hr and the USEPA texture classification, the resulting soil parameter is best described as a loam.

Table 22: Provisional estimates of soil parameters for Green-Ampt Infiltration used in the stormwater model: Sandy Clay Loam (United States Environmental Protection Agency, May 2017).

USDA / USEPA Soil Texture Classification	Avg. Capillary Suction	Saturated Hydraulic Conductivity	Initial Moisture Deficit for Soil (Vol. of Air / Vol. of Voids, expressed as a fraction)
	(mm)	**(mm/hr)**	**Dry Soil Climates**
Loam	88.9	10.0	0.250

The average physical slopes of the sub-catchments were determined from the DEM.

8.4.2 Storm Water Conveyance Channel Input Parameters

All clean channels are designed to be earth-lined and vegetated, trapezoidal channels with side slopes of 1:1.5. The manning's n for the channels was taken as 0.03 based on literature findings (Chow, 1959). The channels are designed to be compound channels which include (minimum) one-meter-high protection berms on the downslope side of the channels to further protect the opencast workings from flood events larger than the specified design event. The eventual design intent will be that the material excavated from the channel, will be used to construct the berm in compacted layers. A cross-sectional view of the clean channels is presented schematically in Figure 33 below.

The channel slopes are determined from the natural topography determined from the DEM. In events where the channel slope is negative or too low, the channel slope has been increased so that the water in the channel flows by gravity. The runoff velocity within earth channels should not exceed 1 m/s to avoid the risk of erosion within the channel (to be verified by geotechnical analysis in detail engineering design). As the topography is steep, with slopes above 4%, the flow velocities within the channels does exceed this provisional limit in most cases. It is recommended that further detailed design of these channels consider stepped channels to reduce the channel slope and shear forces / flow velocity within the channels, reducing the risk of erosion.

The clean channels discharge the runoff collected toward the natural environment at terminal points of the channels. These outfalls must be designed with energy dissipators, such as stilling basins, steps and/or chute blocks, to significantly reduce the velocity from the channels as to prevent erosion at the discharge location.

The channels, colour-coded according to their corresponding phase are shown in Figure 34 to Figure 38 below and the channel input parameters are shown in APPENDIX A.

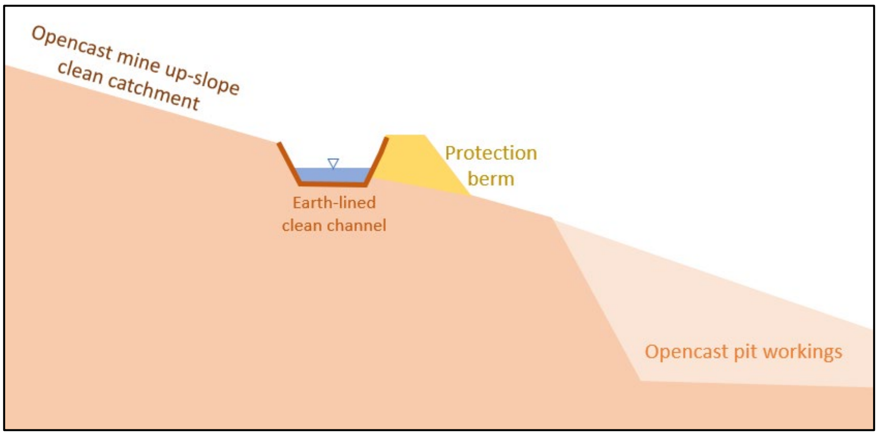


Figure 40: Bench channel cross-section schematic

8.4.3 Post-closure consideration

The SWMP for the BEP opencast mining area does not consider the post-closure scenario. At post-closure stage, it is best-practice to shape the mining spoils to suit the natural topography so that the area is free-draining. In this event, the mining spoils are to be shaped and capped and the constructed clean channels are to be decommissioned so that the runoff drains towards the natural drainage points of the environment. Further design consideration (predicted post-closure landform based on extraction, mine plan and bulking factors) is recommended to ensure that post-closure scenario stormwater management is considered in the project life-cycle planning and budgetary provision.

8.4.4 Model Layout

The model was structured to represent the phased approach to mining at the opencast pit. The model incorporates the mining activity as a phased approach using a two-year interval of the LoM. There are four phases over the life span of the mining, with each phase directing potential clean water running towards the respective phased opencast pit away from the site. The collected clean water from the channels is diverted to the environment’s lower lying areas towards the Kleinkomati stream and other smaller unnamed streams.

The key in Table 14 applies to the symbols use in the model imagery to represent the stormwater management of the BEP opencast mining area:

Table 23: Key to Model Symbols

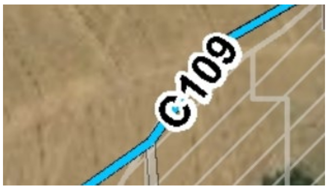
SYMBOL	DESCRIPTION
	Clean sub-catchment
	Phase 1 earth-lined clean channel
	Phase 2 earth-lined clean channel
	Phase 3 earth-lined clean channel
	Phase 4 earth-lined clean channel

Figure 34 shows the model layout and the sub-catchments which are relevant to the proposed infrastructure.

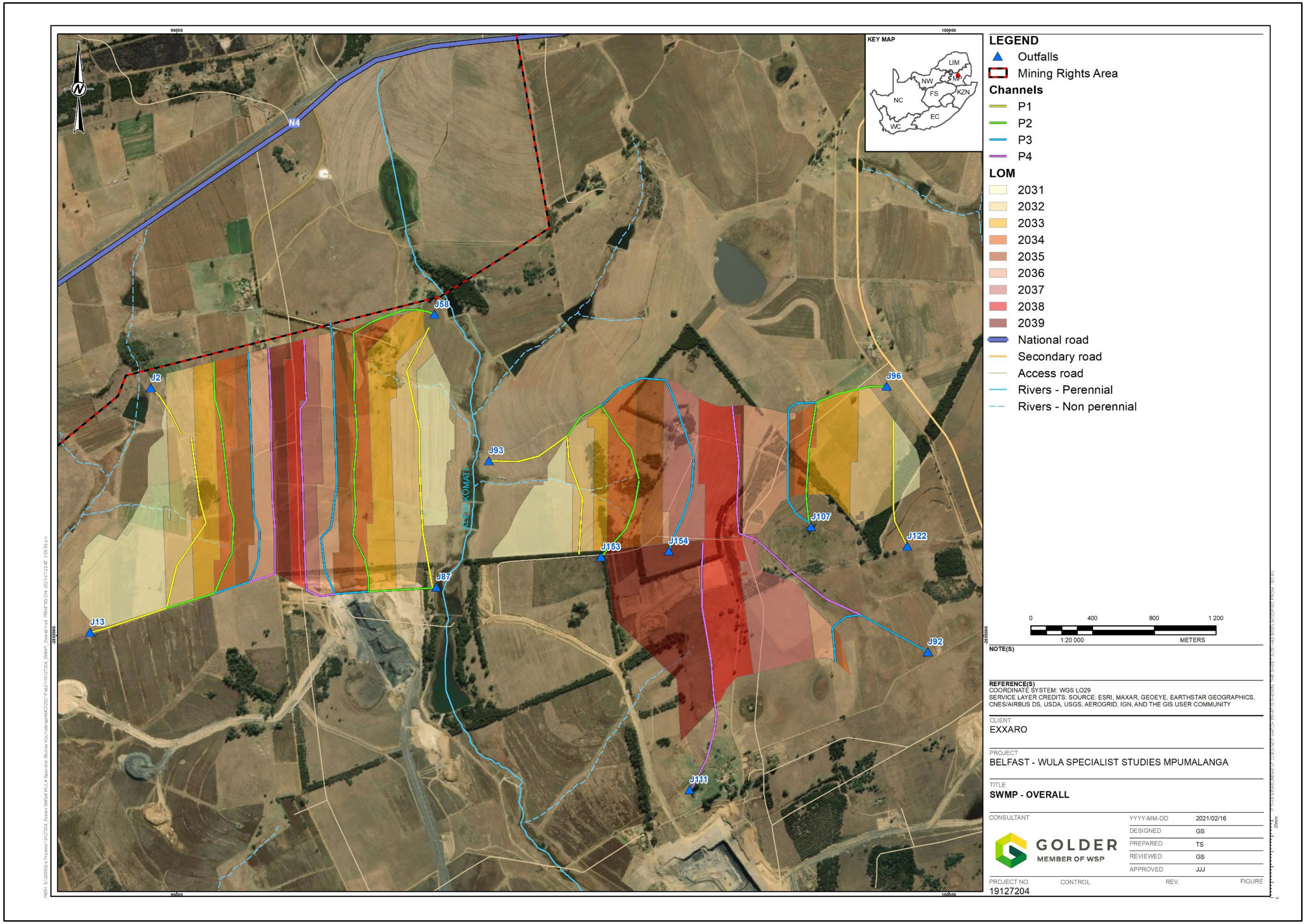


Figure 41 : Overall BEP opencast mine SWMP with the phased collection channels and opencast LoM area

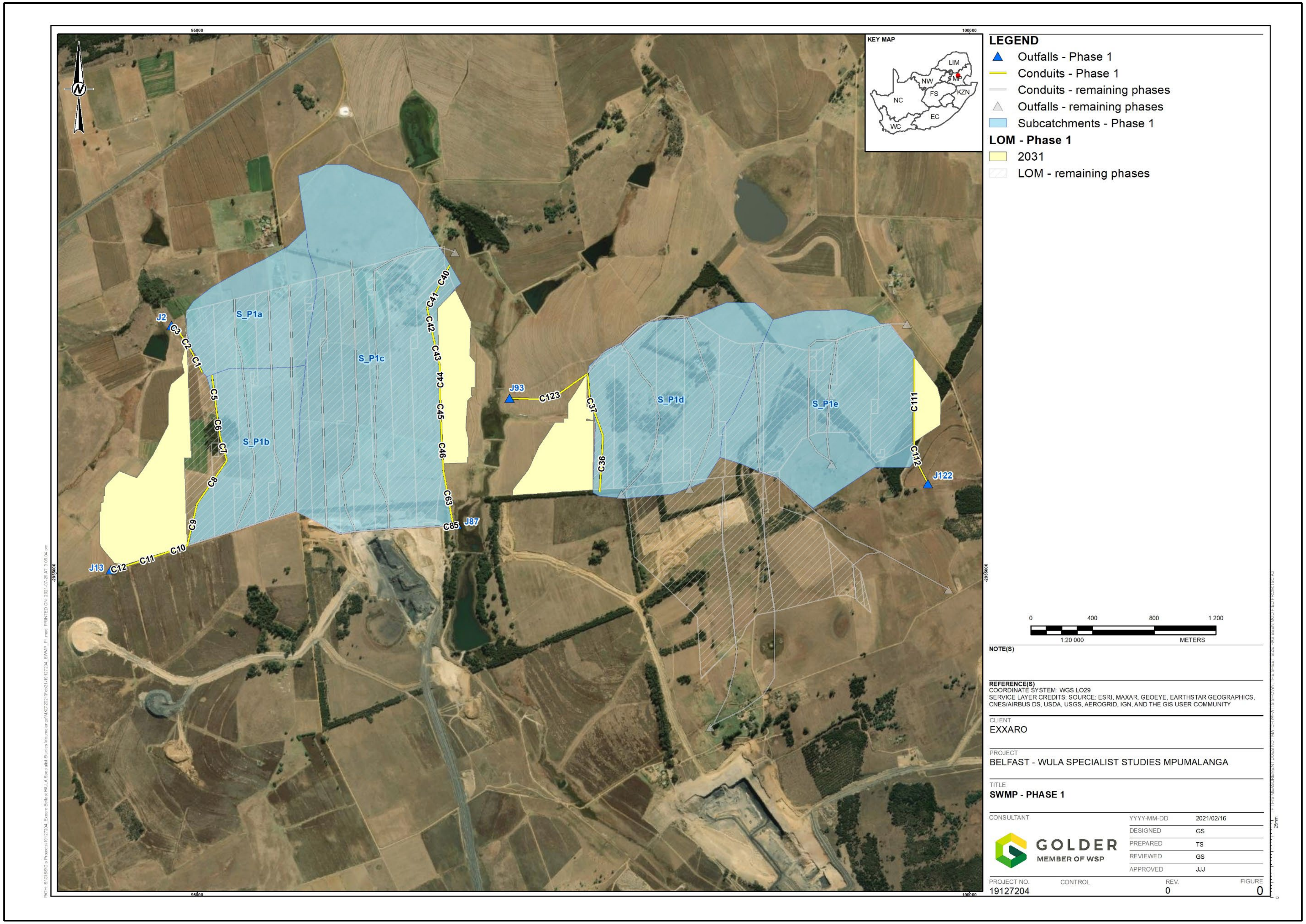


Figure 42 : Phase 1 BEP opencast mine SWMP indicating the clean channels, the reporting sub-catchments and the area to be mined

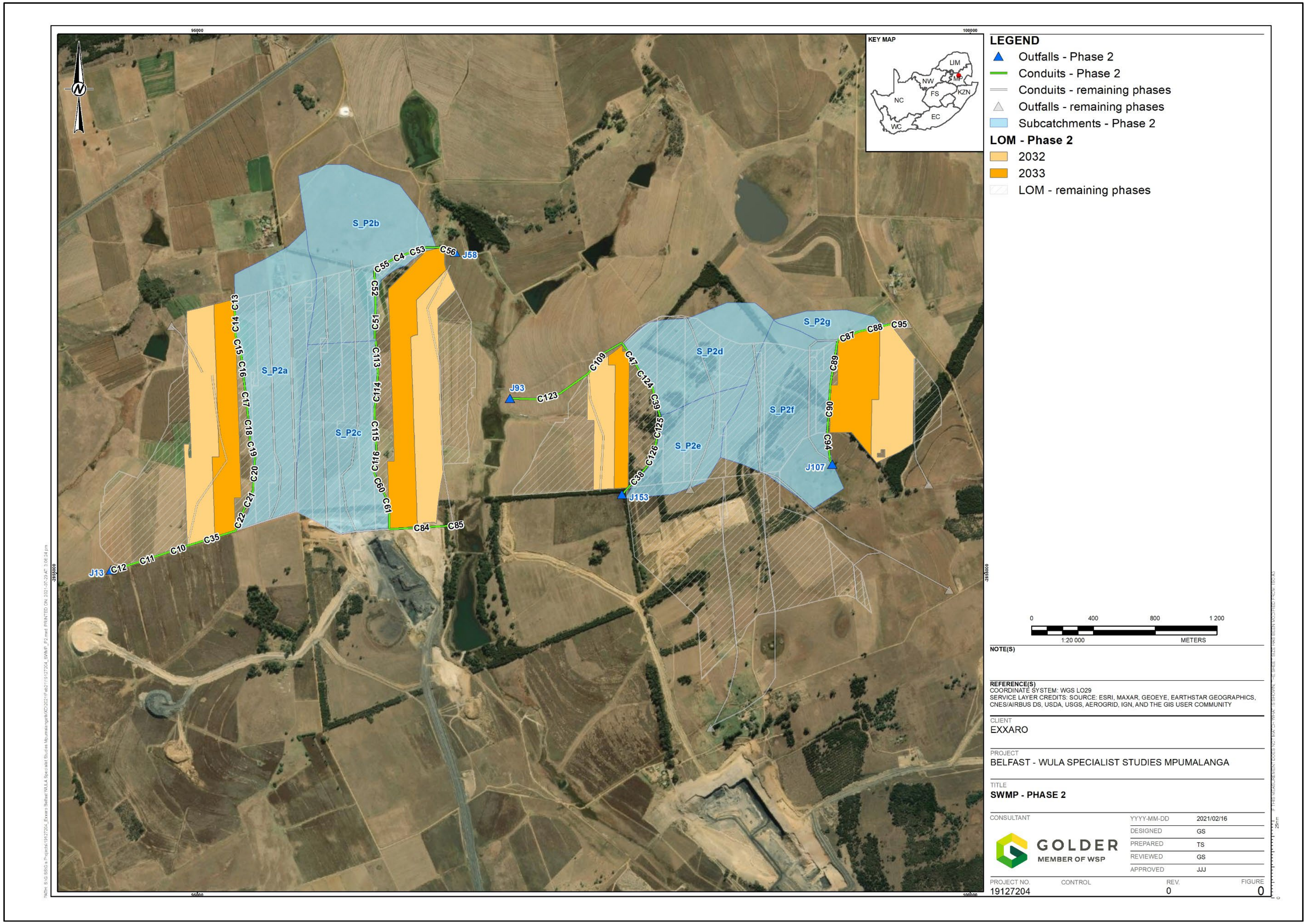


Figure 43 : Phase 2 BEP opencast mine SWMP indicating the clean channels, the reporting sub-catchments and the area to be mined

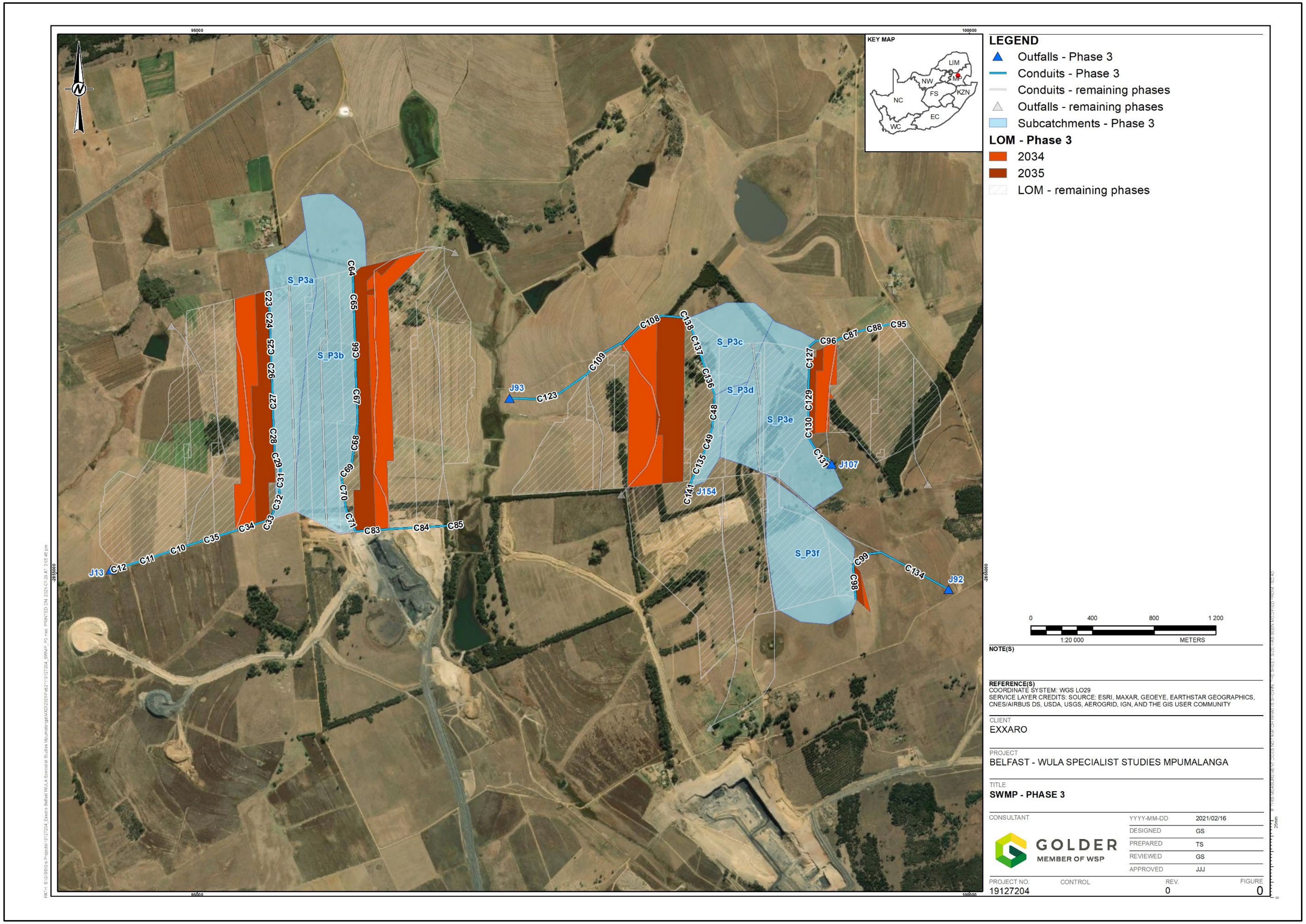


Figure 44 : Phase 3 BEP opencast mine SWMP indicating the clean channels, the reporting sub-catchments and the area to be mined.

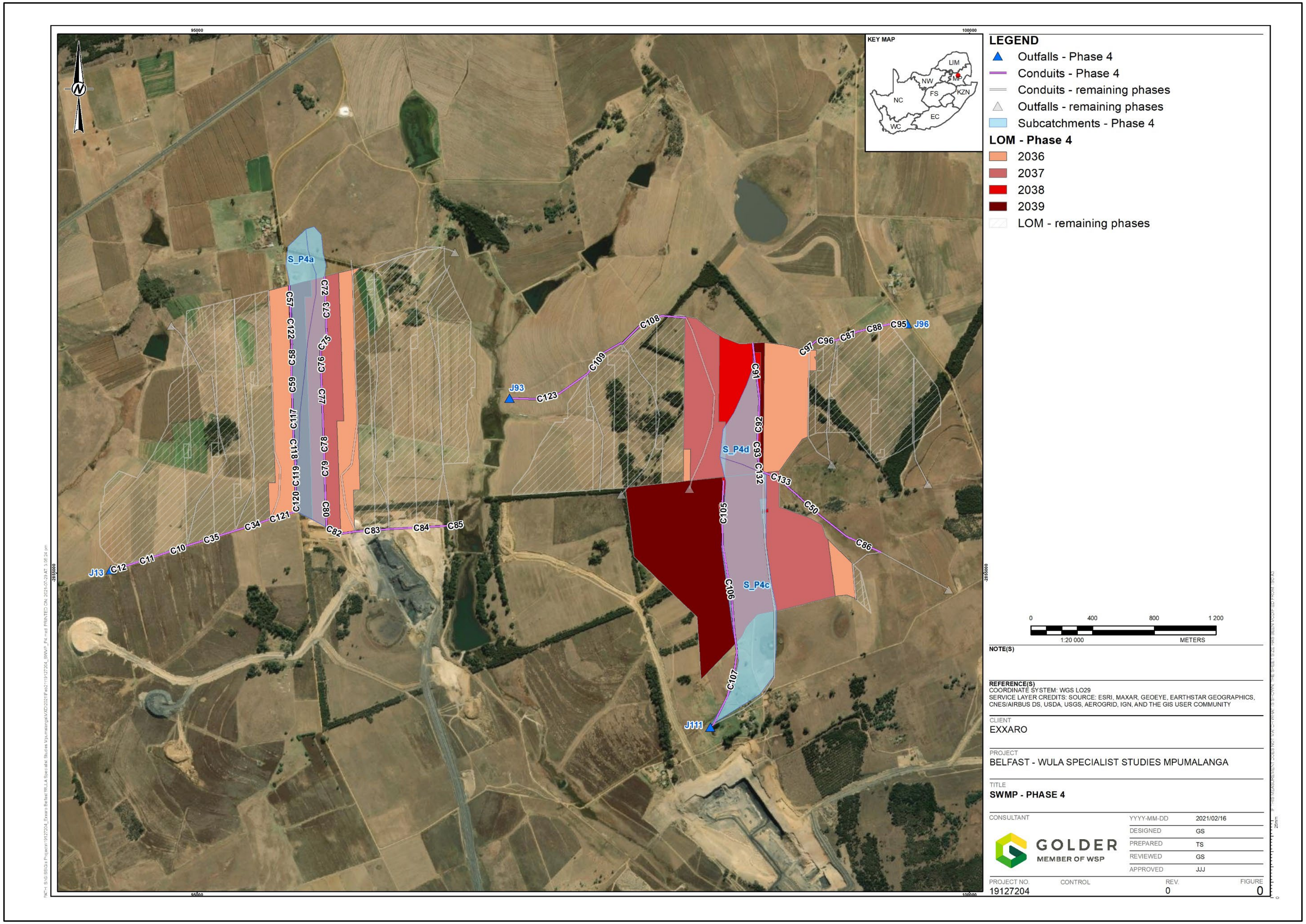


Figure 45 : Phase 4 BEP opencast mine SWMP indicating the clean channels, the reporting sub-catchments and the area to be mined.

8.4.5 Results

Detailed tables of results for the sub-catchments are presented in APPENDIX C. The channel sizes and the respective flow velocities and flow rates are given in APPENDIX D.

Discussion

In summary, the trapezoidal clean channels for Phase 1 were sized to be 1.6 m deep with a bottom width of 2 m. The Phase 2 and Phase 3 channels were sized to be 1.5 m deep with a bottom width of 1.5 m. The Phase 4 channels were sized to be 1.0 m deep with a bottom width of 1.2 m.

Due to the high flow velocities of the runoff in the clean, earth-lined channels it is recommended that energy dissipators be installed at the junction of channels as well as at the discharge points. A combination of drop chutes and stilling basins is recommended to reduce the energy for the runoff and hence reduce the flow velocities. Flattening of the channel slopes and construction of cascading gabion stepped structures will be required to reduce hydraulic energy of the stormwater in the channels, and selected sections including outer radius bends in the channels will required armouring with riprap or gabion mattresses backed with a geotechnical or synthetic filter.

The detailed engineering design phase must identify all necessary technical specifications and additional infrastructure required to give effect to a robust stormwater system at construction and operational phase. Further consideration is required for the post-closure stormwater management of the opencast mining area.

8.5 Stormwater management plan for the BEP underground ramp area

BVI Consulting Engineers (BVI) have developed a SWMP for the BEP underground ramp area. This section provides a summary of the SWMP as taken from BVI Consulting Engineers (BVI Consulting Engineers, 2020).

The BEP underground project area is situated inside a sub-catchment of the Driehoekspruit and has a surface area of 1 km^2. The catchment drains in a south easterly direction and enters a tributary valley of the Driehoekspruit. The area is divided into clean and dirty catchments, refer to Figure 39. The clean water system mainly consists of the open veld area north of the BEP underground development. Only the mine access control area, contractors' area, general parking and administration buildings are classified as clean water areas. All runoff from the clean water areas consist of overland flow and are diverted around the dirty water areas by means of diversion berms located along the north perimeter of the dirty water area. The runoff will follow its natural drainage direction into the Driehoekspruit, Figure 40.

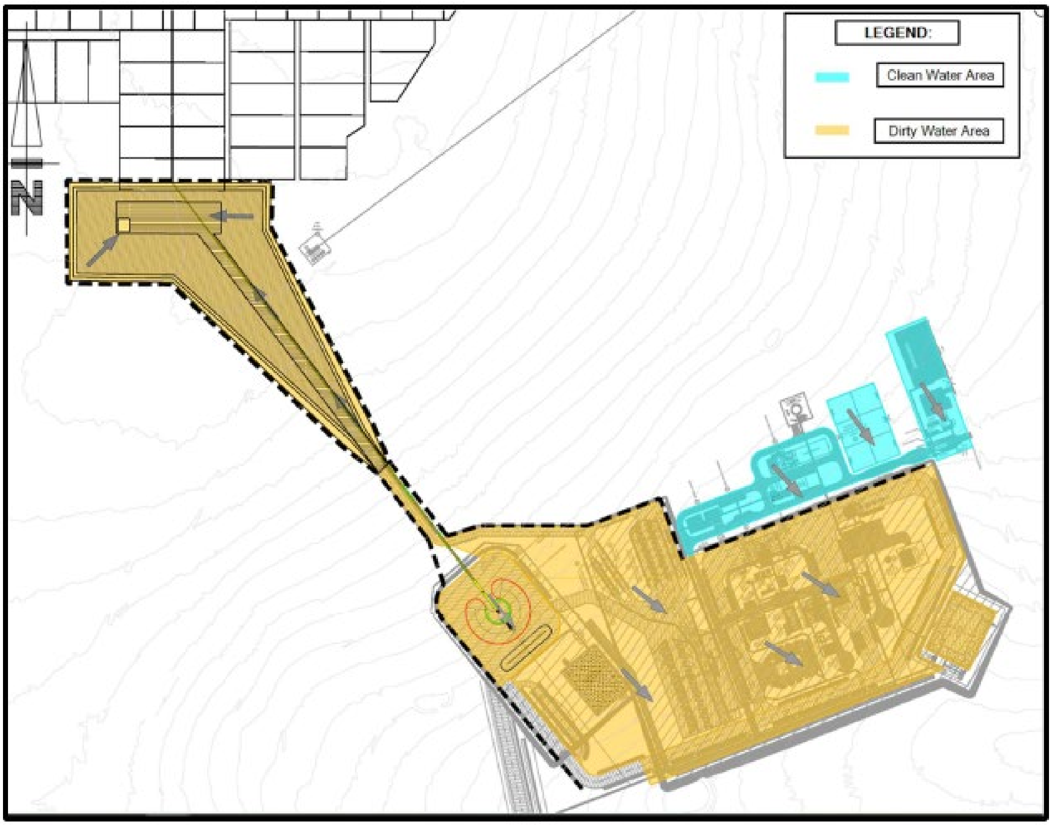


Figure 46 : Clean and dirty water areas (Source: BVI, 2021)

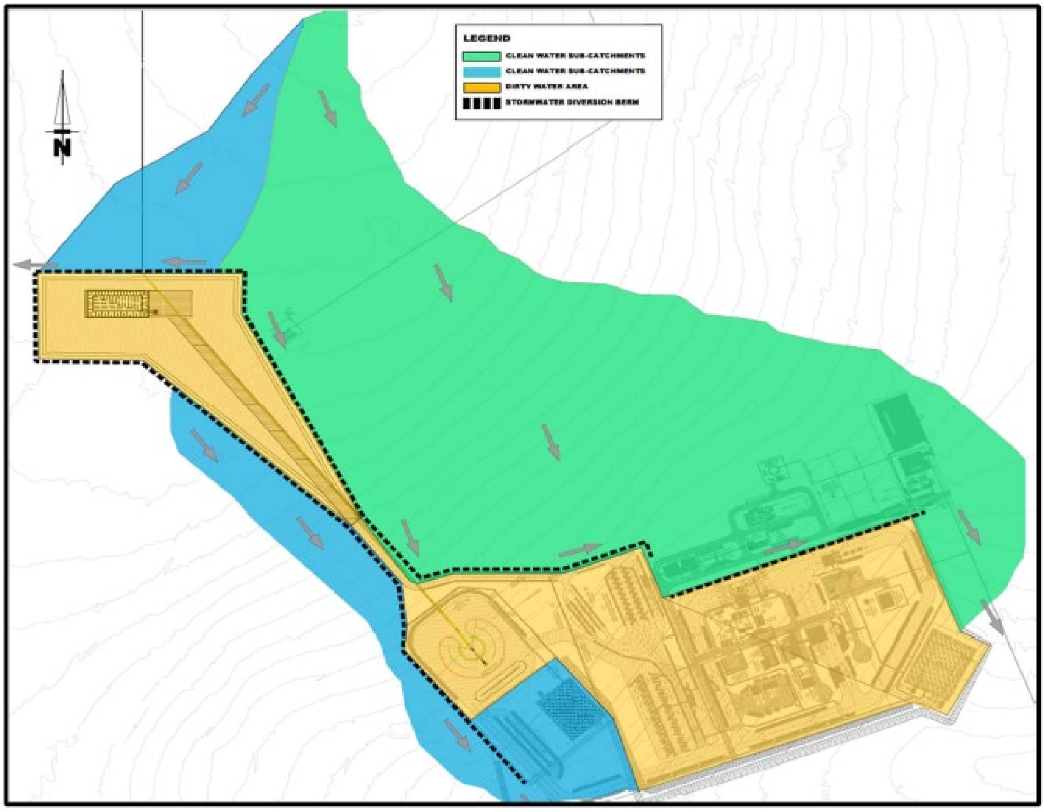


Figure 47 : Clean water area sub-catchment delineation (Source: BVI, 2021)

The dirty water system has been sub-divided into three sub-catchments that each drain into their respective PCDs. It is these catchments sizes and relevant characteristics that have been utilised in the sizing of the PCDs. The three dirty water sub-catchments are discussed below.

8.5.1 Dirty water sub-catchment D1

Refer to Figure 41 for the layout of the dirty water sub-catchment D1. D1 is the main infrastructure development area consisting of various activities and infrastructure that is considered to be potential contamination sources. Therefore, this area has been delineated as dirty area. The different activities and infrastructure include:

- Refuel bay.
- Lubricant storage bay.
- Diesel storage bay.
- Tyre change area.
- Tyre top-up area.
- Nitrogen facility.
- Compressed air building.
- Equipment parking.
- Workshops.
- Oil traps.
- Waste disposal area.
- Wash bay and water filling points.

The total catchment area excluding the BEP PCD is 196 110 m^2 and consists mostly of infrastructure. The dirty stormwater runoff from D1 reports to the BEP PCD.

8.5.2 Dirty water sub-catchment D2

Refer to Figure 42 for the layout of the dirty water sub-catchment D2. D2 includes the Run of Mine (ROM) product and emergency stockpile. A dedicated PCD will receive the contaminated stormwater runoff from this catchment. The total catchment area is 33 408 m^2 and consists mostly of stockpile area. Golder will assume that the area is made up of 80% stockpile and 20% flat area.

8.5.3 Dirty water sub-catchment D3

Refer to Figure 43 for the layout of dirty water sub-catchment D3. The total catchment area is 84 053 m^2 and is made up of the ramp area, i.e., the footprint of the ramp shaft that offers access to the underground mine, hence a sloping area. The dirty stormwater runoff from this catchment reports to a Flood Protection Dam.

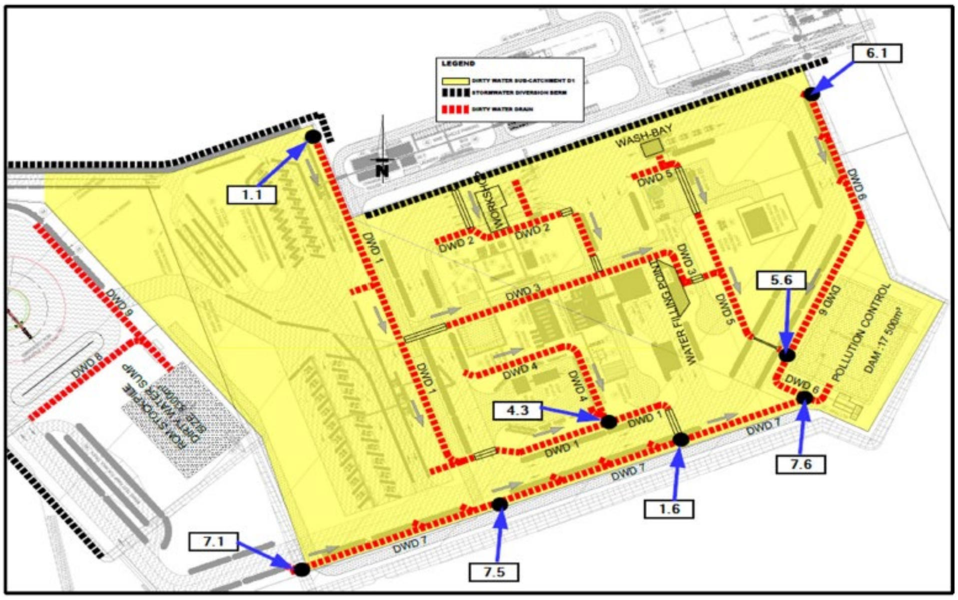


Figure 48 : Dirty water sub-catchment D1 (Source: BVI, 2021)/

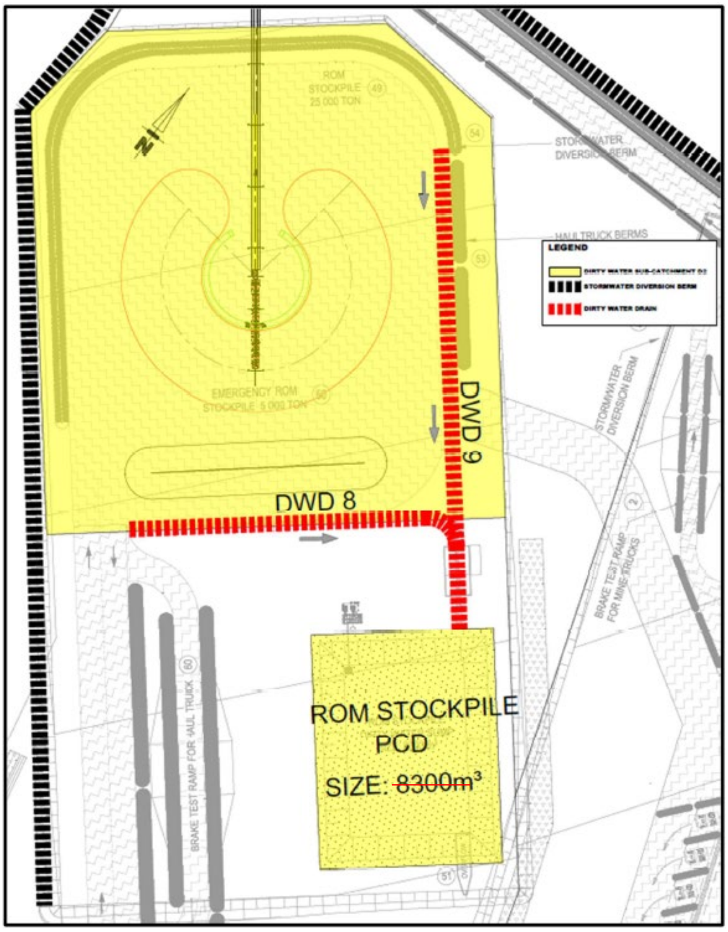


Figure 49 : Dirty water sub-catchment D2 (Source: BVI, 2021)

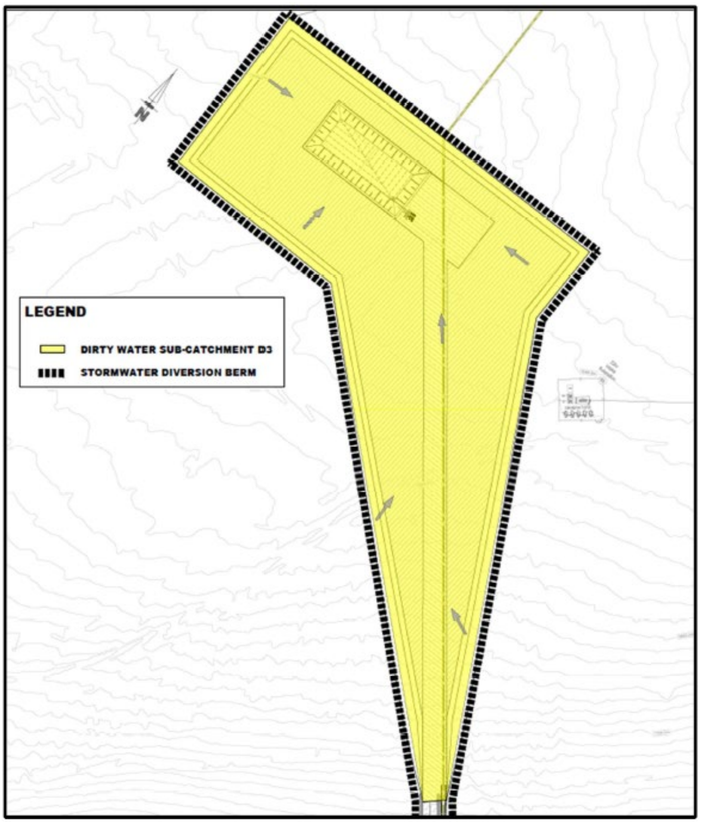


Figure 50 : Dirty water sub-catchment D3 (Source: BVI, 2021)

8.6 Storm water requirements for conveyor routes

BVI has specified storm water management of the conveyor route which will be applicable to all conveyor options. Three transfer stations will be located along the conveyor route. Storm water channels and infrastructure will allow for water to be routed from along the conveyor route to sumps situated at the transfer stations. There are three (3) conveyor sumps along the conveyor route from BEP to BIP. These sumps are situated at the low points along the conveyor route and the purpose of these sumps is to collect dirty stormwater and wash water from the conveyor area and transfer stations. Water from the first two sumps are pumped back to the ROM stormwater sump at the BEP underground area. Water from the sump closest to BIP is pumped into Dam 2 at BIP. The sumps have a capacity of 960 m^3 each.

The preferred conveyor route using the existing crossing of the Klein-Komati River. Storm water measures have been specifically considered to comply with GN 704 requirements to ensure that there is minimal loss of streamflow to the receiving environment. Pollution prevention measures are implemented in the form of erosion control and sediment traps.

9.0 FLOODLINES

Floodline assessment for the mining rights area was conducted as part of the surface water study for the BIP. Flood peaks for the different storm durations for the different recurrence intervals was generated. Flood peaks as generated for the catchment node as per Figure 51 are tabulated in

Table 24: Catchment characteristics

Name	Area (ha)	% Slope (%)
CAT1	122.2	4.1
CAT2	313.3	3.7

Name	Area (ha)	% Slope (%)
CAT3	347.8	4.5
CAT4	85.3	3.3
CAT5	121.4	4.7
CAT6	472.1	4.2
CAT7	415.1	3.9
CAT8	272.1	3.2
CAT9	117.1	2.6
CAT10	221.7	2.9
CAT11	186.3	3.5
CAT12	88.0	3.8
CAT13	215.7	4.3
CAT14	199.6	4.2
CAT15	438.6	3.5
CAT16	693.2	3.2
CAT17	1324.3	2.2
CAT18	319.7	5.8
CAT19	419.9	3.8
CAT20	636.6	2.7
CAT21	355.1	3.8
CAT22	215.9	3.8
CAT23	17.5	3.5
CAT24	1383.6	3.1

Table 25: Flood peak estimates

Name	1 in 50 year flood peaks (m^3/s)	1 in 100 year flood peaks (m^3/s)	RMF (m^3/s)
N1	10.5	12.9	108
N2	23.5	29.5	154
N3	28.7	36.1	161
N4	7.4	9.1	94
N5	59.9	74.0	108
N6	89.5	113.4	180
N7	110.9	135.8	172
N8	17.5	17.5	146
N9	17.5	21.6	106
N10	132.7	163.6	135
N11	16.6	20.4	127
N12	23.5	28.9	95
N13	13.9	17.2	134
N14	16.9	20.7	130
N15	67.7	84.1	175

Name	1 in 50 year flood peaks (m^3/s)	1 in 100 year flood peaks (m^3/s)	RMF (m^3/s)
N16	95.5	120.8	209
N17	130.2	167.3	267
N18	24.6	30.4	156
N19	43.5	53.6	173
N20	71.5	90.5	202
N21	19.0	23.5	162
N22	13.9	17.2	134
N23	32.9	40.6	52
N24	100.0	129.3	271

The different conveyor options falls within the evaluated mining boundary.

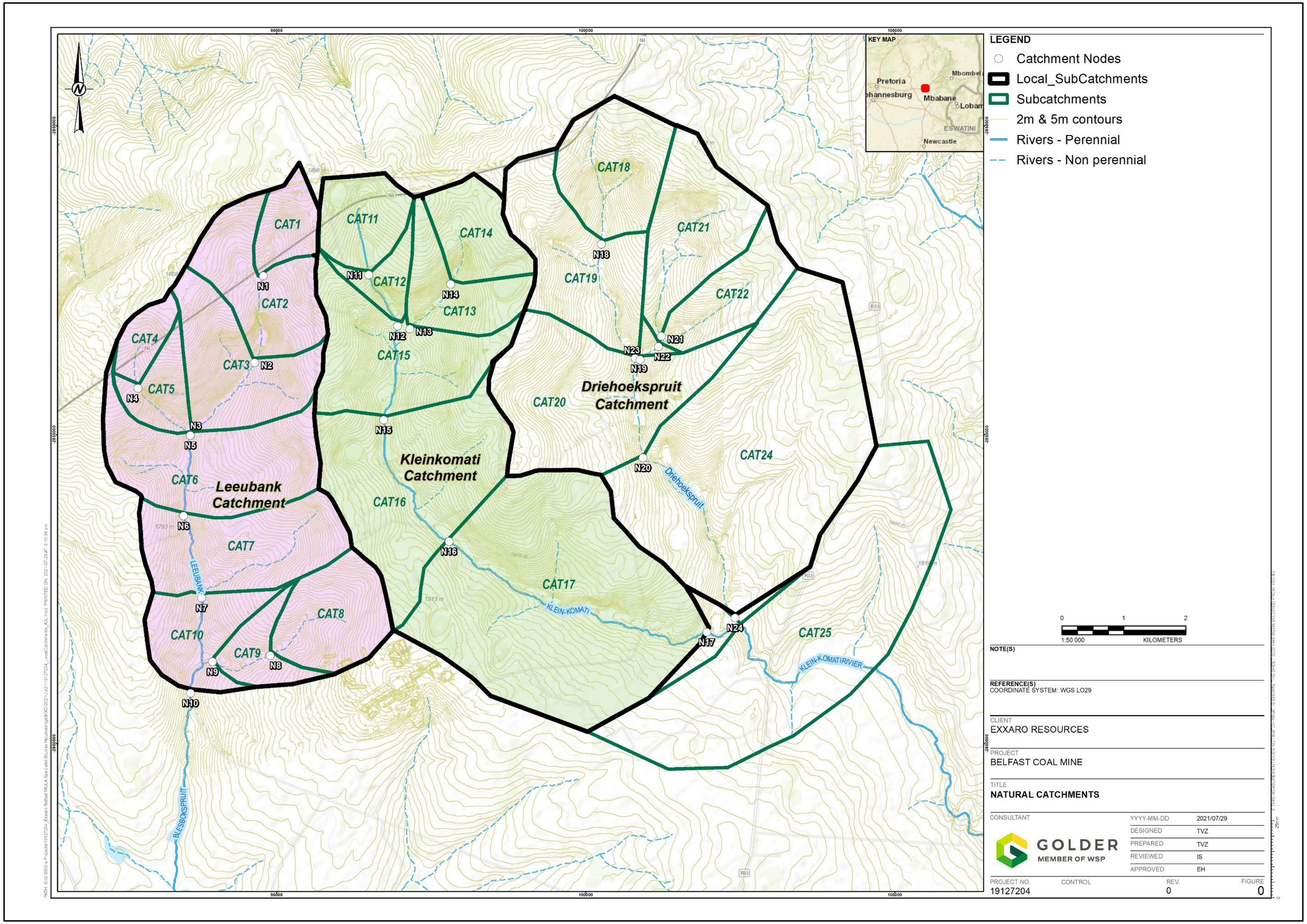


Figure 51: Natural catchment

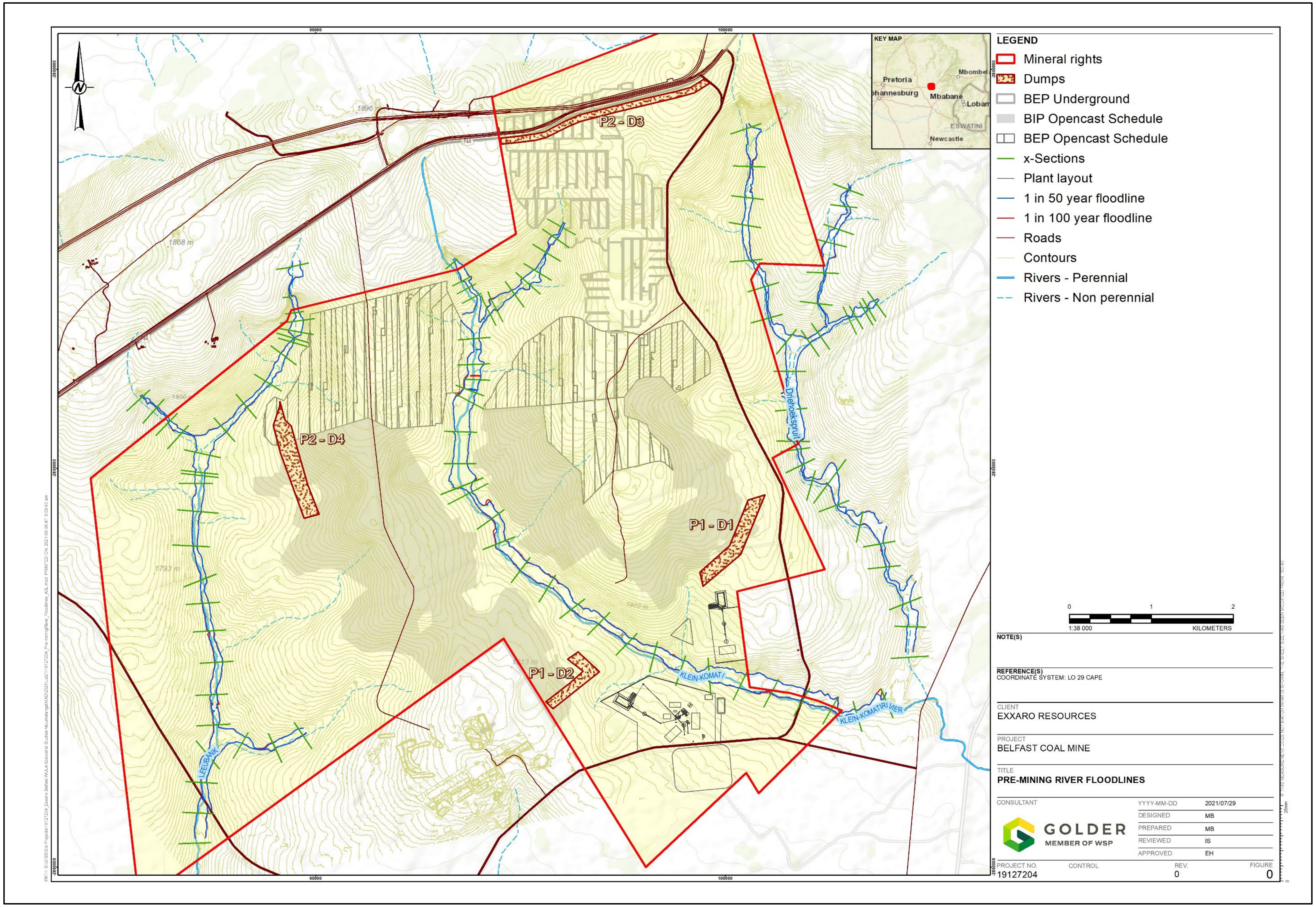


Figure 52: Pre-BIP floodlines

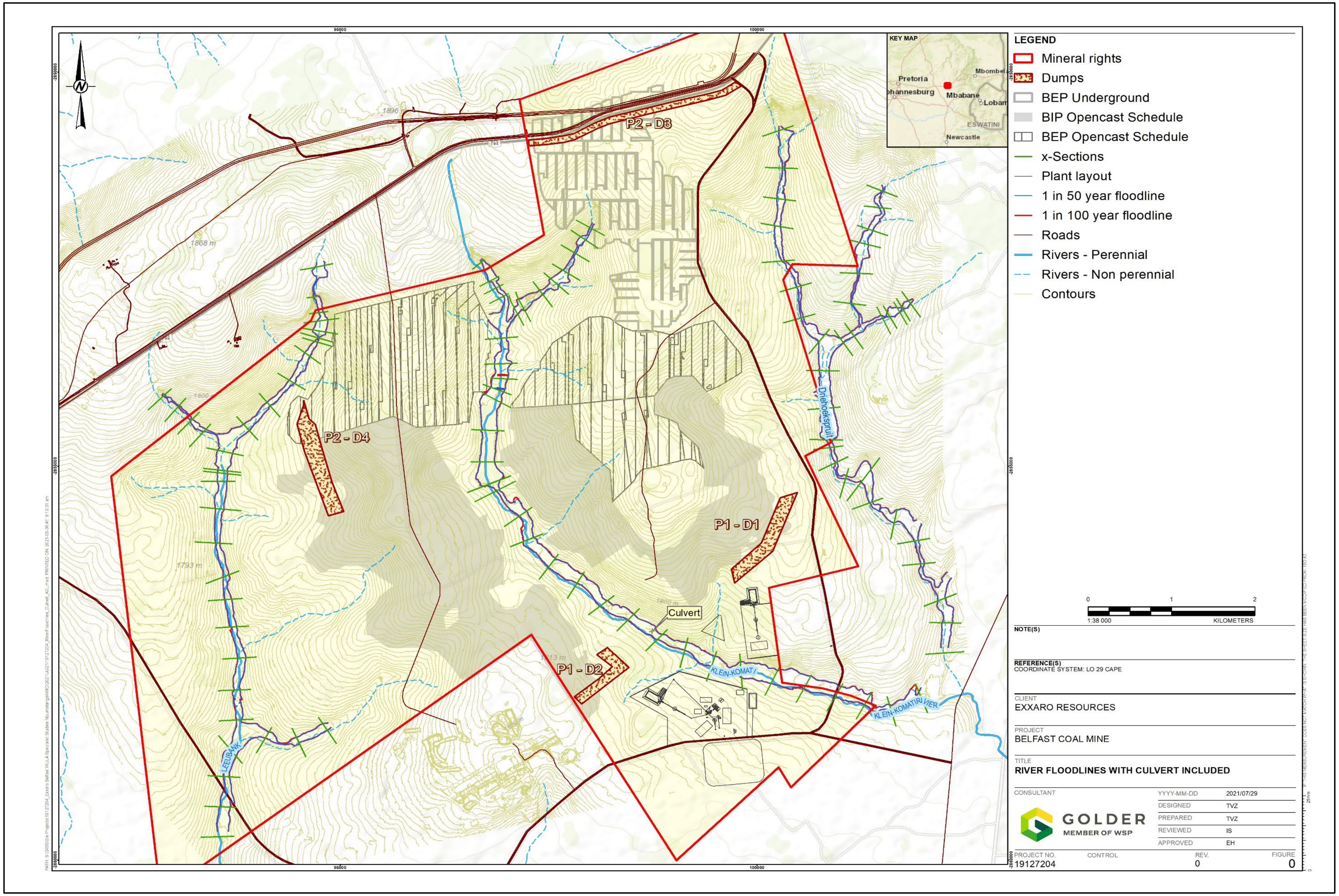


Figure 53: Floodlines with current infrastructure

10.0 SITE-WIDE WATER BALANCE

The water balance information presented in this report focuses on the BEP operation. Some BIP information is provided to allow for the reader to contextualise the integration in water management between the two sites. Golder has developed an integrated water balance for the BIP and BEP operations which is detailed in Golder, 2021b. This chapter will as mentioned focus on the BEP water balance which includes the BEP open cast pits and the BEP underground pits.

10.1 Water management and reticulation at the Belfast Expansion Project

10.1.1 BEP underground operation

The BEP underground and ramp operation consists of various infrastructure systems to support the mining operation which includes the water management system that consists of:

- Process water system.
- Raw water reticulation.
- Borehole water supply.
- Potable water supply.
- Firewater supply.
- Dust suppression.
- Storm water system.

The water management system of the expansion consists of four dams, viz BEP PCD, ROM stormwater sump, Waste Water Treatment (WWT) sump and the Flood Protection Dam, refer to Figure 55 and Figure 56.

By virtue of the underground operation, the underground mine collects groundwater ingress. This groundwater ingress will be managed by various underground sumps that will cascade towards the ramp area. The Flood Protection Dam will be situated at the bottom of the ramp area and will receive the underground dewatering water volume. This dam also receives runoff from the ramp itself. The Flood Protection Dam supplies the underground mining operations with the water required for dust suppression and for the continuous miners. The Flood Protection Dam also supplies the conveyor transfer stations wash water and dust suppression requirements. The level of the dam must be maintained at 20%. Any excess water is pumped out to BIP Dam 2. The dam can also supply water to the RO plant to substitute borehole water supply as well as provide make-up water to the Process Water Tank. This will be initiated in the model once the water level in the dam exceeds 20% and there is excess water in the system. The underground ramp area will also include a Sewage Treatment Plant (STP). Treated effluent from the STP will be routed to either the environment (preferred) or the Process Water Tank (as required).

The BEP PCD collects runoff from the surface area and any excess water will also be pumped to BIP Dam 2. Seepage from the Waste Rock and ROM Stockpile will flow into the ROM stormwater sump. Runoff from Conveyor Sumps 1 and 2 is also collected in the ROM stormwater sump. The RO plant receives raw water from a borehole or water from the Flood Protection Dam, subsequently treating the water before sending it to the Underground ramp Area as potable, with the losses recovered by BEP PCD.

The conveyor option routes have also been considered in the water balance and discussed in more detail in section 10.3.7

10.1.2 BEP open cast operation

Water from the BEP opencast pits will be integrated into the existing BIP dewatering management system. Refer to Figure 57 for the water reticulation associated with the BIP operation. Water from the BEP open cast and underground operations will interface with BIP via the BIP Dam 2.

10.1.2.1 General opencast pit operational philosophy

The open cast mining pits will be modelled to contain a minimum volume of 5 000 m^3 of water in a low point sump without an impact to mining operations. No storage within the spoils and pits during mining operation will be allowed for. Dewatering pump capacities will be determined based on either ensuring that:

- the volume of water in the pits will exceed 5 000 m^3 for more than 2 days with a probability of 1:50 years; or
- the pit can be emptied within 2 days for a 1:5-year flood event. An additional output from the model will be the probability of having the pit flooded for greater than 5 days and 10 days.

Figure 44 represents the open cast pit mining sequence of events and the approach that is used in modelling of the open cast pit.

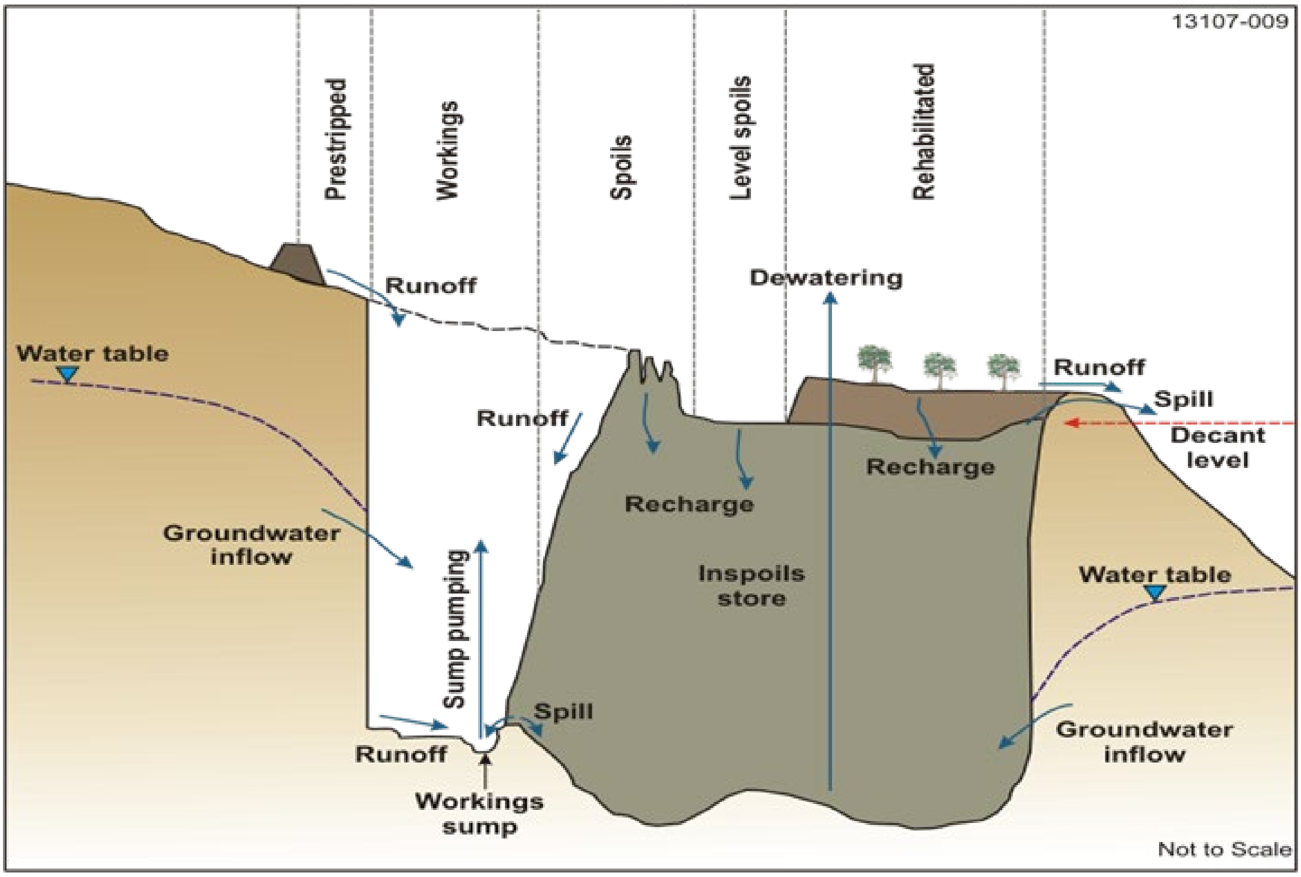


Figure 54: Modelling approach for cut and fill mining

For the BIP and BEP open cast operation there will be no in-pit (workings) sump. The average workings width will be approximately 45 m and a length of 90m giving a total area of 4 050 m^2, while the combined width of workings, spoils and level spoils shall be approximately 250 to 300 m.

10.1.2.2 BEP East OC

Refer to Figure 60 and Figure 61 for the surface topography and floor contours and maps.

The key features of the BE East pit mining are the following:

- The mine plan (Figure 4) for the northern section of the BEP east open cast sections shows mining occurring from the west to the middle of the section and from the east to the middle of the section.
- Mining on the eastern side of the northern section will continue in a downgradient direction with water flowing from the rehabilitated spoils into the active workings area requiring constant dewatering.
- Mining on the western side of the northern section occurs in an upgradient direction with the lowest point at the southwestern most tip of the northern section where water may accumulate. Borehole sump pumping may be required at the rehabilitated spoils at point indicated on the map (level 1788in Figure 60 as mining progresses up until year 2039 to prevent water seeping into the river.
- Mining on the southern section of the west pit will proceed in a westerly direction and will be upgradient. Water will therefore be stored in the backfilled spoils. Borehole sump pumping will be required at the depression as indicated by D2.
- After year 2039, water may flow from D1 to D2 since D2 is now the lowest point of the floor.

Post closure water will be managed by a borehole and pump system located at the decant point.

10.1.2.3 BEP West OC

Refer to Figure 60 and Figure 61 for the surface topography and floor contours and maps for the BIP West pit.

The key features of the pit mining are the following: -

- The mine plan (Figure 4) for the BEP west open cast section (xx), shows mining occurring from the west to the middle of the section in an upgradient direction and from the east to the middle of the section in a downgradient direction.
- Mining on the eastern side will therefore have water flowing into the workings from the backfilled spoils and mining from the western section will have water flowing into the backfilled spoils from the workings. After year 2039 (mining complete) water from the backfilled spoils will all flow down to point D3.

Post closure water will be managed by a borehole and pump system located at the low point at D3.

10.1.2.4 Available storage volume in pits

The storage available in the four pits has been summarised in Table 15 based on a porosity of 25%.

Table 26: Storage available in Pits (m^3)

Year	BEP East	BEP West
2017	0	0
2018	0	0
2019	0	0
2020	0	0
2021	0	0
2022	0	0
2023	0	0
2024	0	0
2025	0	0

Year	BEP East	BEP West
2026	0	0
2027	0	0
2028	0	0
2029	0	0
2030	0	0
2031	246103	396240
2032	301274	465014
2033	344487	480558
2034	440172	486338
2035	541327	486671
2036	754838	486671
2037	1553750	486671
2038	2045968	486671
2039	3064934	486671

The key criteria that must be considered in assessing the water management in the pits are:

- Spill from the pits to the environment. Any spills from the rehabilitated spoils store to the environment must comply with the 1 in 50-year spill frequency as per Regulation 704; and
- Water stored in the workings for periods of time long enough to interrupt mining activities. Exxaro adopt the criteria of draining the runoff from a 5-year rain event from workings within 1.5 days.

The model will be applied over the operational life of the mine to assess the pumping requirements and operational rules from the pits to meet the key criteria.

Assessment of flooding of workings

The criterion generally accepted by Exxaro is to size the pumping system to dewater the pit for the for the 5 year rainfall event (67 mm). The workings, prestrip, spoils, levelled and topsoiled areas will be used in calculating the 5-year runoff volume for each pit. For higher than the 5-year rainfall event, a low probability of water accumulation in the pit sumps > 50 000 m^3 has been modelled.

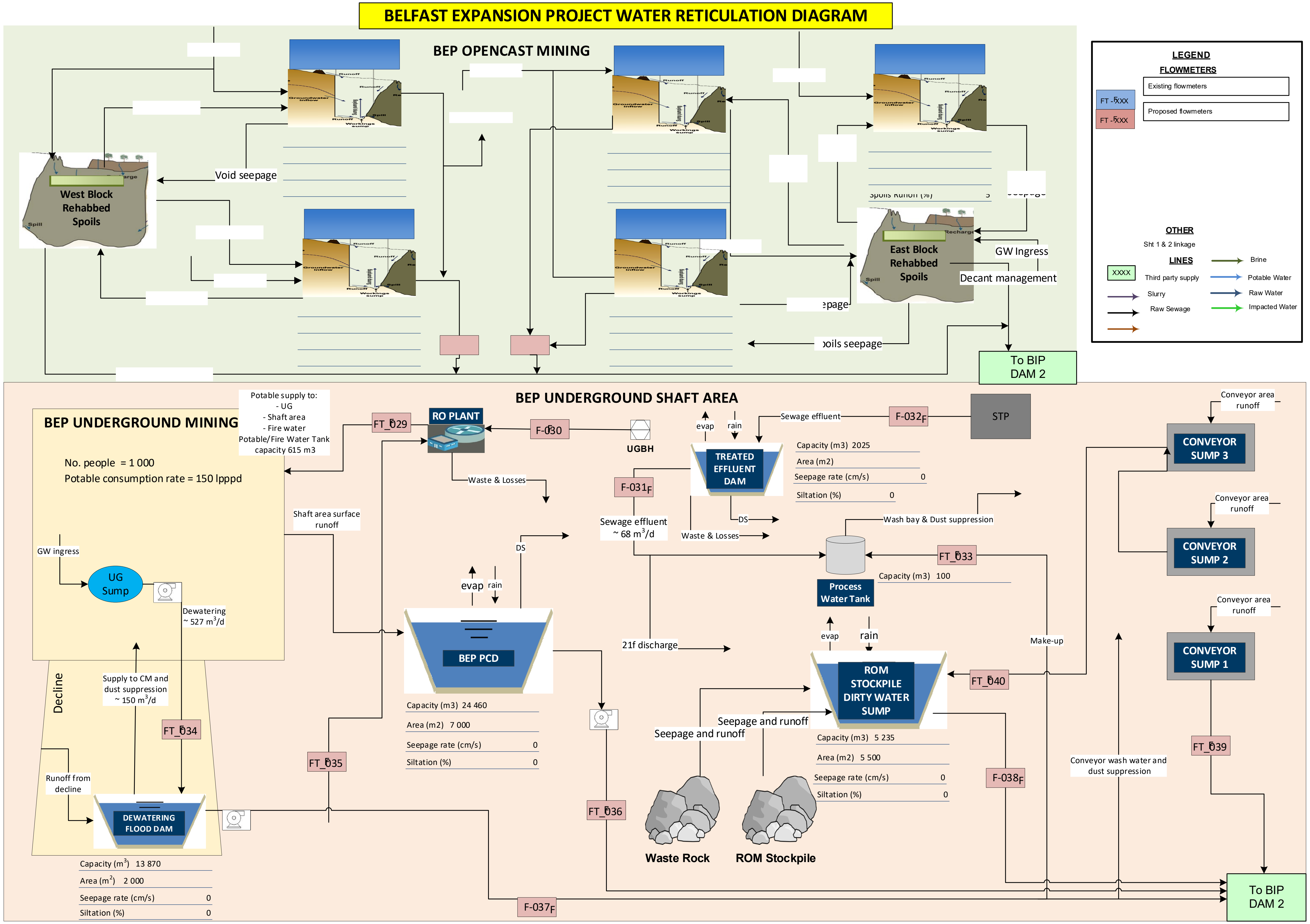


Figure 55: BEP water reticulation diagram

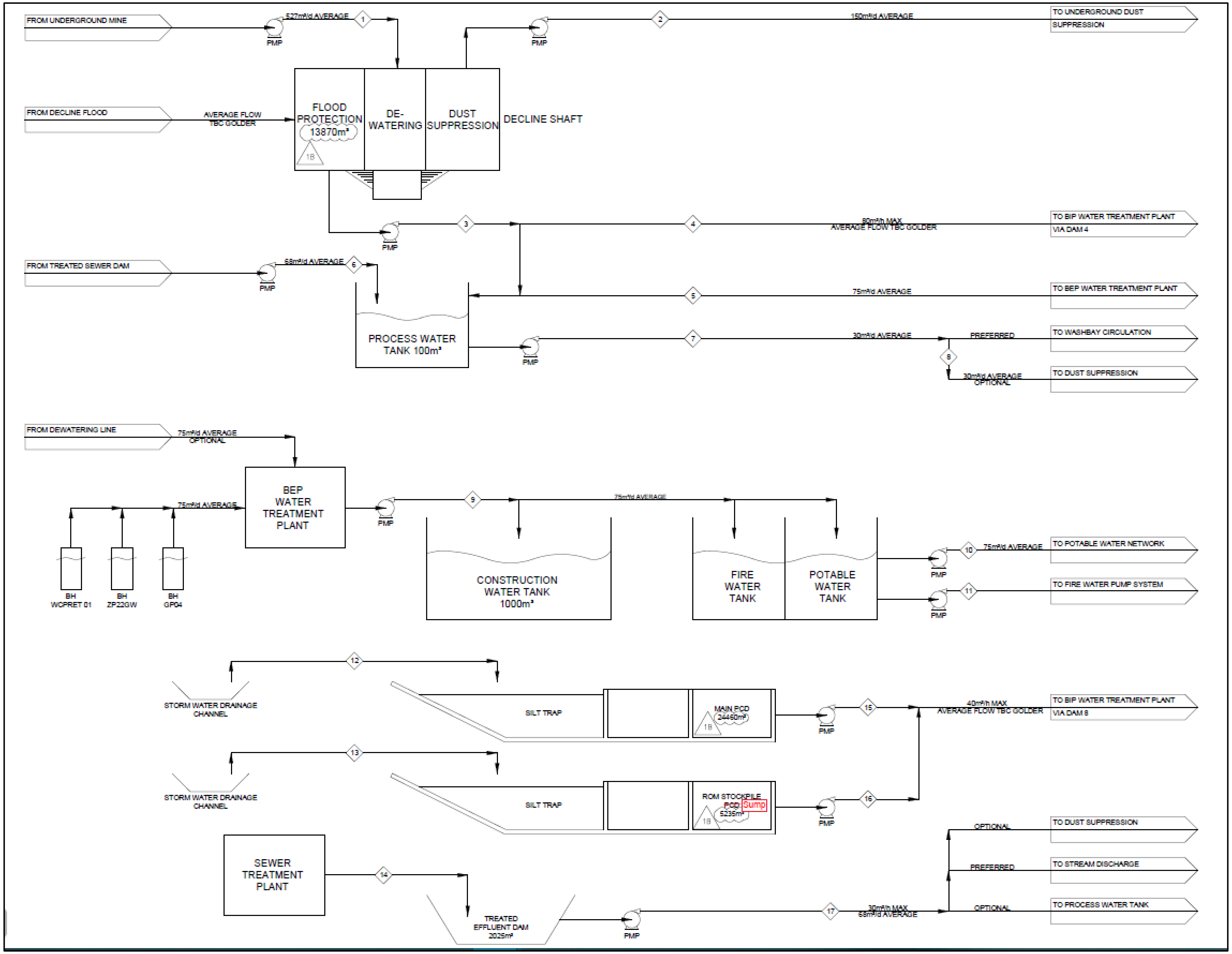


Figure 56: BEP underground area water flow diagram (BVI, 2021)

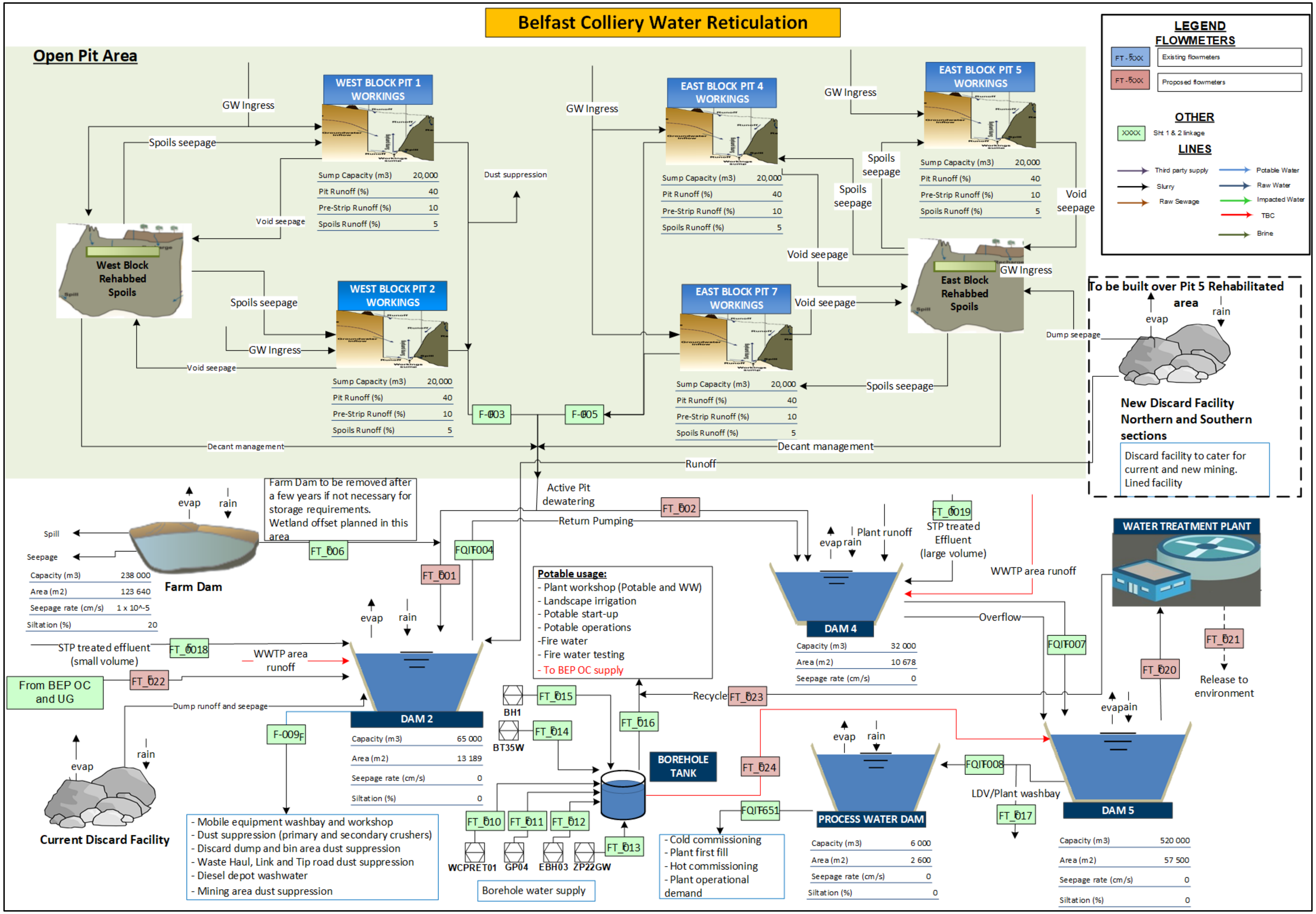


Figure 57: BIP water reticulation diagram

10.2 Groundwater ingress

Groundwater ingress values was taken from Golder, 2021d. Figure 58 and Figure 59 shows the annual average values for the separate pits and combined pits respectively.

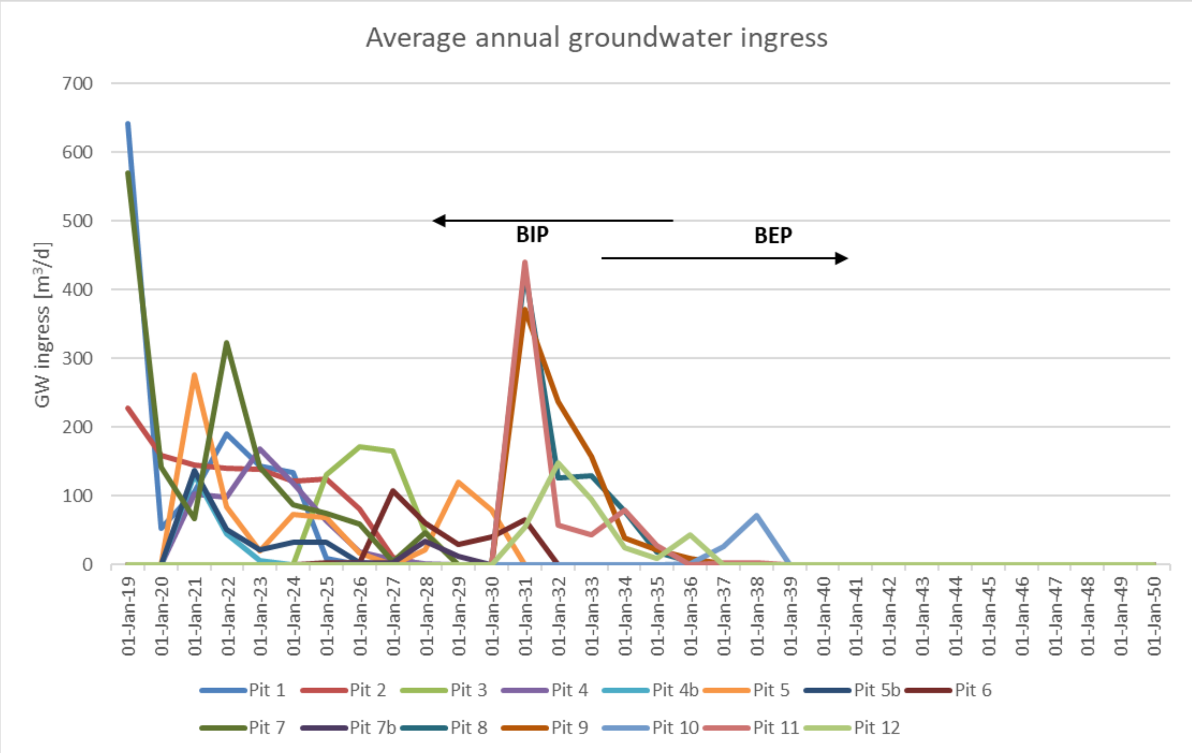


Figure 58: Annual average groundwater ingress rates for the separate pits

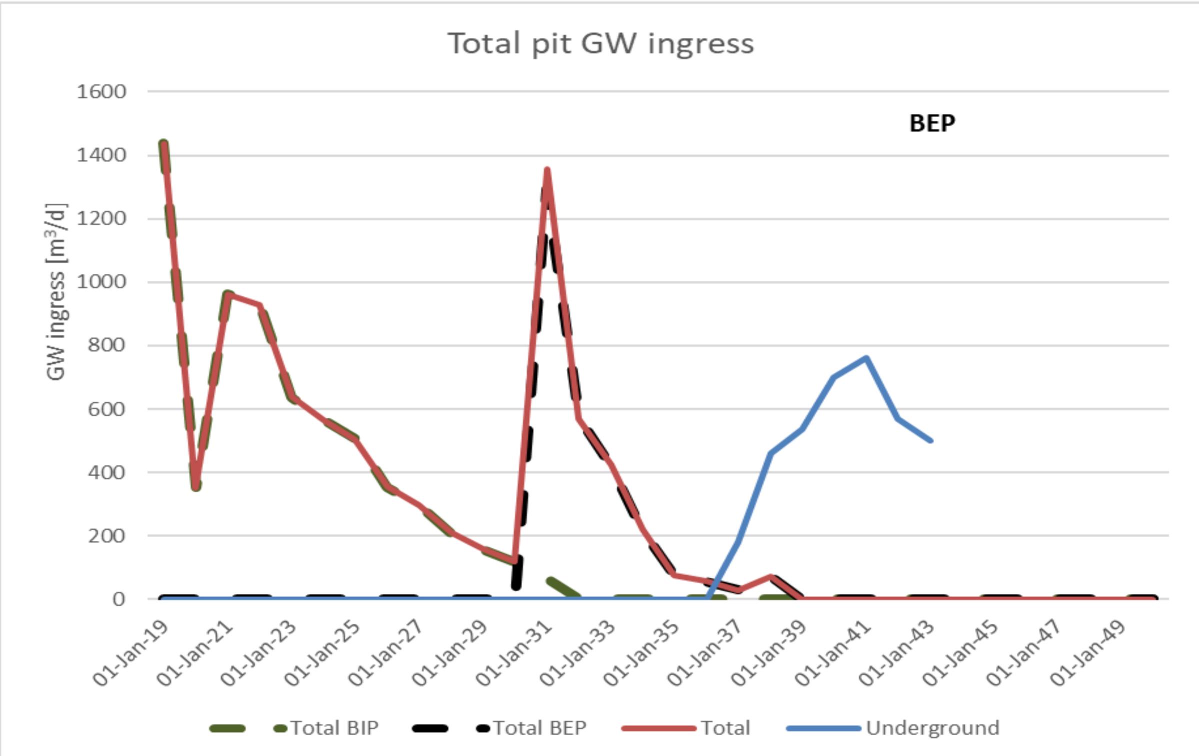


Figure 59: Annual average groundwater ingress rates

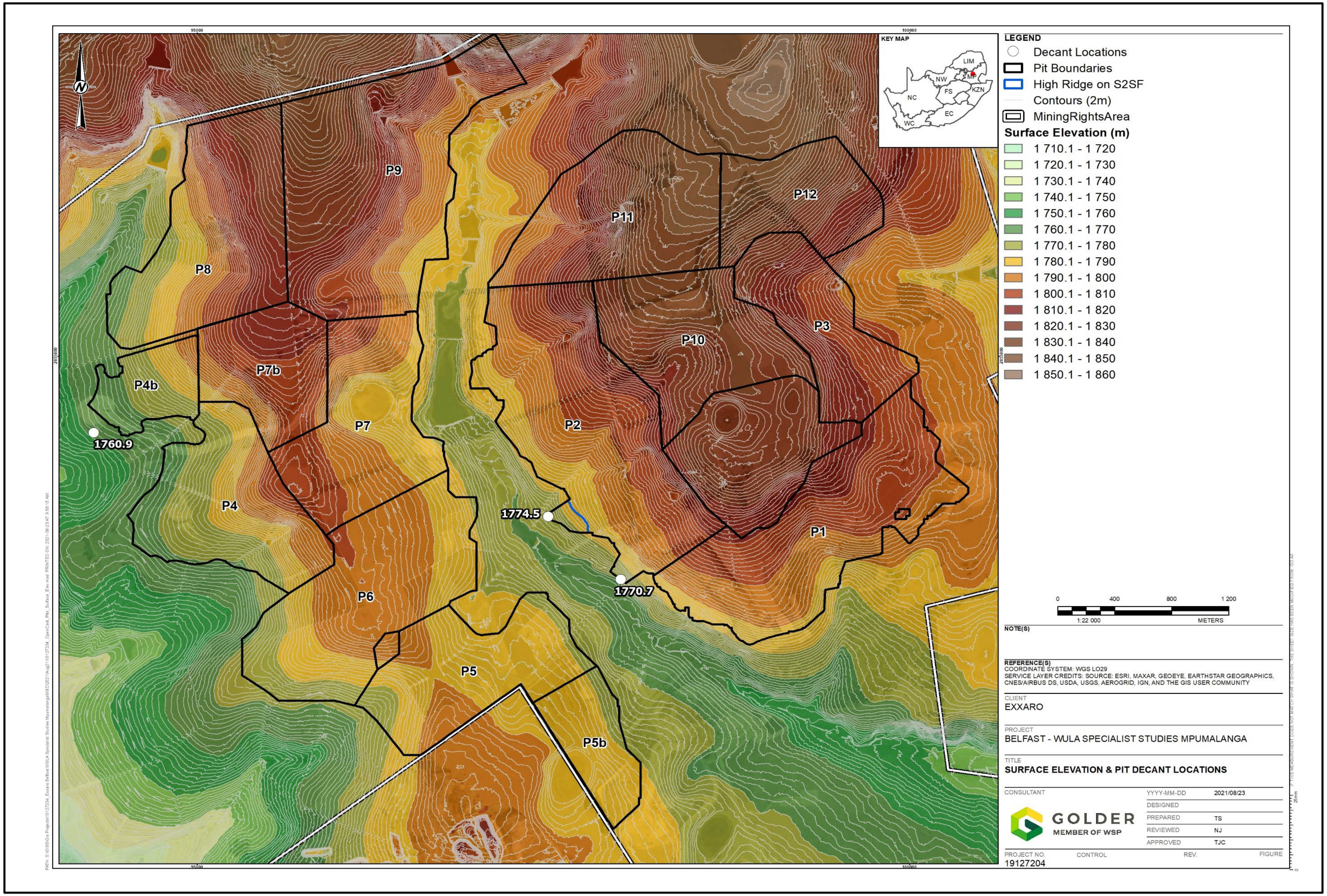


Figure 60: Surface contours over the open cast mining areas showing managed decant points

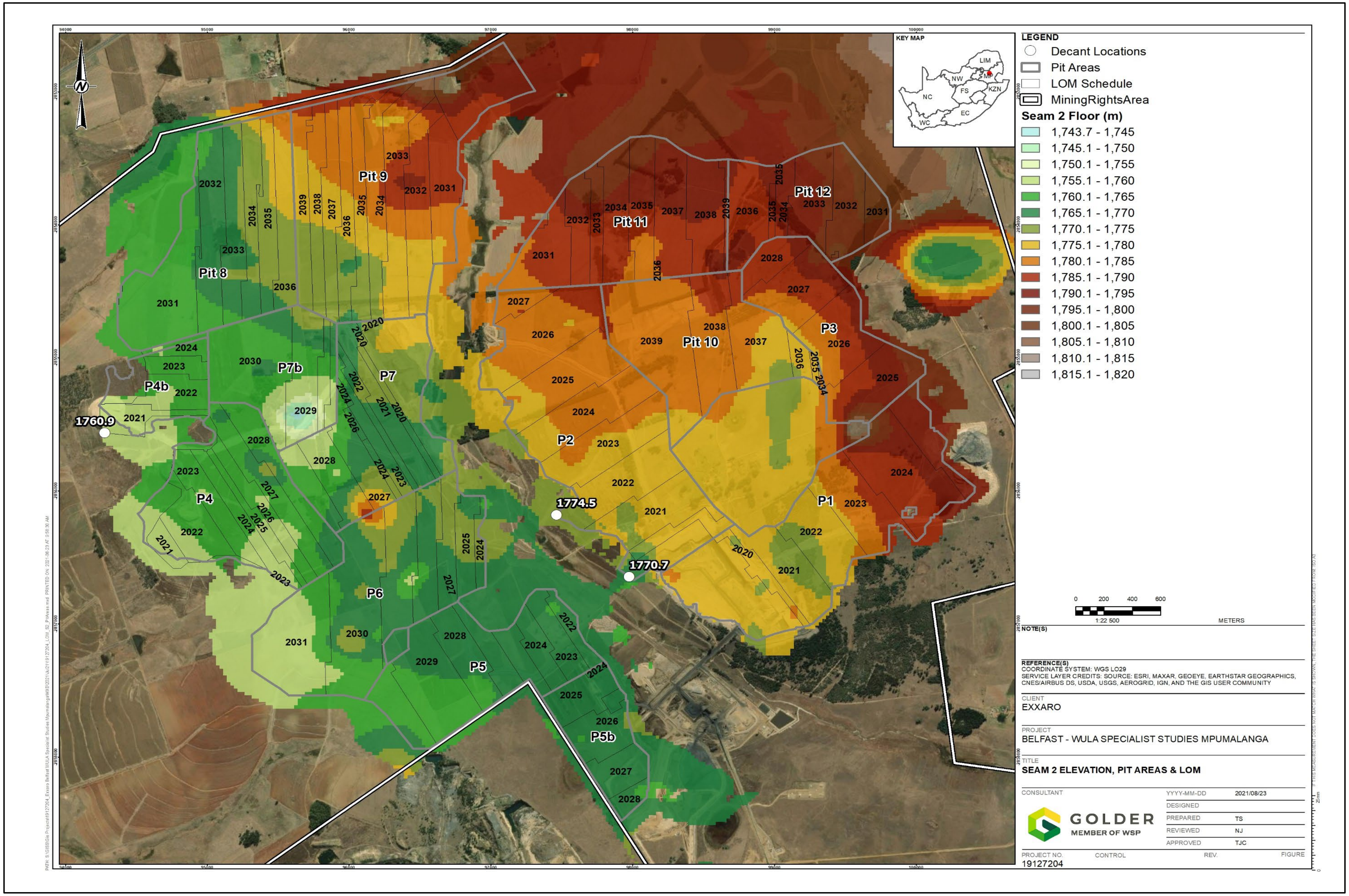


Figure 61: Seam floor elevation over the open cast pit mining area

10.3 BEP water storage facilities

The following water storage infrastructure is relevant to the BEP underground decline area. Refer to Table 27 for a summary of the facilities.

10.3.1 BEP PCD

The BEP PCD collects contaminated storm water runoff from the BEP underground shaft area and routes any excess water to Dam 2 at the BIP area. Dust suppression is also supplied from this dam.

10.3.2 Flood Protection Dam

The flood protection dam collects relatively cleaner water from the decline shaft run-off as well as underground dewatering. This water is used at the conveyor transfer stations for dust suppression and washing as well as for underground dust suppression and continuous miner use. Some of this water can be send to the RO plant for treatment for domestic use or as make-up water to the Process Water Tank. Any excess water from this dam reports to Dam 2 at the BIP area.

10.3.3 Waste Water Treatment Sump

The Waste Water Treatment (WWT) sump receives the treated sewage effluent and discharges it to either the environment (preferred) or to the process water tank.

10.3.4 Process Water Tank

The Process Water Tank receives feed either from the WWT sump or the Flood Protection Dam and supplies the underground shaft area dust suppression and wash water needs.

10.3.5 Fire / Potable Water Tank

Water from the Fire / Potable Water Tank is sourced from the RO plant. The RO plant is either fed by boreholes at the shaft or make-up water is provided from the Flood Protect Dam.

10.3.6 ROM stormwater sump

The RoM stormwater sump collects dirty water runoff from the RoM stockpile area at the BEP underground mining shaft area. A silt trap is situated upstream of this facility. The RoM stormwater sump also receives direct rainfall. Outflows from this facility include evaporation. Any excess water is pumped to the BIP area for storage/treatment. The sump is approximately 8 300 m^3 with a footprint of 5 500 m^2.

10.3.7 Conveyor sumps

There are three (3) conveyor sumps along the conveyor route from BEP to BIP. These sumps are situated at the low points along the conveyor route and the purpose of these sumps is to collect dirty stormwater and wash water from the conveyor area and transfer stations. Water from the first two sumps are pumped back to the ROM stormwater sump at the BEP underground area. Water from the sump closest to BIP is pumped into Dam 2 at BIP. The sumps have a capacity of 960 m^3 each.

Table 27: BEP UG water related infrastructure

Facility	Capacity	Footprint (ha)	Function	Lining	Inflows	Outflows
BEP PCD	24 460	7 000	Main storm water catchment facility for the BEP underground shaft area.	HDPE	■ Storm water runoff – catchment – 19.61 ha ■ Direct rainfall	■ To BIP 500 m^3/d ■ Evaporation ■ Dust suppression of 20 m^3/d (BVI, 2020)
Flood Protection Dam	13 870		To contain runoff from the decline shaft and underground dewatering.	HDPE	■ Storm water runoff – catchment – 8.4 ha ■ Underground dewatering	■ Dust suppression of 150 m^3/d ■ Continuous Miners – 100 m^3/d ■ Excess water to BIP 1 000 m^3/d ■ Make-up to process water tank – 68 m^3/d ■ WW to conveyor 110 m^3/d ■ WW to shaft area 55 m^3/d
WWT sump	2 025	2 000	Stores treated sewage effluent.	HDPE	■ Treated effluent from STP ■ Direct rainfall	■ 67.5 m^3/d to BIP ■ Evaporation ■ Discharge to environment
Process Water Tank	1 00	-	Storage of wash water for wash bay and dust suppression.	Steel	■ WWT sump ■ Flood Protection Dam	■ To wash bay (30 m^3/d avg). ■ Dust suppression (30 m^3/d avg). ■ BEP RO plant
Construction Water Tank	1 000	-	Contain water required for construction purposes	Steel	■ BEP WTP (RO)	■ Construction use

Facility	Capacity	Footprint (ha)	Function	Lining	Inflows	Outflows
Fire / Potable Water Tank	516	-	Storage of water for fire-fighting or potable consumption	Steel	■ BEP WTP (RO)	■ Potable water network ■ Fire water pump system
ROM stormwater sump	5 235	5 500	Contain dirty storm water from the RoM stockpile area.	HDPE	■ Storm water runoff from ROM stockpile – footprint – 3.34 ha ■ Direct rainfall	■ 350 m^3/d to BIP ■ Evaporation
Conveyor Sumps (x3)	960	-	Contain dirty stormwater and wash water from the conveyor area.	Concrete	■ Storm water runoff from conveyor area ■ Wash water return ■ Direct rainfall	■ 150 m^3/d to BEP PCD

10.4 Water sources

10.4.1 BIP

The following are BIP water sources:

- Farm Dam – this is a dam that was established for farm use and is within the Belfast mining rights area.
- Boreholes – refer to Table 19 for a list of water supply boreholes.

Table 28: Water supply boreholes at BIP

Boreholes	Yield [m^3/d]	Actual avg. flow [m^3/d]	Notes
WCPRET01	>130	935	24 hr/d
EBH03	85	0.2	24 hr/d
GP04	60	134	24 hr/d
ZP22GW		43	
BT35W		4.2	
BH1		0	
BBH02	13	0	12 12/d
BBH06	6.5	0	12 hr/d

According to GCS, 2020, the approximate borehole yield capacity is 533 m^3/d. This amount is required to supply the total potable water demand of 145 m^3/d (as discussed in section 9.8.1). In addition, a volume of 200 m^3/d is required for dust suppression on the RoM stockpile. Therefore, there is some water from the borehole supply that can be sent to Dam 3 for plant make-up (190.8 m^3/d).

10.4.2 BEP

Water sources at BEP underground will be boreholes that will supply the RO plant for treatment for domestic use at the decline shaft area. According to Golder 2021d, the yield of a single borehole at the BEP underground area is 75 m^3/d and two boreholes will be used.

10.5 Monitoring data

Available monthly flow monitoring data was provided for the flowmeters listed in Table 20. Very little data was provided. This data will be used in the model however more data will ensure validity and reliability of measured numbers. No level monitoring data was supplied. It is unclear where the "Make-up water" is routed from and to where Exxaro is encouraged to improve on the flow and level monitoring to assist with better ongoing water management.

Table 29: Available flowmeters on site

Type	Flowmeter name	Tag	Record available	Average [m^3/mon]
Abstraction boreholes	WCPRET01	-	Jul 2020 – Mar 2021	28 008
	EBH03	-	Only Jan 2021	6
	GP04	-	Only Jan 2021	4 012
	ZP22GW	-	Jan 2021 – Mar 2021	1 281
	BT35W	-	Jan 2021 – Mar 2021	125

Type	Flowmeter name	Tag	Record available	Average [m^3/mon]
	BH1	-	No data available	0
Pit dewatering	Pit 1/2	-	Jan 2021 – Mar 2021	50 338
	Pit 4/5/7	-	Jul 2020 – Feb 2021	22 730
Farm Dam	Dam 1 Main line	-	No data available	0
Dust suppression	Water Sprayers	-	No data available	0
	Goosenecks	-	Jan 2020 – Mar 2021	13 276
Dam flows	Dam 2 to Dam 4	FQIT004	Jul 2020 – Mar 2021	24 637
	Dam 4 to Dam 5	FQIT007	Nov 2020 – Feb 2021	46 877
	Dam 5 to Dam 3	FQIT008	Jul 2020 – Mar 2021	27 549
	Siding Dam	-	No data available	0
Sewage effluent	40Kl STP	-	Oct, Nov, Dec 2020, Mar 2021	31.39
	70Kl STP	-	No data available	0
Plant demand	Dam 3 to Plant	FQIT641	Jul 2020 – Mar 2021	31 871
	Dam 5 to Plant	-	Jul 2020 – Feb 2021	27 588
Internal recycle	Make-up water	FQIT405	Jan 2021 – Mar 2021	31 635
	FP Recycled	-	No data available	0
Potable use	Domestic	-	Jan 2021 – Mar 2021	2 898

10.5.1 Production data

Recorded production data for the current mining operation was provided. Figure 57 and Figure 59 shows recorded data for RoM and product and discard and slurry respectively. Figure 58 and Figure 60 shows the projected production values that includes the coal mined at BEP. Note that no slurry will be produced since the plant operation includes a filtration step that filters out the water from the slurry.

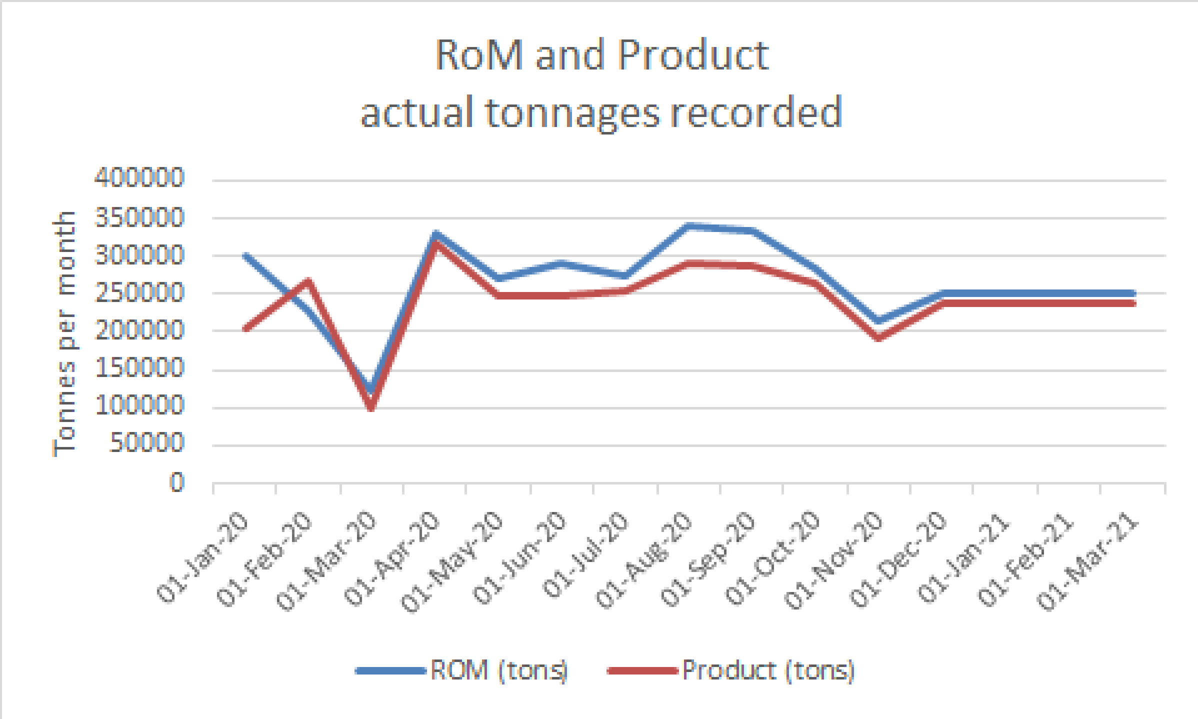


Figure 62: Recorded BIP product and RoM tonnages

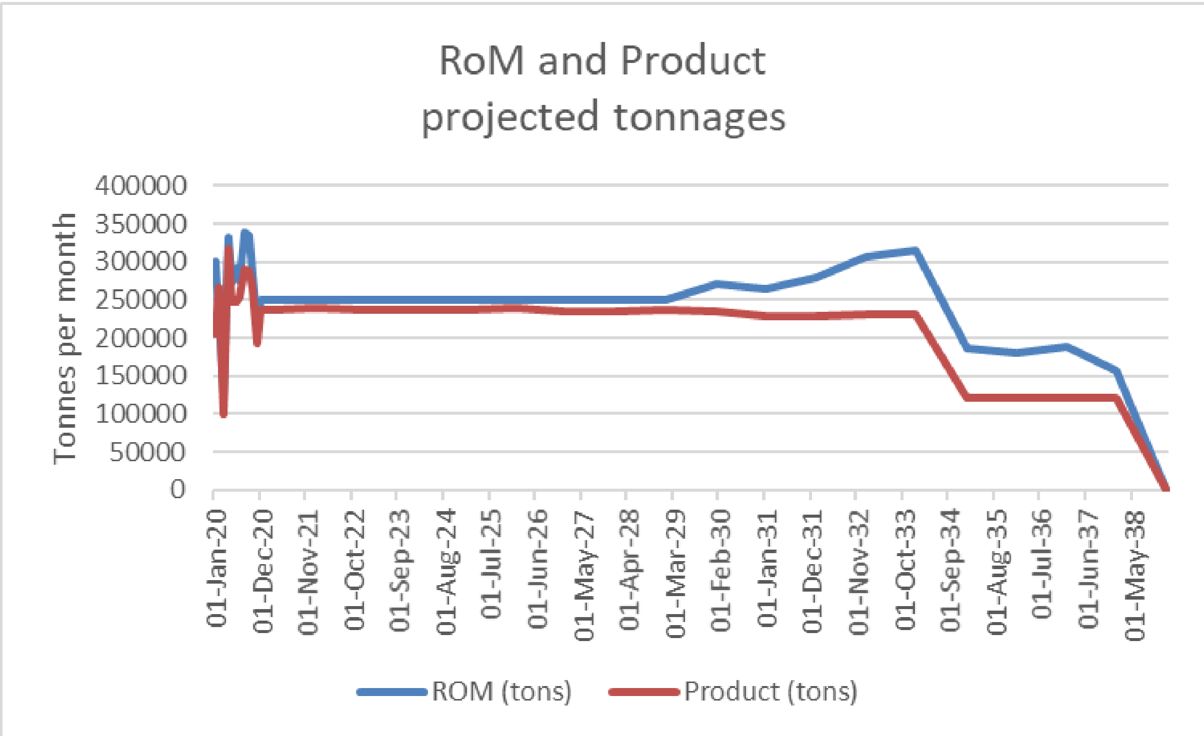


Figure 63: Projected BIP product and RoM tonnages

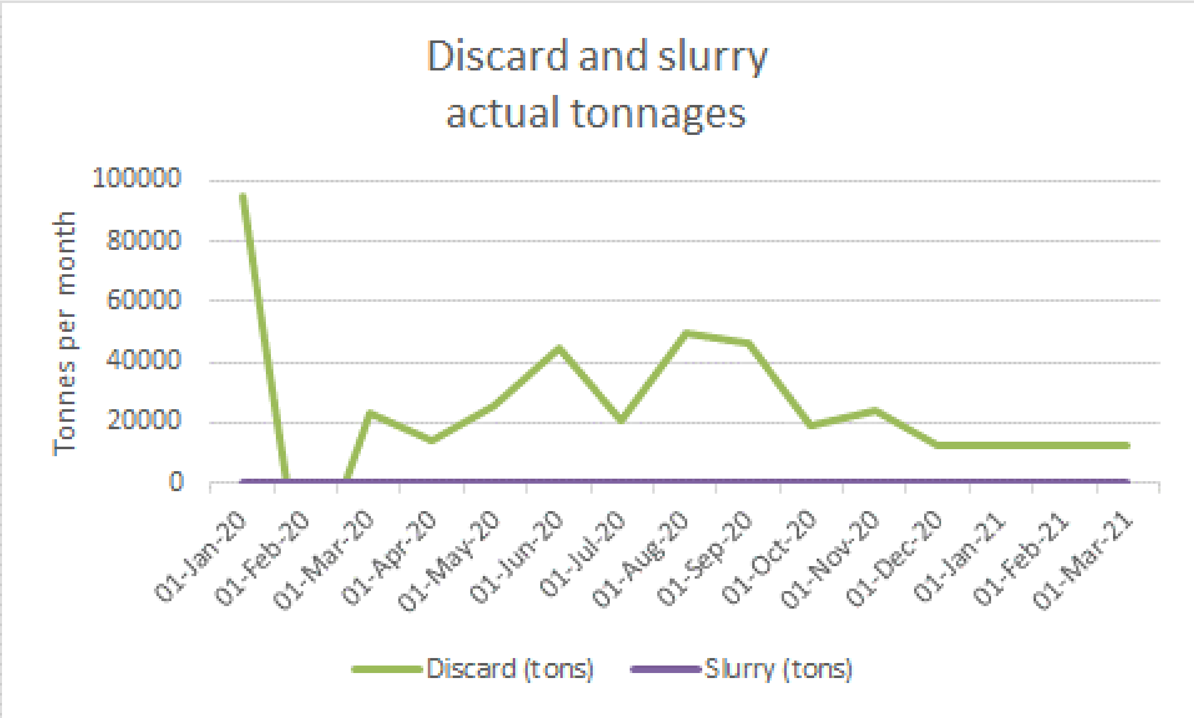


Figure 64: Recorded BIP discard and slurry tonnages

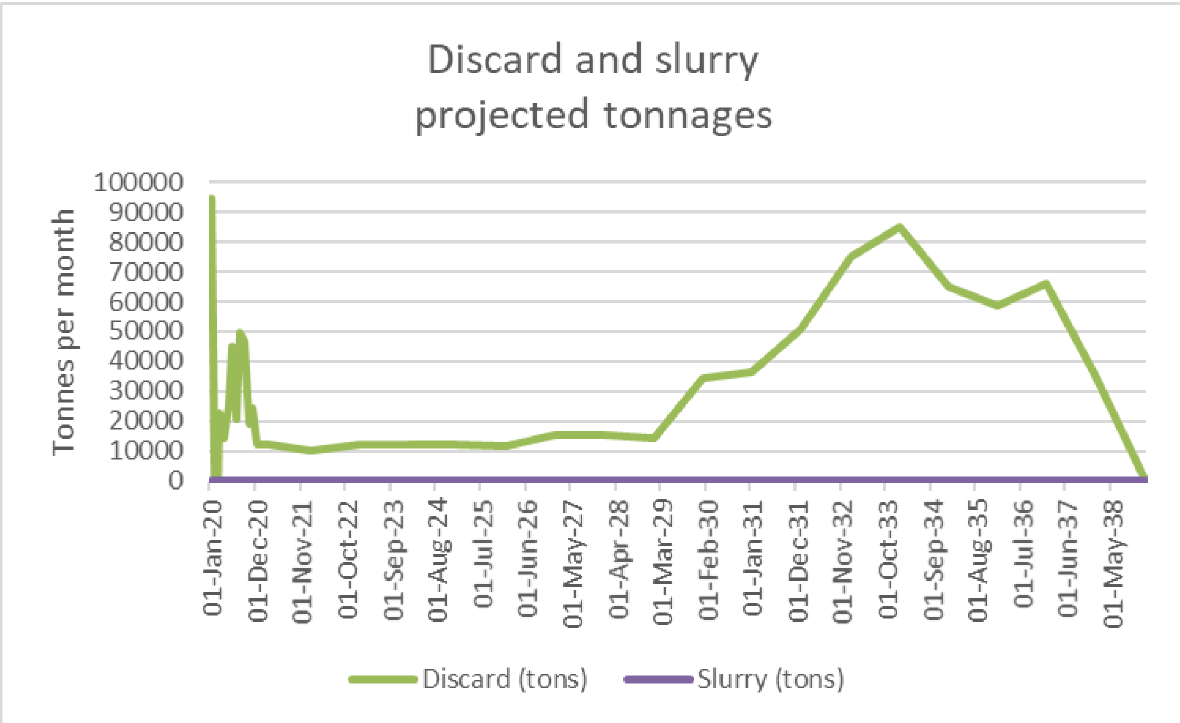


Figure 65: Projected BIP discard and slurry tonnages

- The product and discard moisture content will be assumed at 5%.
- Production tonnages provided are assumed to be wet tonnages.
- The minimum, average and moisture content of the ore will be taken as being 6, 9 and 12% respectively.

- Slurry density is assumed to be a minimum of 1.26 t/m^3, an average of 1.27 t/m^3 and a maximum of 1.28 t/m^3.
- In-situ dry discard density after compaction – 1.575 t/m^3 (Jones & Wagener, 2021).
- Discard DG – 1.89 (Jones & Wagener, 2021).
- Spoils SG – 2.53 (Jones & Wagener, 2021).

10.5.2 Potable water use

- Potable water is supplied from boreholes at all operations and is treated prior to use.
  - BEP UG – single borehole yield - 75 m^3/d
- Assumed consumption rate is
  - Admin and office staff – 70 lpppd
  - Mining, workshop and maintenance staff – 100 lpppd
- BIP boreholes supplies the following uses
  - Weighbridge tap stand
  - Weighbridge control room.
  - Truck entrance ablution block.
  - Plant workshop and LDV washbay.
  - Supply chain management store.
  - Plant control room.
  - Laboratory.
  - Export tip bin tap stand.
  - Middlings tip bin tap stand.
  - Main security and induction.
  - Main office block and irrigation of gardens at office – plant and mine.
  - Plant and mining change house.
  - Conference facility.
  - Wastewater treatment plant.
  - Mining area access security.
  - Prill silo water tank.
  - Diesel depot.
  - Discard contractor.
  - Sasol explosives management office.
  - Mining ME workshop.

- Heavy ME washbay.
- Dust suppression contractor.
- Shovel laydown area office.

10.6 Rehabilitation

Rehabilitation of the opencast pits is especially relevant to mine water make and the requirements for dewatering and water management. The water balance model therefore must consider rehabilitation planning to predict the future water make and requirements for dewatering and water storage. The mine plan for the BIP and BEP operations is shown in Figure 4. Exxaro practices concurrent rehabilitation and this will be modelled as such. Concurrent rehabilitation also applies to the discard facilities. This will be done via the roll-over method. The following assumptions were made in terms of pit mining and rehabilitation progression:

- Pre-stripping occurs a year prior to mining;
- Workings will be exposed during the year of operation as shown in the LoM plan in;
- The area mined out will be backfilled with spoils in the next year;
- Top soiling of this area will occur in the following year together with seeding; and
- Rehabilitated area (grassed) will be fully established two years after that.

10.7 Sewage treatment

There are two Sewage Treatment Plants (STP) at the BIP operation. The treated effluent from the smaller STP is sent to the Dam 2 (small volume) and the treated effluent from the larger area is sent to Dam 4 (large volume). The figure below shows the trend of the final effluent monitoring data.

At steady state, the total potable requirement at BIP is 145 m^3/d, 135 m^3/d of which is consumption at mining and the plant area that will potentially report as sewage. The treated effluent will be either returned to Dam 2 or Dam 4 as discussed above. Estimated return volumes are 68.35 m^3/d to Dam 2 and 35.76 m^3/d to Dam 4. This is 77% of the total potable water consumption, GCS, 2020.

The BEP UG area will have a separate STP. The treated effluent will be routed to a WWT sump from where it will be pumped to the BEP PCD. This water can also be discharged to the environment if the water quality data is within specification for discharge. Refer to Golder 2021 for further details of the BEP underground area water balance.

The BEP opencast area will make use of portable systems.

10.8 Reverse Osmosis

An RO plant exists at the BIP area for treatment of 145 m^3/d of borehole water to potable water standards for domestic use.

The BEP underground area plans to incorporate an RO plant to treat the borehole water supply for domestic use at the underground area and shaft area.

10.9 Water balance results

10.9.1 BEP operation water balance

For the BEP operation the simulation was run from 2031 until 2042 to correspond to the open cast and underground LoM plan. The results of this simulation for the average annual, maximum and minimum scenarios are shown in Figure 66, Figure 67 and Figure 68 respectively. The interface between BIP and BEP occurs via BIP Dam 2. Dam 2 receives an excess flow from the BEP underground (and surface infrastructure) operations as well as water from the dewatering of the BIP pits. The outflow to the BIP Dam 2 is indicated on Figure 66.

Table 30 represents the average overall average BEP water balance over the LoM operation.

Table 30: Overall average water balance for LoM operation [m^3/d]

INFLOWS		Water stored	OUTFLOWS	
	BEP	**BEP**		**BEP**
Rain	23		**Evaporation**	17
Runoff	339		**Seepage**	0
Recharge	689		**Dust suppression & Wash water**	106
GW Ingress	248		**Losses and waste**	13
Boreholes	0		**Plant consumption**	16
Sewage	49		**To BIP from BEP**	972
TOTAL	**1 349**	**248**	**TOTAL**	**1 124**
	Imbalance	**2%**		

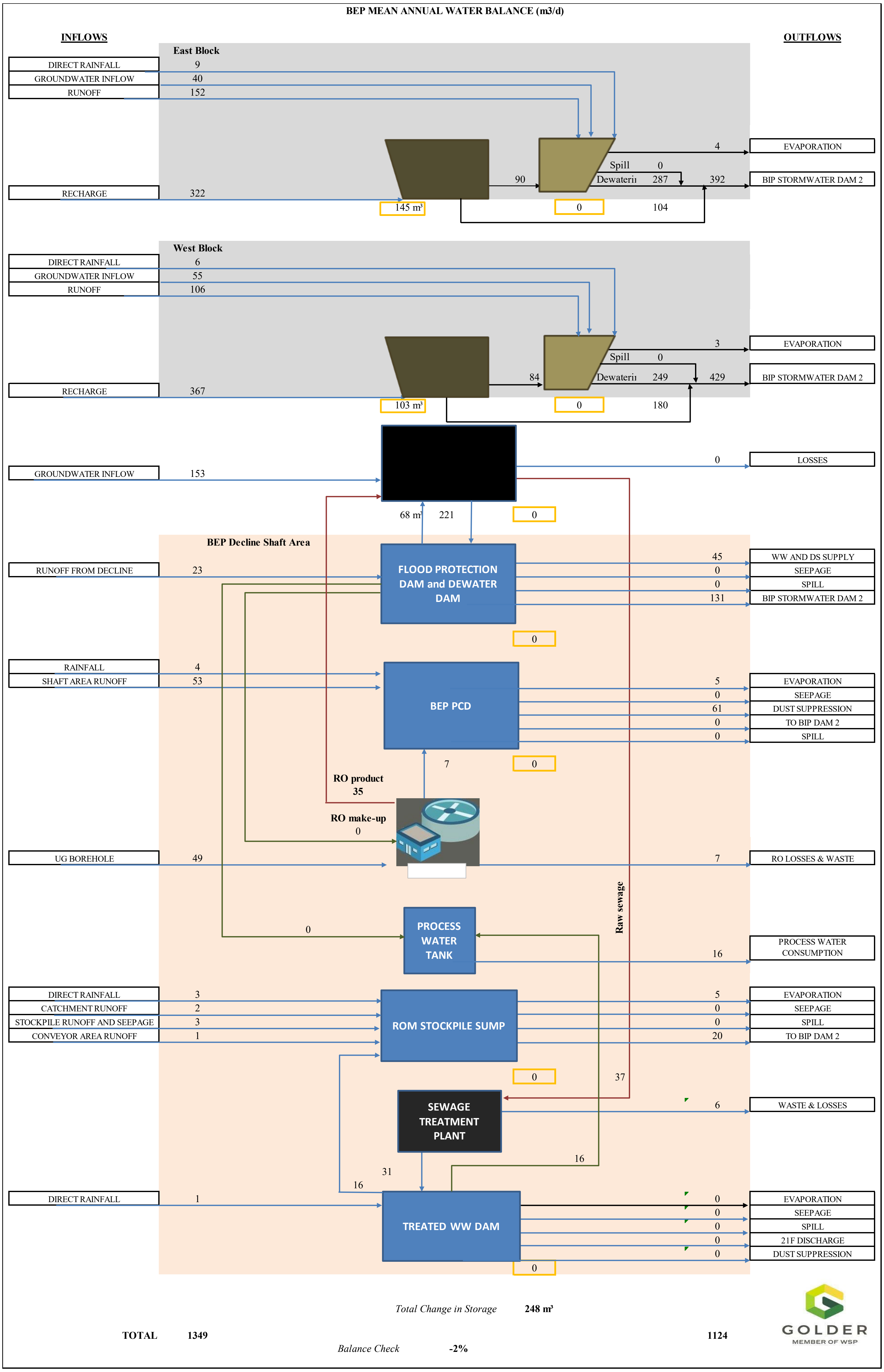


Figure 66: BEP annual average water balance over the LoM operation (2031 – 2042)

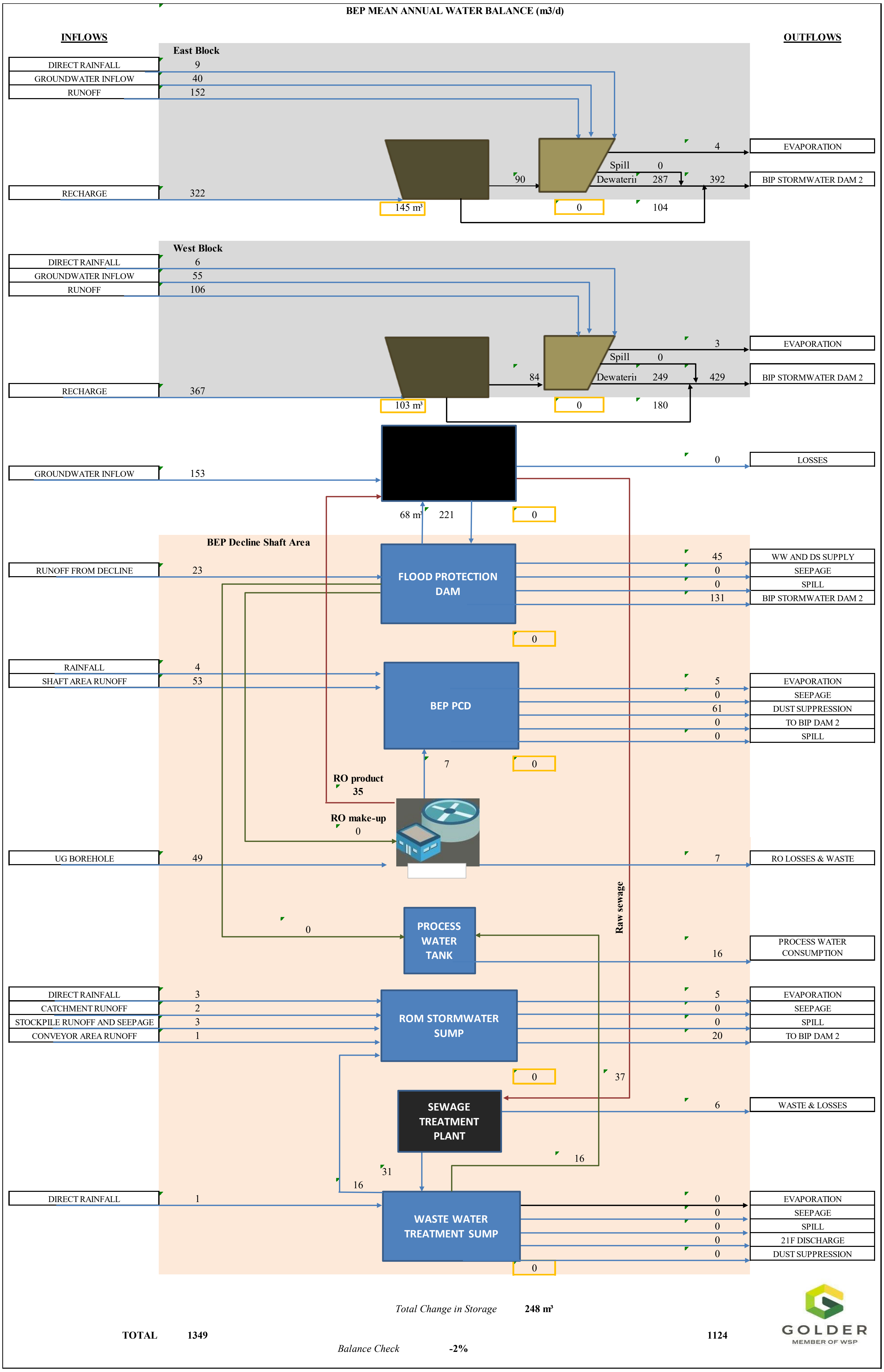


Figure 67: BEP annual maximum (95th percentile) water balance over the LoM operation (2031 – 2042)

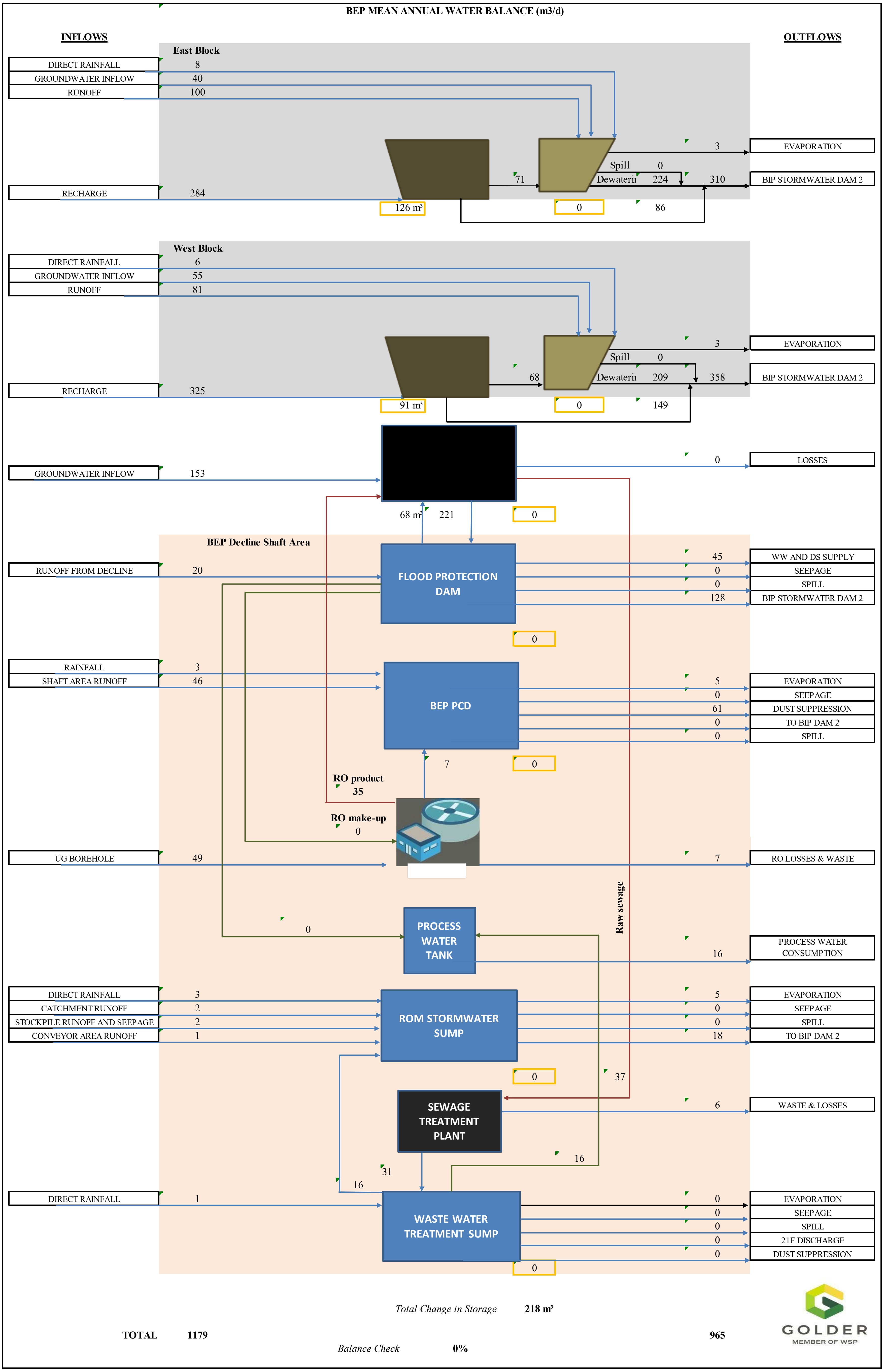


Figure 68: BEP annual minimum (10th percentile) water balance over the LoM operation (2031 – 2042)

10.9.2 BEP Dam sizing

The sizing of the dams at the BEP underground decline area were evaluated taking the inflows and outflows as indicated in Table 27 into account as well as the following philosophy:

- The sizing is to conform to the 1:50 year spillage criteria as per Government Regulation, GN704, i.e., the dams can only 1 spillage event can occur in a 50-year cycle.
- The outflow of the BEP dams to the BIP Dam 2 was minimised as much as possible to minimise treatment capacity at the dams but still allowed for the BEP dam functioning as designed.

Based on the above dam sizing, the total excess water from the BEP underground decline area to be routed to the BIP Dam 2 is a ***maximum*** of 3 467.5 m^3/d and is made up of:

- 500 m^3/d from the BEP PCD;
- 1 000 m^3/d from the Flood Protection Dam;
- 350 m^3/d from the RoM stormwater sump; and
- 67.5 m^3/d sewage effluent.

Figure 69 and Figure 70 shows the spillage from the BEP PCD, Flood Protection Dam over a 50-year period.

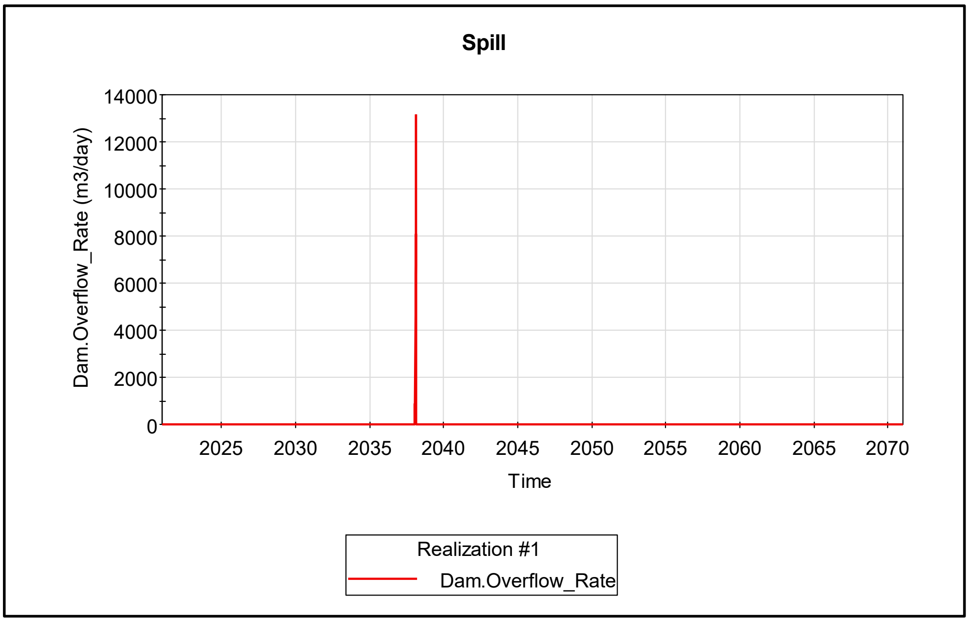


Figure 69: Spillage from the BEP PCD over a 50-year future period

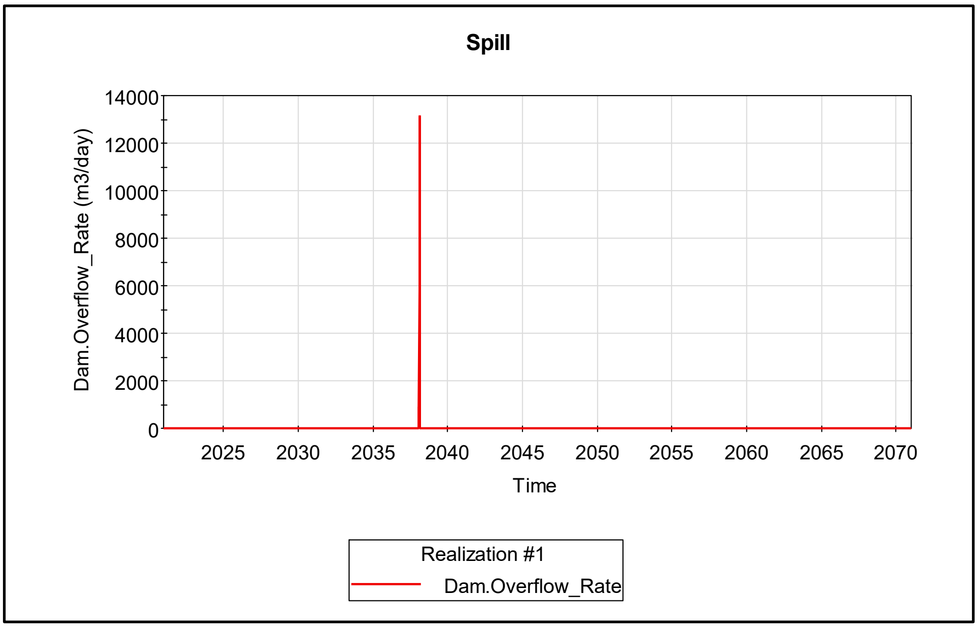


Figure 70: Spillage from the Flood Protection Dam over a 50-year period

10.9.3 Plant water demand

The plant water demand varies over the years due to changes in tonnages. The yearly average water demand fluctuates and peaks in 2039 at 1,850 m^3/d when it operates at 455 ROM tonnes/hr. The lowest plant demand during phase 2 is reached in 2013 at about 1,500 m^3/d. Fluctuations within a year are due to change of moisture in the ROM, discard and product.

It is to be noted that the values are in accordance with the macro balance value of 1,878 m^3/d when the plant operates at a ROM feed of 480 tonnes/hr.

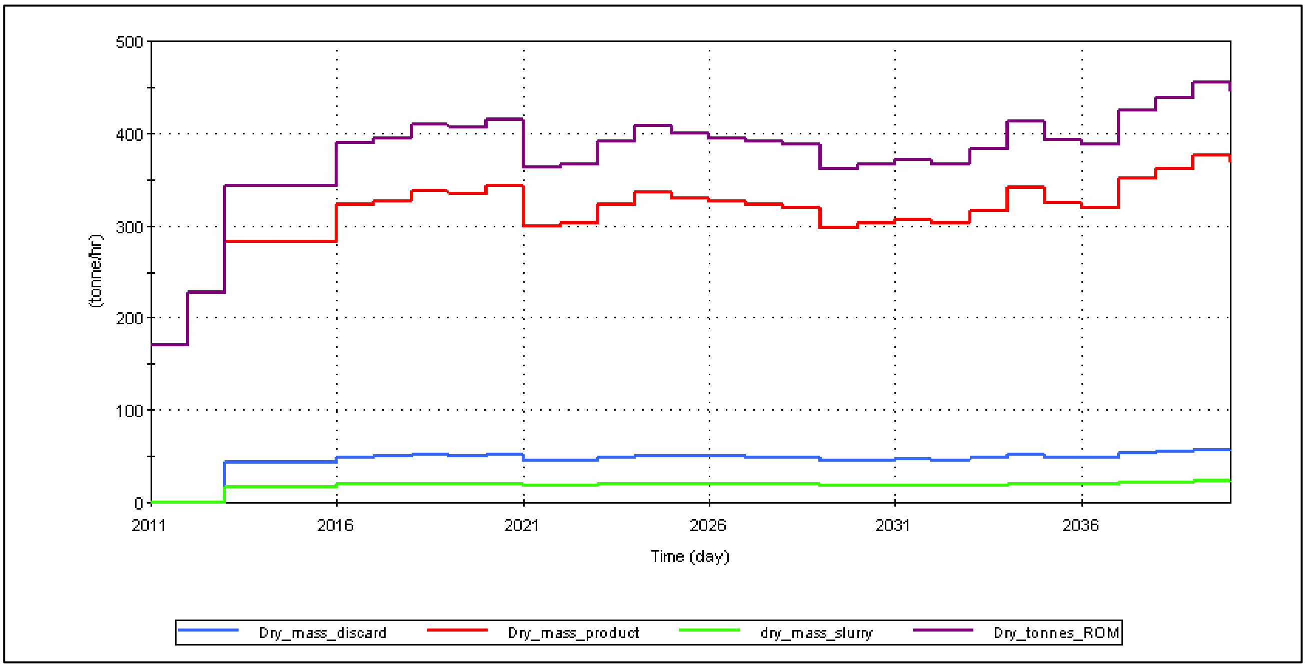


Figure 71: Modelled plant hourly tonnages

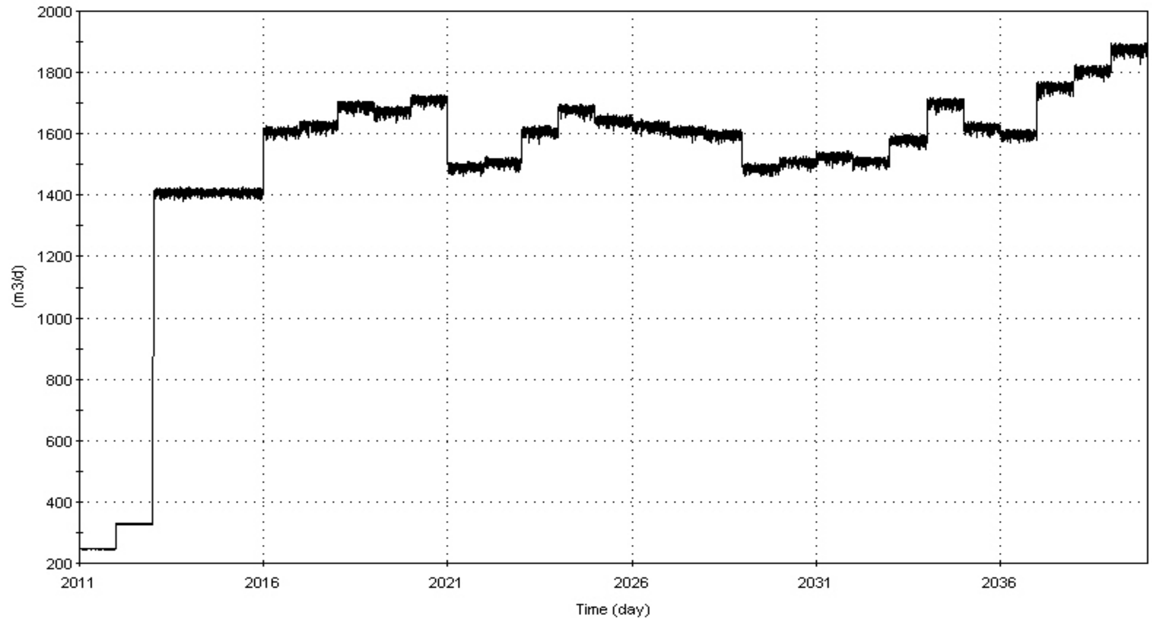


Figure 72: Plant daily water demand

10.9.4 Pit dewatering

The pit sumps should be kept dry at all times to limit pit flooding interfering with the mining operation. Table 31 shows the simulated average dewatering rates from the individual pits over the operational period of the specific pit. Table 32 shows the required pump capacity from the individual pits and the total BIP and BEP pump capacity required. The pump capacity for each pit was capped at 1 500 m^3/d.

Table 31: Simulated average dewatering rates from the individual pits

Pit description	Average dewatering rate for BEP pits only[m^3]
Pit 8	165
Pit 9	321
Pit 10	200
Pit 11	210
Pit 12	178

Table 32: Maximum pit dewatering rate (pump capacity)

Description	Dewatering rate [m^3/d]
Individual pits	1 500
Total BIP pits	10 500
Total BEP pits	7 500

Figure 73 shows the dewatering rate from the BEP East pits (Pit 10, Pit 11 and Pit 12) and

Figure 74 shows the dewatering rate from the BEP West pits (Pit 8, Pit 9). Figure 75 shows the total BEP dewatering to the BIP Dam 2 and Figure 76 shows the total BIP and BEP dewatering to the BIP Dam 2.

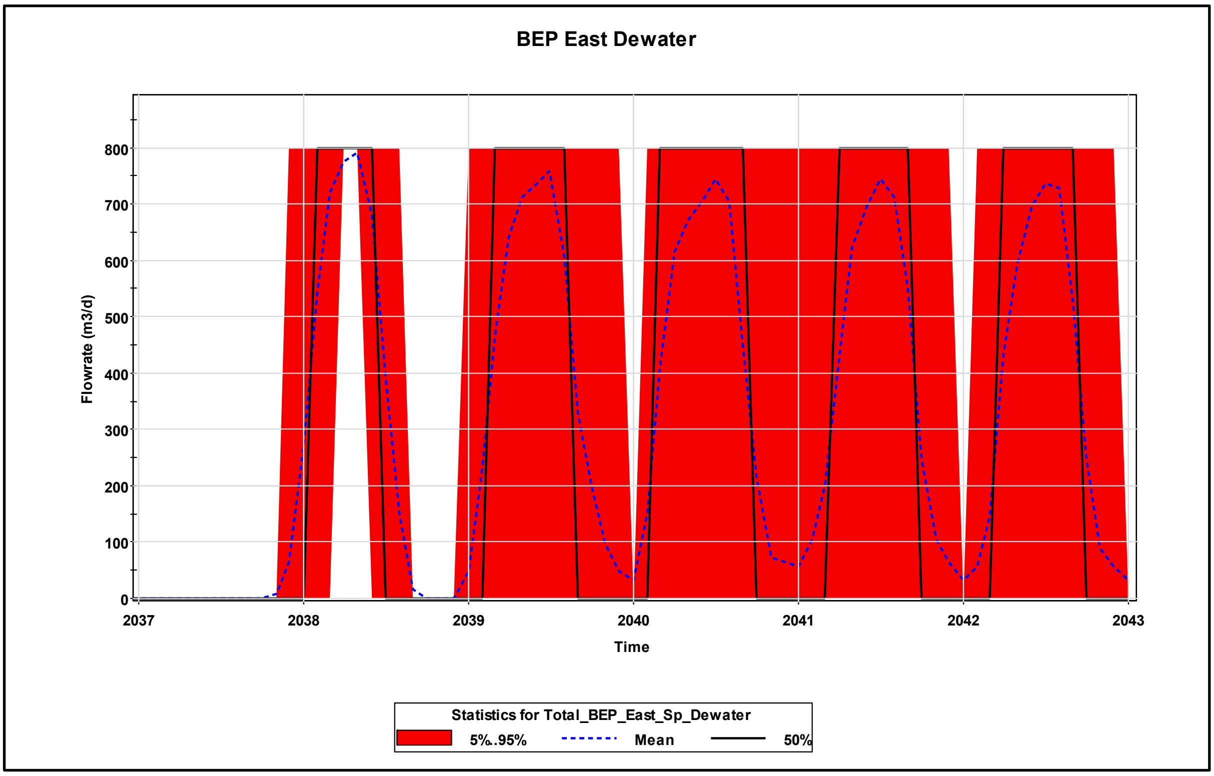


Figure 73: BEP East Pit dewatering rate

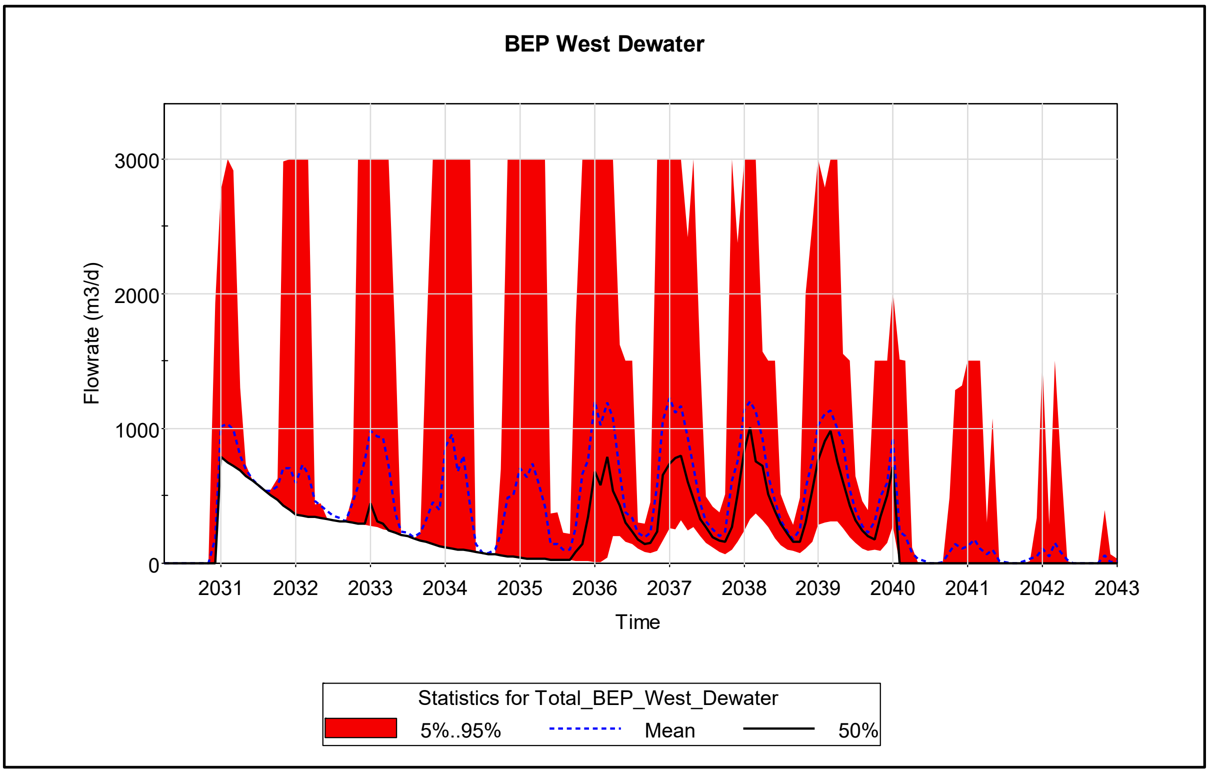


Figure 74: BEP West Pit dewatering rate

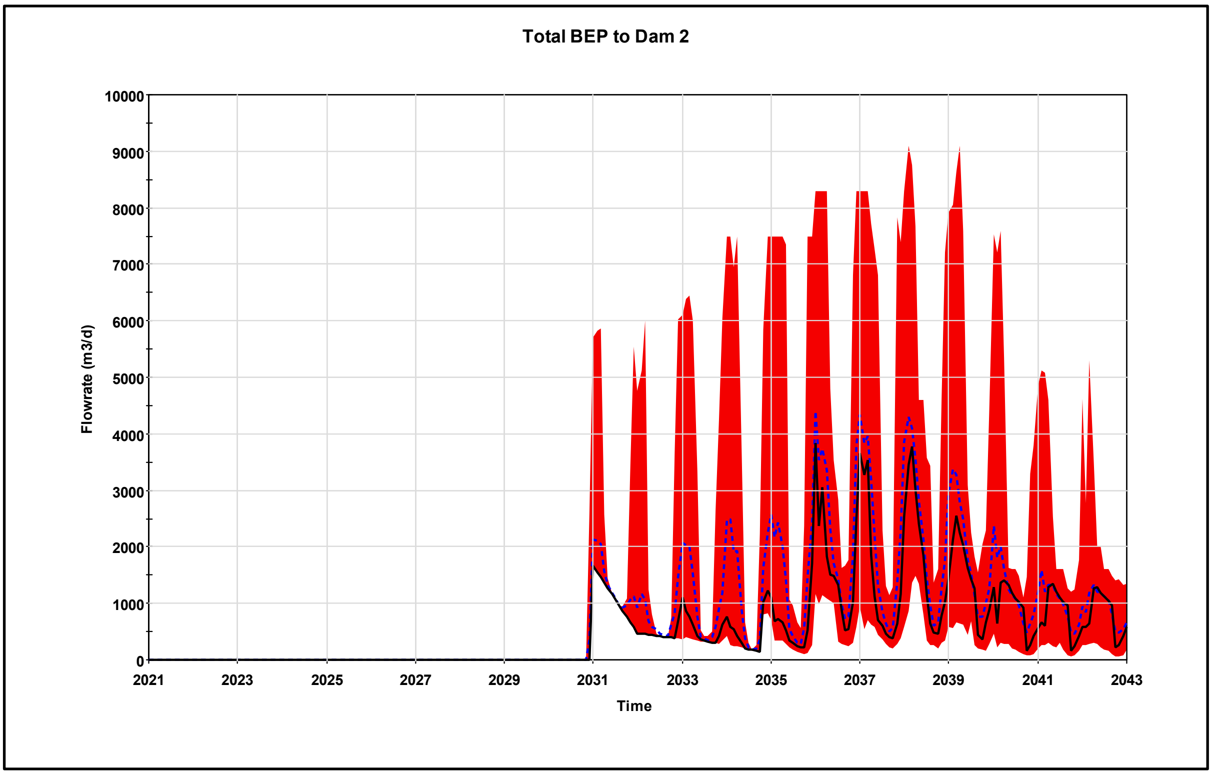


Figure 75: Total flowrate from BEP dewatering to BIP Dam 2

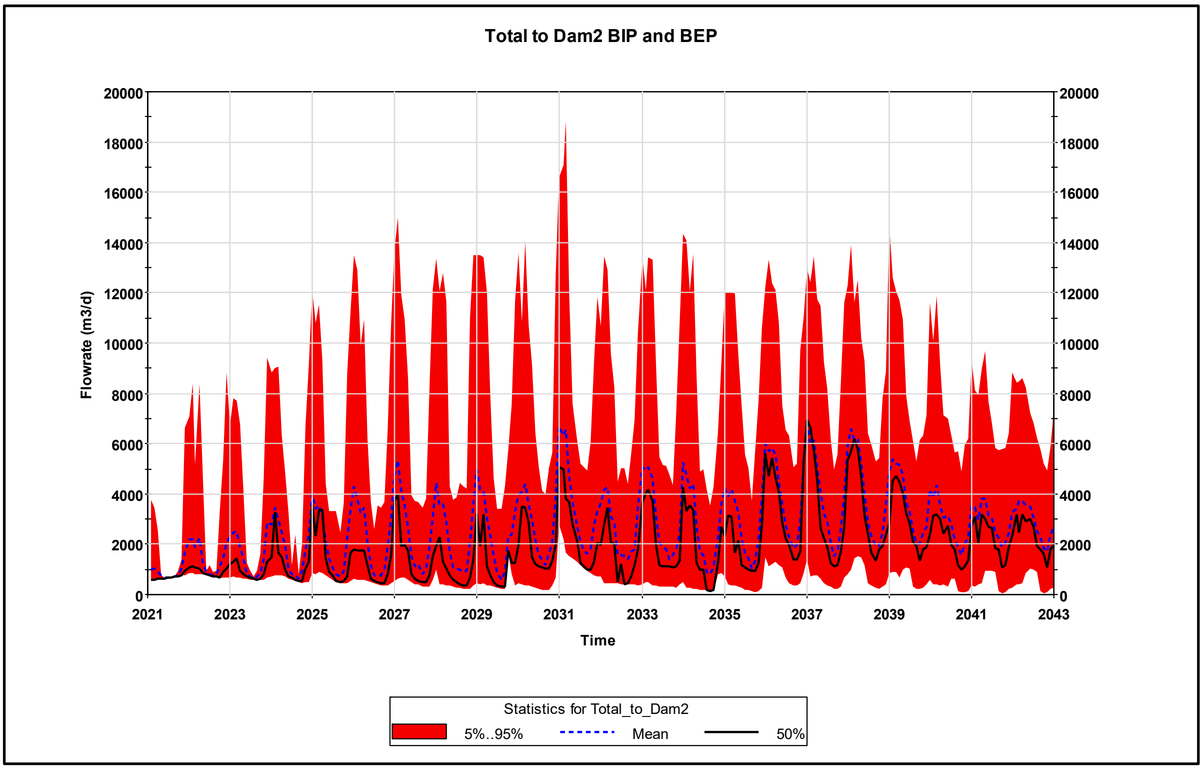


Figure 76: Total flowrate from BEP and BIP dewatering to BIP Dam 2

10.9.5 LoM water treatment requirements

The volume of mine water will grow as the mine grows until the volume generated on the mine exceeds the storage capacity. Treatment will be required to manage the excess water. Excess water from BEP is routed to the BIP Dam 2 and will be treated in the BIP water treatment plant (already authorised as per the BIP WUL). Figure 77 shows the average water treatment capacity requirements over the LoM. As mentioned, this is part of an existing authorisation and do not form part of the BEP WULA.

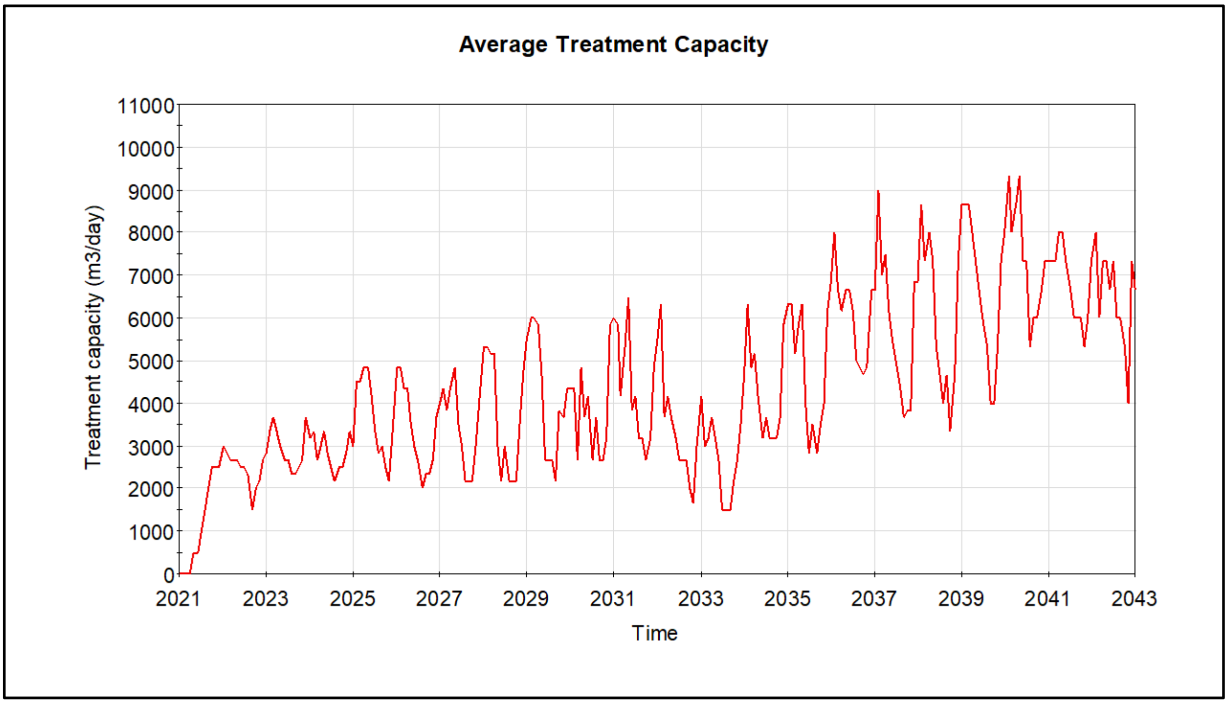


Figure 77: Average water treatment capacity requirement over the LoM

10.9.6 Pit decant

Refer to the Groundwater report, Golder, 2021c, for information on decant.

10.9.7 Post closure water treatment requirement

For the surface water balance, Golder has taken an integrated BIP/BEP approach and evaluated the post closure scenario from 2040 onwards assuming that all pits (BIP and BEP) have been mined through and that there are no barrier pillars between the pits. The post closure modelling was conducted from 2040 on the total east (BIP and BEP) and total west (BIP and BEP) pit sizes.

Figure 78 shows the post closure groundwater inflow rates including recharge over the rehabilitated spoils (Golder, 2021d). Figure 79 shows the monthly assessment of pit inflows post closure.

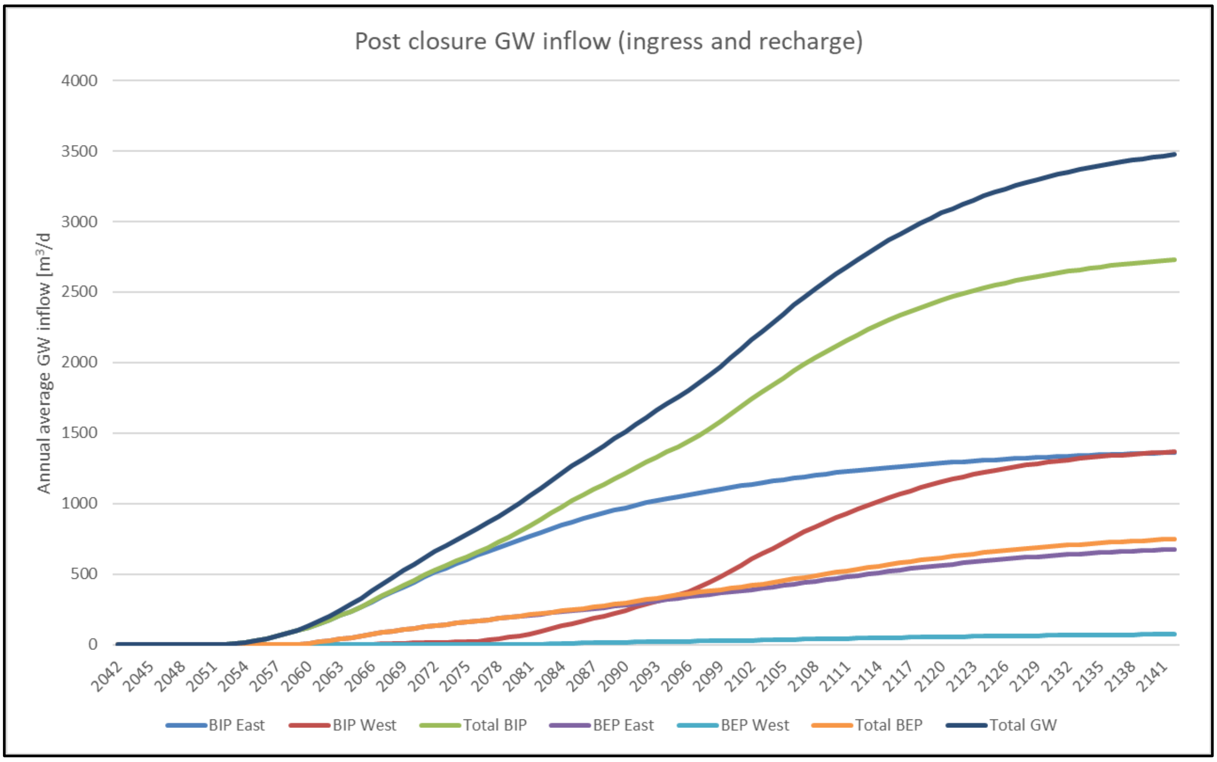


Figure 78: Post closure groundwater ingress rates

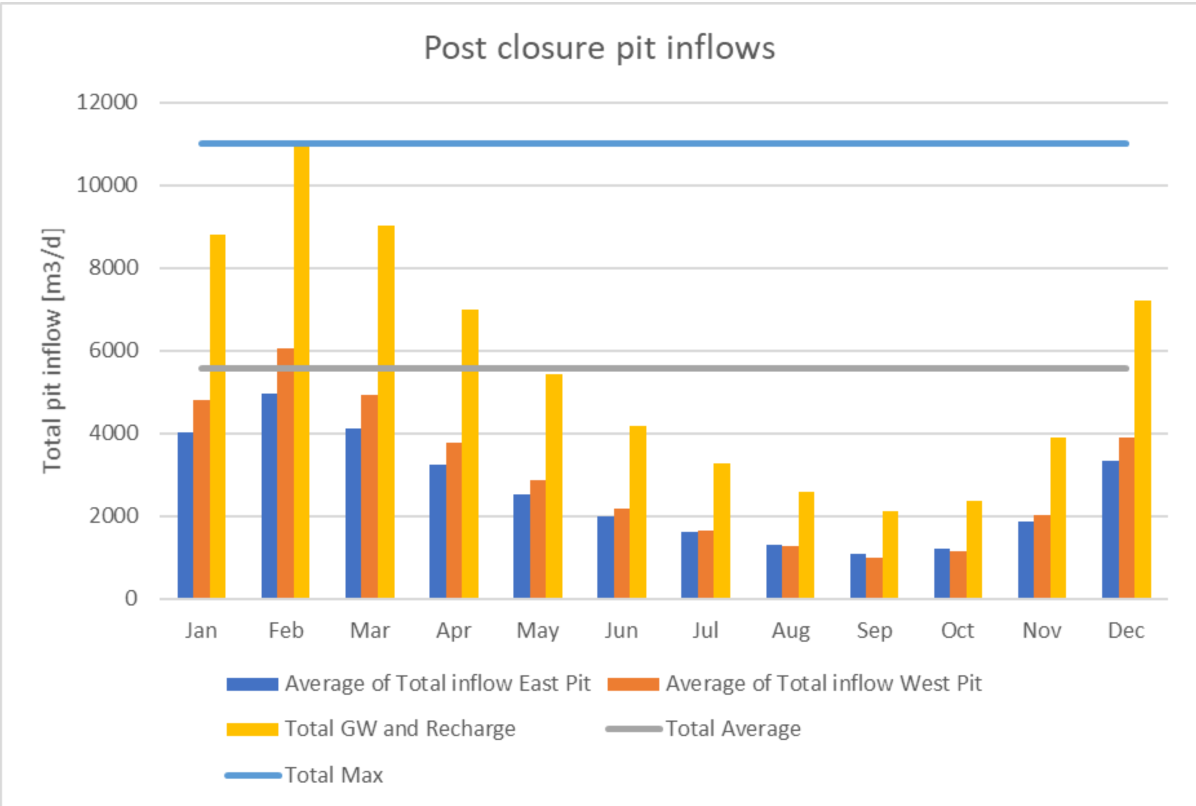


Figure 79: Monthly assessment of post closure pit inflows

10.9.8 Volumes associated with water uses

Table 33 and Table 34 shows the water balance that is required for water use licence authorisation purposes for BEP, dust suppression and dewatering from the mining pits respectively. Volumes are in total annual cubic meters. Water is dewatered from the BEP underground mine and the BEP opencast pits and this water is routed to the BIP Dam 2 from where the water is either used for evaporation purposes, for ore processing purposes or will be treated at the water treatment plant and discharged. The maximum daily volume including the BEP underground and open cast operations is 12 100 m^3/d for dewatering and 1 948 m^3/d for dust suppression.

Table 33: Water balance associated with the dewatering water use requiring authorisation

Water in (m^3/a)		Water out (m^3/a)	
Input	Volume	Output	Volume
Rainfall	33 286	Evaporation	24 090
Runoff	1 876 077	Pit Dewatering	3 738 013
Recharge	1 485 550		
Groundwater ingress	367 190		
Total	**3 762 103**	**Total**	**3 762 103**

Table 34: Water balance associated with the dust suppression water use requiring authorisation

Water in (m^3/a)		Water out (m^3/a)	
Input	**Volume**	**Output**	**Volume**
Rainfall	9 269	Evaporation	12 100
Runoff	1 704 502	Dust suppression	646 736
Dewatering from Pits	3 738 013	Ore Processing demand	730 000
Sewage Effluent	29 200	Treatment and Discharge	3 795 148
Total	**20 232**	**Total**	**20 232**

11.0 POTENTIAL IMPACT ASSESSMENT

This impacts assessment is conducted to assess both surface water quality and quantity impacts resulting from the proposed Belfast Expansion Project mine activities for the life of mine (Construction, Operation, Decommissioning and Closure as well as Post Closure phase).

11.1 Impact Assessment Methodology

The significance of each identified impact was determined using the approach outlined below (terminology from the Department of Environmental Affairs and Tourism Guideline document on EIA Regulations, April 1998).

This approach incorporates two aspects for assessing the potential significance of impacts, namely occurrence and severity, which are further sub-divided as follows:

Occurrence		Severity	
Probability of occurrence	Duration of occurrence	Scale/extent of impact	Magnitude (severity) of impact

To assess each of these factors for each impact, the following four ranking scales are used:

Probability **(the likelihood of the impact actually occurring)**	**Duration of the impact** **(the length that the impact will last for)**
5 - Definite	5 - Permanent
4 - Highly probability (most likely to occur)	4 - Long-term (ceases after the operational lifespan of the project)
3 - Medium probability (distinct probability that the impact will occur)	3 - Medium-term (5 - 15 years)
2 - Low probability (unlikely to occur)	2 - Short-term (1 - 5 years)
1 – Improbable (probability very low due to design or experience)	1 – Immediate (< 1 year)
0 – None (the impact will not occur)	
Scale **(Extent of the impact)**	**Magnitude** **(the intensity or severity of the impact is indicated as)**
5 - International	10 - Very high / unsure (environmental functions permanently cease)
4 - National	8 – High (environmental functions temporarily cease)
3 – Regional (within the Belfast area)	6 – Moderate (environmental functions altered but continue)
2 – Local (site boundary and immediate surrounds)	4 - Low
1 - Site (site only)	2 - Minor
	0 - None

Definitions

Magnitude is a measure of the degree of change in a measurement or analysis (e.g., the area of pasture, or the concentration of a metal in water compared to the water quality guideline value for the metal), and is classified as none/negligible, low, moderate or high. The categorisation of the impact magnitude may be based on a set of criteria (e.g. health risk levels, ecological concepts and/or professional judgment) pertinent to each of the discipline areas and key questions analysed. The specialist study must attempt to quantify the magnitude and outline the rationale used. Appropriate, widely recognised standards are to be used as a measure of the level of impact;

Scale/ Geographic extent refers to the area that could be affected by the impact and is classified as site, local, regional, national, or international;

Duration refers to the length of time over which an environmental impact may occur *i.e.* immediate/transient, short-term (0 to 7 years), medium term (8 to 15 years), long-term (greater than 15 years with impact ceasing after closure of the project), or permanent; and

Probability of occurrence is a description of the probability of the impact actually occurring as improbable (less than 5% chance), low probability (5% to 40% chance), medium probability (40% to 60% chance), highly probable (most likely, 60% to 90% chance) or definite (impact will definitely occur).

Once these factors are ranked for each impact, the significance of the two aspects, occurrence and severity, is assessed using the following formula:

SP (significance points) = (magnitude + duration + scale) x probability

The maximum value is 100 significance points (SP). The impact significance will then be rated as follows:

SP >60	Indicates high environmental significance	An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation.
SP 30 – 60	Indicates moderate environmental significance	An impact or benefit which is sufficiently important to require management and which could have an influence on the decision unless it is mitigated.
SP <30	Indicates low environmental significance	Impacts with little real effect and which should not have an influence on the decision to develop in the area.
+	Positive impact	An impact that constitutes an improvement over pre-project conditions

11.2 Surface Water Impacts

Any development either within a natural system or an already built-up system will impact on the environment, usually with adverse effects. From a technical, conceptual or philosophical perspective the focus of impact assessment ultimately narrows down to a judgment on whether the predicted impacts are significant or not. To this end, a discussion guiding impact characterisation is provided in the sections below, with the rating calculations shown in the accompanying tables (Table 23 for surface water and aquatic ecosystem respectively).

Table 35: Summary of activities and related surface water impacts with proposed mitigation

Issue	Mitigation measures	Impact rating criteria					Significance
		Nature	Extent	Duration	Magnitude	Probability	
CONSTRUCTION PHASE							
Siltation and/or contamination of surface water resources							
The footprint clearance for the underground ramp area, conveyor/road storm water infrastructure development open cast and MRF storm water infrastructure development, will expose bare soil that could result in sheet wash into nearby watercourses during a precipitation event. In addition, dust can further be transported into watercourses or be deposited on infrastructure near watercourses thereby exacerbating the impact of siltation during rainfall events. During the construction phase, the impact of the expansion activities on the hydrology is low with and without mitigation measures.							
MRF extension	No	Negative	1 (Site)	1 (Immediate)	4 (Low)	4 (High)	24 (Low)
	Yes	Negative	1 (Site)	1 (Immediate)	2 (Minor)	2 (Low)	12 (Low)
UG ramp area	No	Negative	2 (Local)	1 (Immediate)	6 (Moderate)	4 (High)	36 (Medium)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)
OC storm water infrastructure	No	Negative	1 (Site)	1 (Immediate)	4 (Low)	4 (High)	24 (Low)
	Yes	Negative	1 (Site)	1 (Immediate)	2 (Minor)	2 (Low)	12 (Low)
Route option 1	No	Negative	2 (Local)	1 (Immediate)	6 (Moderate)	4 (High)	36 (Medium)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)
Route option 2	No	Negative	2 (Local)	1 (Immediate)	6 (Moderate)	4 (High)	36 (Medium)
	Yes	Negative	1 (Site)	1 (Immediate)	4 (Low)	2 (Low)	12 (Low)
Mitigation measures							
■ Ensure that clean and dirty water separation infrastructure is in place prior to the commencement of construction; ■ Prevent spillage of fuel and oils by using drip trays and storing hazardous substances and vehicles in bunded areas; ■ Design criteria should prevent the seepage of contaminated water to avoid lateral subsurface movement of contaminants into drainage lines; ■ The conveyor belt must be constructed across drainage lines and not along drainage lines. Spanning across drainage lines is encouraged; ■ Watercourses and their buffers affected by unavoidable construction activities should be rehabilitated soon after construction. Emphasis should be placed on the reinstatement of the topography to a similar profile as was present pre-construction; ■ Construction activities and access tracks roads should be located outside of watercourses as far as practically possible; ■ Avoid driving in watercourses during the construction phase to prevent vehicle track incision and the potential for channel initiation; and ■ The implementation of erosion protection measures, such as energy dissipaters, at new formalised vehicle tracks the contain pipes or culverts.							
Change in the hydrological regime							
The development of the underground ramp area, haul road between the underground area and the existing mine and new open cast pit will remove drainage area from the catchment thereby changing the hydrological regime resulting in a potential reduction in flow to the catchment and a reduction in catchment yield. During the construction phase the impact of the reduction in catchment yield starts off being low and increases with the increase in construction activity. The impact before mitigation is medium. With the mitigation measures to divert clean flow around the future impacted areas changes the impact to low.							
UG ramp area	No	Negative	2 (Local)	1 (Immediate)	6 (Moderate)	4 (High)	36 (Medium)
	Yes	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)
Opencast area	No	Negative	2 (Local)	1 (Immediate)	6 (Moderate)	4 (High)	36 (Medium)

Issue	Mitigation measures	Impact rating criteria					Significance
		Nature	Extent	Duration	Magnitude	Probability	
	Yes	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)
Route option 1	No	Negative	2 (Local)	1 (Immediate)	6 (Moderate)	4 (High)	36 (Medium)
	Yes	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)
Route option 2	No	Negative	2 (Local)	1 (Immediate)	6 (Moderate)	4 (High)	36 (Medium)
	Yes	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)
Mitigation measures							
■ Ensure that the principles of Government Regulation, GN 704, is implemented in storm water designs to maximise the diversion of clean water around the proposed mining areas. ■ Implement relevant flow calming devices to allow for diversion back into the impacted watercourses.							
Climate change							
Climate change is an important consideration for mining operations worldwide. The impact on water resources and water management facilities due to climate change must be assessed in order to manage and mitigate future and latent risks. Construction phase for the BEP project is assumed to occur pre-2050. For this period, the projected temperature increases are 2°C to 3°C. General reductions in rainfall are expected. The impacts to the construction due to climate change are therefore minimal however the following precautions are noted: ▪ Higher temperatures mean more hazardous outdoor working conditions. ▪ Lower rainfalls imply an possible issue with water supply sources.							
UG ramp area	No	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)
Opencast area	No	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)
Route option 1	No	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)
Route option 2	No	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)
Mitigation measures							
■ Minimise personnel exposure to high heats and ensure adequate PPE is provided. ■ Provide an alternative supply of water if required							
OPERATIONAL PHASE							
Deterioration of surface water quality and siltation of water resources							
The BEP will reduce the sub-catchment areas and runoff volumes. This impact refers to changes in water flow patterns caused by operational activities within watercourses. It is also associated with watercourse habitat loss, but focusses more on habitat modification, specifically regarding changes in water movement. Water flow changes can also occur as a result of heavy motorised vehicles driving through watercourse and the need for access tracks in watercourses that have channels. Vehicle track entrenchment commonly occur due to vehicles driving in wetlands with temporary, seasonal or permanent zones of wetness. During operational phase, this impact was rated medium and low without and with the implementation of mitigation measures respectively.							
	No	Negative	1 (Site)	1 (Immediate)	4 (Low)	4 (High)	24 (Low)

Issue	Mitigation measures	Impact rating criteria					Significance
		Nature	Extent	Duration	Magnitude	Probability	
Open cast pits and new MRF	Yes	Negative	1 (Site)	1 (Immediate)	2 (Minor)	2 (Low)	12 (Low)
UG ramp area	No	Negative	2 (Local)	1 (Immediate)	6 (Moderate)	4 (High)	36 (Medium)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)
Route option 1	No	Negative	2 (Local)	1 (Immediate)	6 (Moderate)	4 (High)	36 (Medium)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)
Route option 2	No	Negative	2 (Local)	1 (Immediate)	6 (Moderate)	4 (High)	36 (Medium)
	Yes	Negative	1 (Site)	1 (Immediate)	4 (Low)	2 (Low)	12 (Low)

Mitigation measures

- No furrows or drains should be made to channel water from infrastructure. Where this is unavoidable, these furrows and drains need to be closed and revegetated as soon as possible.
- Where this is unavoidable in watercourses with channels or wetlands with temporary seasonal or permanent zones of wetness, crossing structures should be in place within affected wetlands and other watercourses.
- Additional benefits of using a formal crossing structure that has engineering input to mitigate watercourse impacts based on site conditions, include the following:
  - It defines a single route alignment for vehicle travel.
  - Provides a 'wear and carry' surface over unsuitable and easily compactable wetland soils.
  - This results in a stable, durable crossing surface for vehicle access, including heavy motor vehicle traffic.
- Halts the widening and the development of braided crossing sections, while formerly used track alignments are allowed to naturally stabilise and revegetate.

Change in the hydrological regime

The development of the underground ramp area, haul road between the underground area and the existing mine and new open cast pit will remove drainage area from the catchment thereby changing the hydrological regime resulting in a potential reduction in flow to the catchment and a reduction in catchment yield. During the operational phase, the impact is the maximum of that experience during the construction phase. The impact before mitigation is medium. With the mitigation measures to divert clean flow around the future impacted areas changes the impact to low.

Issue	Mitigation measures	Nature	Extent	Duration	Magnitude	Probability	Significance
UG ramp area	No	Negative	2 (Local)	1 (Immediate)	6 (Moderate)	4 (High)	36 (Medium)
	Yes	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)
Opencast area	No	Negative	2 (Local)	1 (Immediate)	6 (Moderate)	4 (High)	36 (Medium)
	Yes	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)
Route option 1	No	Negative	2 (Local)	1 (Immediate)	6 (Moderate)	4 (High)	36 (Medium)
	Yes	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)
Route option 2	No	Negative	2 (Local)	1 (Immediate)	6 (Moderate)	4 (High)	36 (Medium)
	Yes	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)

Mitigation measures

- Ensure that the principles of Government Regulation, GN 704, is implemented in storm water designs to maximise the diversion of clean water around the proposed mining areas.
- Implement relevant flow calming devices to allow for diversion back into the impacted watercourses.

Deterioration of ecological function in receiving surface water resources and wetland systems

Issue	Mitigation measures	Impact rating criteria					Significance
		Nature	Extent	Duration	Magnitude	Probability	
The ecological functioning of the receiving surface water resources and wetland systems will be impacted by unauthorised discharges and plume migration due to spillages from contaminated water storage facilities, seepages through contaminated water storage facilities, spillages from the conveyor system mobilised by a rainfall event and inadequate decant management at Pit 5 resulting in contamination from the new MRF. The impact before mitigation is medium and is low after mitigation.							
UG ramp area	No	Negative	2 (Local)	2 (Short term)	6 (Moderate)	3 (Medium)	30 (Medium)
	Yes	Negative	1(Site)	1 (Immediate)	4 (Low)	2 (Low)	12 (Low)
Opencast area	No	Negative	2 (Local)	2 (Short term)	6 (Moderate)	3 (Medium)	30 (Medium)
	Yes	Negative	1(Site)	1 (Immediate)	4 (Low)	2 (Low)	12 (Low)
New MRF	No	Negative	2 (Local)	2 (Short term)	6 (Moderate)	3 (Medium)	30 (Medium)
	Yes	Negative	1(Site)	1 (Immediate)	4 (Low)	2 (Low)	12 (Low)
Route option 1	No	Negative	2 (Local)	2 (Short term)	6 (Moderate)	3 (Medium)	30 (Medium)
	Yes	Negative	1(Site)	1 (Immediate)	4 (Low)	2 (Low)	12 (Low)
Route option 2	No	Negative	2 (Local)	2 (Short term)	6 (Moderate)	3 (Medium)	30 (Medium)
	Yes	Negative	1 (Site)	1 (Immediate)	4 (Low)	2 (Low)	12 (Low)
Mitigation measures							
■ All new water storage facilities should be designed to in compliance with Regulation GN704 to prevent spillages. ■ All new water storage facilities should be lined to prevent the seepage of contaminated water to the groundwater. ■ Implement adequate monitoring and measurement devices for proactive operational management to prevent spillages and decant. ■ Ensure pit water management infrastructure is available and adequate to allow for management of the pit water level. ■ Line / isolate all areas that are classified as potentially polluting areas and ensure adequate berming. ■ Develop emergency procedures to contain any pollution incidents that may occur.							
Adverse water quality in receiving surface and groundwater resource impacting of water users							
The water quality in the receiving surface water resource will be impacted by unauthorised discharges and plume migration due to spillages from contaminated water storage facilities, seepages through contaminated water storage facilities, spillages from the conveyor system mobilised by a rainfall event and inadequate decant management at Pit 5 resulting in contamination from the new MRF. This is similar to the previous item. The impact before mitigation is medium and is low after mitigation.							
UG ramp area	No	Negative	2 (Local)	2 (Short term)	6 (Moderate)	3 (Medium)	30 (Medium)
	Yes	Negative	1(Site)	1 (Immediate)	4 (Low)	2 (Low)	12 (Low)
Opencast area	No	Negative	2 (Local)	2 (Short term)	6 (Moderate)	3 (Medium)	30 (Medium)
	Yes	Negative	1(Site)	1 (Immediate)	4 (Low)	2 (Low)	12 (Low)
MRF	No	Negative	2 (Local)	2 (Short term)	6 (Moderate)	3 (Medium)	30 (Medium)
	Yes	Negative	1(Site)	1 (Immediate)	4 (Low)	2 (Low)	12 (Low)
Route option 1	No	Negative	2 (Local)	2 (Short term)	6 (Moderate)	3 (Medium)	30 (Medium)
	Yes	Negative	1(Site)	1 (Immediate)	4 (Low)	2 (Low)	12 (Low)
Route option 2	No	Negative	2 (Local)	2 (Short term)	6 (Moderate)	3 (Medium)	30 (Medium)

Issue	Mitigation measures	Impact rating criteria					Significance
		Nature	Extent	Duration	Magnitude	Probability	
	Yes	Negative	1 (Site)	1 (Immediate)	4 (Low)	2 (Low)	12 (Low)

Mitigation measures

- All new water storage facilities should be designed to in compliance with Regulation GN704 to prevent spillages.
- All new water storage facilities should be lined to prevent the seepage of contaminated water to the groundwater.
- Implement adequate monitoring and measurement devices for proactive operational management to prevent spillages and decant.
- Ensure pit water management infrastructure is available and adequate to allow for management of the pit water level.
- Line / isolate all areas that are classified as potentially polluting areas and ensure adequate berming.
- Develop emergency procedures to contain any pollution incidents that may occur.

Climate change

Climate change is an important consideration for mining operations worldwide. The impact on water resources and water management facilities due to climate change must be assessed in order to manage and mitigate future and latent risks. Operational phase for the BEP project is assumed to occur pre-2050. For this period, the projected temperature increases are 2°C to 3°C. General reductions in rainfall are expected. The impacts to the operations due to climate change are therefore the following:

- Higher temperatures imply higher evaporation which coupled with lower rainfall can impact on water supply.
- Lower rainfalls can also impact on water supply.

Issue	Mitigation measures	Nature	Extent	Duration	Magnitude	Probability	Significance
UG ramp area	No	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)
Opencast area	No	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)
MRF	No	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)
Route option 1	No	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)
Route option 2	No	Negative	2 (Local)	1 (Immediate)	4 (Low)	2 (Low)	14 (Low)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)

Mitigation measures

- Ensure a contingency plan is put together to address possible water supply issues. Identify a possible alternative supply if needed.
- Minimise personnel exposure to the outdoors during high temperature times.

CLOSURE AND DECOMMISSONING PHASE

- No furrows or drains should be made to channel water from infrastructure. Where this is unavoidable, these furrows and drains need to be closed and revegetated as soon as possible.
- Where this is unavoidable in watercourses with channels or wetlands with temporary seasonal or permanent zones of wetness, crossing structures should be in place within affected wetlands and other watercourses.

<table>
<tr><th rowspan="2">Issue</th><th rowspan="2">Mitigation measures</th><th colspan="5">Impact rating criteria</th><th rowspan="2">Significance</th></tr>
<tr><th>Nature</th><th>Extent</th><th>Duration</th><th>Magnitude</th><th>Probability</th></tr>
<tr><td colspan="8">■ Additional benefits of using a formal crossing structure that has engineering input to mitigate watercourse impacts based on site conditions, include the following:
▪ It defines a single route alignment for vehicle travel.
▪ Provides a ‘wear and carry’ surface over unsuitable and easily compactable wetland soils.
▪ This results in a stable, durable crossing surface for vehicle access, including heavy motor vehicle traffic.
■ Halts the widening and the development of braided crossing sections, while formerly used track alignments are allowed to naturally stabilise and revegetate.</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="8">Siltation and/or contamination of surface water resources</td></tr>
<tr><td colspan="8">The rehabilitation of the underground ramp area, conveyor/road infrastructure, the open cast area and MRF, will expose and loosen contaminated soil that could result in sheet wash into nearby watercourses during a precipitation event. In addition, dust can further be transported into watercourses or be deposited on infrastructure near watercourses thereby exacerbating the impact of siltation during rainfall events. During the closure and decommissioning phase, the impact of the expansion activities on the hydrology is medium without mitigation and is low with mitigation measures. This rating is higher than the same impact for the construction since in this instance the mobilised material is contaminated due to the years of operational activity.</td></tr>
<tr><td rowspan="2">UG ramp area</td><td>No</td><td>Negative</td><td>2 (Local)</td><td>2 (Short term)</td><td>6 (Moderate)</td><td>4 (High)</td><td>36 (Medium)</td></tr>
<tr><td>Yes</td><td>Negative</td><td>1(Site)</td><td>2 (Short term)</td><td>2 (Minor)</td><td>2 (Low)</td><td>10 (Low)</td></tr>
<tr><td rowspan="2">OC storm water infrastructure</td><td>No</td><td>Negative</td><td>1 (Site)</td><td>2 (Short term)</td><td>6 (Moderate)</td><td>4 (High)</td><td>36 (Medium)</td></tr>
<tr><td>Yes</td><td>Negative</td><td>1 (Site)</td><td>2 (Short term)</td><td>2 (Minor)</td><td>2 (Low)</td><td>10 (Low)</td></tr>
<tr><td rowspan="2">Route option 1</td><td>No</td><td>Negative</td><td>2 (Local)</td><td>2 (Short term)</td><td>6 (Moderate)</td><td>4 (High)</td><td>36 (Medium)</td></tr>
<tr><td>Yes</td><td>Negative</td><td>1(Site)</td><td>2 (Short term)</td><td>2 (Minor)</td><td>2 (Low)</td><td>10 (Low)</td></tr>
<tr><td rowspan="2">Route option 2</td><td>No</td><td>Negative</td><td>2 (Local)</td><td>2 (Short term)</td><td>6 (Moderate)</td><td>4 (High)</td><td>36 (Medium)</td></tr>
<tr><td>Yes</td><td>Negative</td><td>1 (Site)</td><td>2 (Short term)</td><td>2 (Minor)</td><td>2 (Low)</td><td>10 (Low)</td></tr>
<tr><td colspan="8">■ No furrows or drains should be made to channel water from infrastructure. Where this is unavoidable, these furrows and drains need to be closed and revegetated as soon as possible.
■ Where this is unavoidable in watercourses with channels or wetlands with temporary seasonal or permanent zones of wetness, crossing structures should be in place within affected wetlands and other watercourseDEs.
■ Additional benefits of using a formal crossing structure that has engineering input to mitigate watercourse impacts based on site conditions, include the following:
▪ It defines a single route alignment for vehicle travel.
▪ Provides a ‘wear and carry’ surface over unsuitable and easily compactable wetland soils.
▪ his results in a stable, durable crossing surface for vehicle access, including heavy motor vehicle traffic.
▪ Halts the widening and the development of braided crossing sections, while formerly used track alignments are allowed to naturally stabilise and revegetate.
■ Ensure a logical phased decommissioning is conducted to ensure storm water infrastructure is still available for most of the decommissioning activities.</td></tr>
<tr><td colspan="8">POST-CLOSURE PHASE</td></tr>
<tr><td colspan="8">Adverse water quality in receiving surface and groundwater resource and wetland systems</td></tr>
<tr><td colspan="8">The water quality in the receiving surface water resource will be impacted by inadequate rehabilitation of surface areas and inadequate decant management of the pits. The impact before mitigation is medium for the pit and MRF areas and is low after mitigation. For all other areas the impact is low for both pre and post mitigation.</td></tr>
<tr><td></td><td>No</td><td>Negative</td><td>2 (Local)</td><td>3 (Medium term)</td><td>6 (Moderate)</td><td>4 (Highly probable)</td><td>44 (Medium)</td></tr>
</table>

Issue	Mitigation measures	Impact rating criteria					Significance
		Nature	Extent	Duration	Magnitude	Probability	
Rehabilitated pits including MRF area	Yes	Negative	1(Site)	1 (Immediate)	4 (Low)	2 (Low)	12 (Low)
Opencast area	No	Negative	2 (Local)	2 (Short term)	4 (Low)	2 (Low)	16 (Low)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	1 (Improbable)	12 (Low)
Route option 1	No	Negative	2 (Local)	2 (Short term)	4 (Low)	2 (Low)	16 (Low)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	1 (Improbable)	12 (Low)
Route option 2	No	Negative	2 (Local)	2 (Short term)	4 (Low)	2 (Low)	16 (Low)
	Yes	Negative	1 (Site)	1 (Immediate)	2 (Minor)	1 (Improbable)	12 (Low)

Mitigation measures

- Ensure rehabilitation of impacted areas are conducted according to best practices.
- Implement adequate post-closure water management infrastructure (pumping and piping and treatment capacity) for pro-active management of decant.

Climate change

Climate change is an important consideration for mining operations worldwide. The impact on water resources and water management facilities due to climate change must be assessed in order to manage and mitigate future and latent risks. Post closure phase for the BEP project will be post 2050. For this period, the projected temperature increases are 2°C to 3°C. General reductions in rainfall are expected. Post 2071 temperature increases as high as 6 are expected but this is for the extreme scenario. Post 2071, further reduction in rainfall is expected. The following should be noted for the post closure phase.

- Higher temperatures mean more hazardous outdoor working conditions. This poses a minimal impact for the post closure phase due to fewer to no people on site. Any dewatering and pumping infrastructure required post closure is either to be designed to withstand higher atmospheric temperatures or be housed to shield against atmospheric condition.
- Lower rainfalls imply an possible issue with water supply sources. This is not an issue for the post closure phase.

Issue	Mitigation measures	Nature	Extent	Duration	Magnitude	Probability	Significance
Rehabilitated pits including MRF area	No	Negative	1(Site)	1 (Immediate)	2 (Minor)	1 (Improbable)	12 (Low)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)
Opencast area	No	Negative	1(Site)	1 (Immediate)	2 (Minor)	1 (Improbable)	12 (Low)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)
Route option 1	No	Negative	1(Site)	1 (Immediate)	2 (Minor)	1 (Improbable)	12 (Low)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)
Route option 2	No	Negative	1(Site)	1 (Immediate)	2 (Minor)	1 (Improbable)	12 (Low)
	Yes	Negative	1(Site)	1 (Immediate)	2 (Minor)	2 (Low)	8 (Low)

Mitigation measures

- Any dewatering and pumping infrastructure required post closure is either to be designed to withstand higher atmospheric temperatures or be housed to shield against atmospheric condition.

12.0 MONITORING PROGRAMME AND PLAN

12.1 Objectives

As per DWAF (2006) and DWAF (2008) Best Practice Guidelines (BPG) G3: Water Monitoring Systems the most common environmental management actions require data and thus the objectives of water monitoring include:

- Development of environmental and water management plans based on incident and impact monitoring which facilitates decision making and serves as an early warning system to allow remedial measures and subsequent actions to be taken for the mine and region.
- Generation of baseline / background data before the project implementation phase.
- Identifying the sources of pollution and the extent thereof, which constitutes legal implications or liabilities associated with risks of contamination, moving off site from the current mining operations or activities.
- Detect operational spillages and early signs of deterioration of the surface water resource for the complexes as well as upstream users.
- Monitoring of water usage (including downstream and upstream) by various users. This also implies costs in usage of water and water re-use activities and potentials.
- Monitor water quality to develop trends that will demonstrate that the receiving surface watercourse/s in the three sub-catchments, are not impacted by the mining operations or that the mine has managed to reverse trends where deterioration has been noted.
- Compare surface water quality in terms of the physical, chemical and microbiological characteristics of surface water with baseline values to identify possible trends and detect changes timeously by tracking contaminants of concern as indicators of pollution and to develop onsite environmental and water management plans to facilitate decision making.
- Investigate possible surface water contaminants that could serve as an early warning system to allow remedial measures to be implemented timeously and in collaboration with relevant mine divisions, and even with other mining organisations in the area which may be contributing to the same downstream point.
- Verification and calibration of various prediction and assessment models. This includes planning for decommissioning and closure pertaining to financial provisions and required actions.
- Assessment of compliance with set standards and legislation such as Integrated Water Use licenses, Environmental Management Plans, etc.
- Assessment of the impacts of the mining operation and activities on the receiving water environment.
- Quantification of waste discharge changes.
- To inform mitigation as necessary.

The water quality monitoring system should therefore be designed to allow for remedial action and for sustainable water management.

12.2 Pollution sources

The following are identified pollutions sources and the control measures presented will help to manage the associated impacts.

12.2.1 Point sources

The following sources have been identified as potential point sources of pollution:

- Pit decant.
- Dam spillages.
- Sewage treatment plant discharge.

12.2.2 Diffuse sources

The following sources have been identified as potential diffuse sources of pollution:

- Dam seepages.
- Discard dump seepage.
- Other dumps seepage.
- Dust.
- Dirty water area runoff.

12.3 Storm water management

- Increased erosion and sedimentation load are a recurring impact associated with many activities within the construction and operational phases of the project. Frequent maintenance of the diversion channels is recommended. Maintenance will include excavation of sediments, reinstatement of channels eroded out during storms, removal of washed down vegetation, refuse, etc.
- Implement erosion protection as recommended by the storm water studies.
- Implement still basins as recommended by the storm water studies.
- Conduct regular inspection and maintenance of all storm water channels.

12.4 Pollution sources

12.4.1 Point sources

The following sources have been identified as potential point sources of pollution:

- Pit decant.
- Dam spillages.
- Sewage treatment plant discharge.

12.4.2 Diffuse sources

The following sources have been identified as potential diffuse sources of pollution:

- Dam seepages.
- Discard dump seepage.
- Other dumps seepage.
- Dust.
- Dirty water area runoff.

12.5 Surface water quality

Table 37 lists the surface water monitoring sites (existing and proposed) where surface water samples must be collected for analysis and laboratory results compared against the parameters and proposed limit values set out in Table 36. Figure 80 shows the surface water monitoring map together with the two additional points. The current monitoring points have been optimised according to Golder, 2018. Table 37 therefore shows the optimised existing monitoring points with recommendations for optimised frequencies. The current water quality monitoring programme must be maintained with the following changes recommended:

- Monitoring point BWQ08 should be moved onto the small dam on the unnamed tributary draining south east towards the LeeubankspruitL
- Two new water quality monitoring points need to be established in the upper reaches of the unnamed tributaries (wetland areas) in quaternary Catchment B12C, at the proposed site for the rail siding:
- Flow monitoring must be undertaken monthly at points up and downstream of the mining area on the Leeubankspruit and Klein Komati River.

Table 36: Parameters to be measured with associated current (BIP) WUL limit values

Parameter	Units	Streams & Rivers	Pans/ *dams
Section for 21(c and i) Watercourse diversion or alteration)			
Aluminium	mg/l	<0.7	<0.7
Boron	mg/l	<0.15	<0.15
Iron	mg/l	<2	<6.8
Manganese	mg/l	<0.5	<2.0
Sodium	mg/l	<20	<350
Sulphate	mg/l	<150	<305
Chloride	mg/l	<55	<700
Nitrate	mg/l	<2	<10
Nitrite	mg/l	<2	<2
Orthophosphate	mg/l	<0.1	<0.05
Ammoniacal Nitrogen	mg/l	<1.6	<5.2
Ammonium	mg/l	<1.7	<5.5
Total Alkalinity	mg/l	<120	<154
Dissolved Oxygen	mg/l	>6	>1
Electrical Conductivity	mS/m	<40	<280
pH	s.u	6.5-7.8	
Total Dissolved Solids	mg/l	<450	<1,800
Total Suspended Solids	mg/l	<120	<7,500
Turbidity	NTU	<150	<130

Parameter	Units	Streams & Rivers	Pans/ *dams
Faecal Coliforms	CFU /100 ml	<1400	<1400
Section 21g (waste disposal affecting resource) & b (water storage)			
Magnesium	mg/l	<30	<30*
Sodium	mg/l	<70	<70*
Fluoride	mg/l	<1	<1*
Sulphate	mg/l	<200	<200*
Chloride	mg/l	<100	<121*
Nitrate as NO_3^-	mg/l	<6	<6*
Electrical Conductivity	mS/m	<40	<40*
pH	mg/l	6.5-8.5	6.5-8.5*
Total Dissolved Solids	mg/l	<450	<450*
Dissolved Oxygen	mg/l	>6	>6*
Faecal Coliforms	Colonies/100 ml	<1400	<1300*

Table 37: Existing optimised and proposed surface water monitoring sites

Site Name	Monitoring frequency	Y Co-ordinates	X Co-ordinates	Description	Notes (Recommendations from Golder, 2018)	Parameters
Driefonteinspruit sub-catchment						
BWQ01	Originally monthly with a recommendation to change to quarterly according to Golder, 2018.	-25.759729	29.998024	■ Small dam located close to N4 highway and secondary road; ■ Upstream point of Driehoekspruit; and ■ North of the future production zone (Phase 2) of East pit.	The frequency should change from monthly to quarterly as there is a good understanding of the baseline water quality for this site. 6 months prior to the operational phase, the monitoring frequency must increase to monthly.	All monthly parameters to remain the same as per Table 36.
DS12	Monthly	-25.793887	29.998238	■ Small tributary/wetland area opposite entrance road to ZZK farm, upstream of the cherry farm; and ■ Located east of the future production zone of East pit.	Important site to monitor.	All monthly parameters to remain the same as per Table 36.
BWQ02	Monthly	-25.798896	30.005524	■ Dam on Driehoekspruit, below ZZK farm; and ■ East of the future production zone of East pit.	Consider instrumentation/Loggers to be installed. Retain monthly. The site is adjacent to the cherry farm for international exports and thus it is important the water quality be assessed as they irrigate with the dam water. Continual management for compliance monitoring	All monthly parameters to remain the same as per Table 36.
Klein Komati sub-catchment						
BWQ06	Originally monthly with a recommendation to change to quarterly according to Golder, 2018.	-25.77584	29.961913	■ Most northerly upstream point of the entire mining area, on the Klein Komati which drains north between East and West pits.	The frequency should change from monthly to quarterly as there is a good understanding of the baseline water quality for this site. 6 months prior to the operational phase, the monitoring frequency must increase to monthly.	All monthly parameters to remain the same as per Table 36.
KS08	Monthly	-25.786837	29.966778	■ Located on the Klein Komati river, upstream point at the confluence; and ■ Between East and West pits.	Consider instrumentation/Loggers to be installed. Top end of the Klein-Komati River between the east and west pit inside the construction area and thus monitoring must be maintained.	All monthly parameters to remain the same as per Table 36.
FD (Farm Dam)	Monthly	-25.79592	29.96373	■ Dam located on Klein Komati, upstream of the construction area and between the two pits.	This is important site as it is in between the two proposed West and East pit.	All monthly parameters to remain the same as per Table 36.
KPFD (Koos Pretorius farm dam)	Monthly	-25.80432	29.96413	■ Dam located on Klein Komati below FD; and ■ Between East and West pits.	This is important site as it is in between the two proposed West and East pit.	All monthly parameters to remain the same as per Table 36.

Site Name	Monitoring frequency	Y Co-ordinates	X Co-ordinates	Description	Notes (Recommendations from Golder, 2018)	Parameters
BWQ05	Monthly	-25.81334	29.972468	■ Located at old bridge on the secondary road on the Klein Komati upstream of the construction site; and ■ Between East and West pits.	As the Klein-Komati flows between the east and west pit, it is important to retain monthly monitoring at this site.	All monthly parameters to remain the same as per Table 36.
KS13	Originally monthly/weekly with a recommendation to change to monthly according to Golder, 2018.	-25.815137	29.976788	■ On Klein Komati, about 200 m downstream of construction site area. ■ Located east of the future production of East pit.	As this site is upstream of the construction area and in future the plant area, it will be important to retain this site for continual monitoring. Consider instrumentation/Loggers to be installed. This site will provide an indication as to what is taking place at site KS14 and KS15 chemically.	Include a probe to replace the weekly monitoring as an early warning system to detect sudden changes and trends in water quality. Proposed to monitor Electrical Conductivity (EC), temperature and water level, and where sudden changes are noted, a sample should immediately be retrieved for laboratory analyses. Monthly samples to be taken for all parameters as per Table 36.
KS18	Monthly	-25.822317	29.991198	■ Located downstream on a non-perennial tributary feeding into the Klein Komati opposite the construction site. ■ South of East pit.	This site will indicate impacts from the proposed pit and thus should be retained	All monthly parameters to remain the same as per Table 36.
BWQ04	Originally monthly/weekly with a recommendation to change to monthly according to Golder, 2018.	-25.828062	30.006357	■ Located under newly constructed culvert on secondary road close between construction site and workshop. ■ East of the general construction area, at mining rights boundary.	Consider instrumentation/Loggers to be installed.	Include a probe to replace the weekly monitoring as an early warning system to detect sudden changes and trends in water quality. Proposed to monitor EC, temperature and water level, and where sudden changes are noted, a sample should immediately be retrieved for laboratory analyses. Monthly samples to be taken for all parameters as per Table 36.
KS22	Monthly	-25.833757	30.026618	■ This site represents the most downstream site located south-east beyond the proposed mining boundary on the Klein-Komati River.	This site will function as the final compliance point.	All monthly parameters to remain the same as per Table 36.
Pan07	Originally monthly/weekly with a recommendation to change to monthly according to Golder, 2018.	-25.827837	29.973568	■ North western corner just above the construction of the Return Water Dam which is currently taking place. Area is just outside construction boundary and will be at southern tip of West pit.	This site is located in the drainage area of the construction site and physically located at the southern extremity of the west pit and is likely to be the most impacted pan during construction however can be changed to monthly once the construction phase is complete, as there is a good	Include a probe to replace the weekly monitoring as an early warning system to detect sudden changes and trends in water quality. Proposed to monitor EC, temperature and water level, and where sudden changes

Site Name	Monitoring frequency	Y Co-ordinates	X Co-ordinates	Description	Notes (Recommendations from Golder, 2018)	Parameters
					baseline history. May need to consider weekly monitoring as pit development takes place.	are noted, a sample should immediately be retrieved for laboratory analyses. Monthly samples to be taken for all parameters as per Table 36.
Pan08	Originally monthly/weekly with a recommendation to change to monthly according to Golder, 2018.	-25.831417	29.983828	■ Located within the main construction site and will be surrounded by the plant area.	This site is located in the drainage area of the construction site and physically located at the southern extremity of the west pit. This will be the second most impacted pan by construction, however can be changed to monthly once the construction phase is complete, as there is a good baseline history..	Include a probe to replace the weekly monitoring as an early warning system to detect sudden changes and trends in water quality. Proposed to monitor EC, temperature and water level, and where sudden changes are noted, a sample should immediately be retrieved for laboratory analyses. Monthly samples to be taken for all parameters as per Table 36.
Pan09	Monthly	-25.813847	29.998058	■ This pan only has water during peak wet season; and ■ South east of the future East pit production zone.	This pan is located at the south east corner of the east pit and therefore this pan is significant once the east pit has been opened. May need to consider weekly monitoring as pit development takes place.	Include a probe to replace the weekly monitoring as an early warning system to detect sudden changes and trends in water quality. Proposed to monitor EC, temperature and water level, and where sudden changes are noted, a sample should immediately be retrieved for laboratory analyses. Monthly samples to be taken for all parameters as per Table 36.
Pan12	Originally monthly with a recommendation to change to quarterly according to Golder, 2018.	-25.802587	29.988988	■ Located in the middle of a field on dirt road on Farm Zoekop; and ■ Within the future production zone of East pit (Phase 2).	This site is phase 2 of life of mine (LOM) and so maintain quarterly.	All monthly parameters to remain the same as per Table 36.
Pan13	Originally monthly with a recommendation to change to quarterly according to Golder, 2018.	-25.803637	29.984508	■ Located west of Pan 12 on Farm Zoekop; and ■ Within the future production zone of East pit (Phase 2).	This site is phase 2 of LOM and so maintain quarterly.	All monthly parameters to remain the same as per Table 36.
Pan16	Originally monthly with a recommendation to change to quarterly according to Golder, 2018.	-25.799537	29.981268	■ Located about 200 m north west of Pan13 in a depression, also on Farm Zoekop; and ■ Pan only has water in peak wet season. ■ Within the future production zone of East pit.	This site is phase 2 of LOM and so maintain quarterly.	All monthly parameters to remain the same as per Table 36.
Leeubankspruit sub-catchment						

Site Name	Monitoring frequency	Y Co-ordinates	X Co-ordinates	Description	Notes (Recommendations from Golder, 2018)	Parameters
BWQ07	Originally monthly with a recommendation to change to quarterly according to Golder, 2018.	-25.78084	29.944413	▪ Dam located close to N4 on Roos farm, west of BWQ6; ▪ Upstream point on Leeubankspruit; and ▪ North-west of West pit.	The frequency should change from monthly to quarterly as there is a good understanding of the baseline water quality for this site. 6 months prior to the operational phase, the monitoring frequency must increase to monthly.	All monthly parameters to remain the same as per Table 36.
LS04	Originally monthly with a recommendation to change to quarterly according to Golder, 2018.	-25.79551	29.93813	▪ Located upstream in Leeubankspruit above BWQ8 dam; and ▪ West of the future of West pit production zone.	The frequency should change from monthly to quarterly as there is a good understanding of the baseline water quality for this site. Frequency to change to monthly, 6 months prior to mining of that construction block.	All monthly parameters to remain the same as per Table 36.
BWQ08	Originally monthly with a recommendation to change to quarterly according to Golder, 2018.	-25.800562	29.933857	▪ Dam located on Leeubankspruit below LS04; and ▪ West of the future West pit production zone.	The frequency should change from monthly to quarterly as there is a good understanding of the baseline water quality for this site. 6 months prior to the operational phase, the monitoring frequency must increase to monthly.	All monthly parameters to remain the same as per Table 36.
LS08	Originally monthly with a recommendation to change to quarterly according to Golder, 2018.	-25.807347	29.938078	▪ Small pond on unnamed non-perennial tributary draining west to the Leeubankspruit, with water in peak wet season; and ▪ West of the future West pit production zone.	The frequency should change from monthly to quarterly as there is a good understanding of the baseline water quality for this site. Frequency to change to monthly, 6 months prior to mining of that construction block.	All monthly parameters to remain the same as per Table 36.
LS12	Originally monthly with a recommendation to change to quarterly according to Golder, 2018.	-25.817277	29.948338	▪ Site located on a non-perennial tributary draining into Leeubankspruit; water during peak wet season; and ▪ West of the future West pit production zone.	The frequency should change from monthly to quarterly as there is a good understanding of the baseline water quality for this site. Frequency to change to monthly, 6 months prior to mining of that construction block.	All monthly parameters to remain the same as per Table 36.
LS16	Originally monthly with a recommendation to change to quarterly according to Golder, 2018.	-25.826177	29.955488	▪ Located on a non-perennial tributary draining into Leeubankspruit. Tributary is north of defunct Lefa Mine; and ▪ West of the future West pit production zone.	The frequency should change from monthly to quarterly as there is a good understanding of the baseline water quality for this site. Frequency to change to monthly 6 months prior to mining of that construction block.	All monthly parameters to remain the same as per Table 36.
BWQ09	Monthly	-25.840007	29.93358	▪ Located on the Eerstelingsfontein secondary road. Slight change in exact location due to construction work. Water now collected at old bridge 10 m upstream; and ▪ Far southwest of the construction area, upstream of culvert at haul road crossing.	This site is important and needs to be maintained as it is the largest stream on this part of the haul road.	All monthly parameters to remain the same as per Table 36.
New BEP monitoring points						

Site Name	Monitoring frequency	Y Co-ordinates	X Co-ordinates	Description	Notes (Recommendations from Golder, 2018)	Parameters
BEP01	Monthly	***-25.859144***	***29.855715***	***New monitoring point 1 in upper reaches of the unnamed tributaries (wetland areas) in quaternary Catchment B12C)***	NA	All monthly parameters to remain the same as per Table 36.
BEP02	Monthly	***-25.866224***	***29.852109***	***New monitoring point 2 in upper reaches of the unnamed tributaries (wetland areas) in quaternary Catchment B12C)***	NA	All monthly parameters to remain the same as per Table 36.

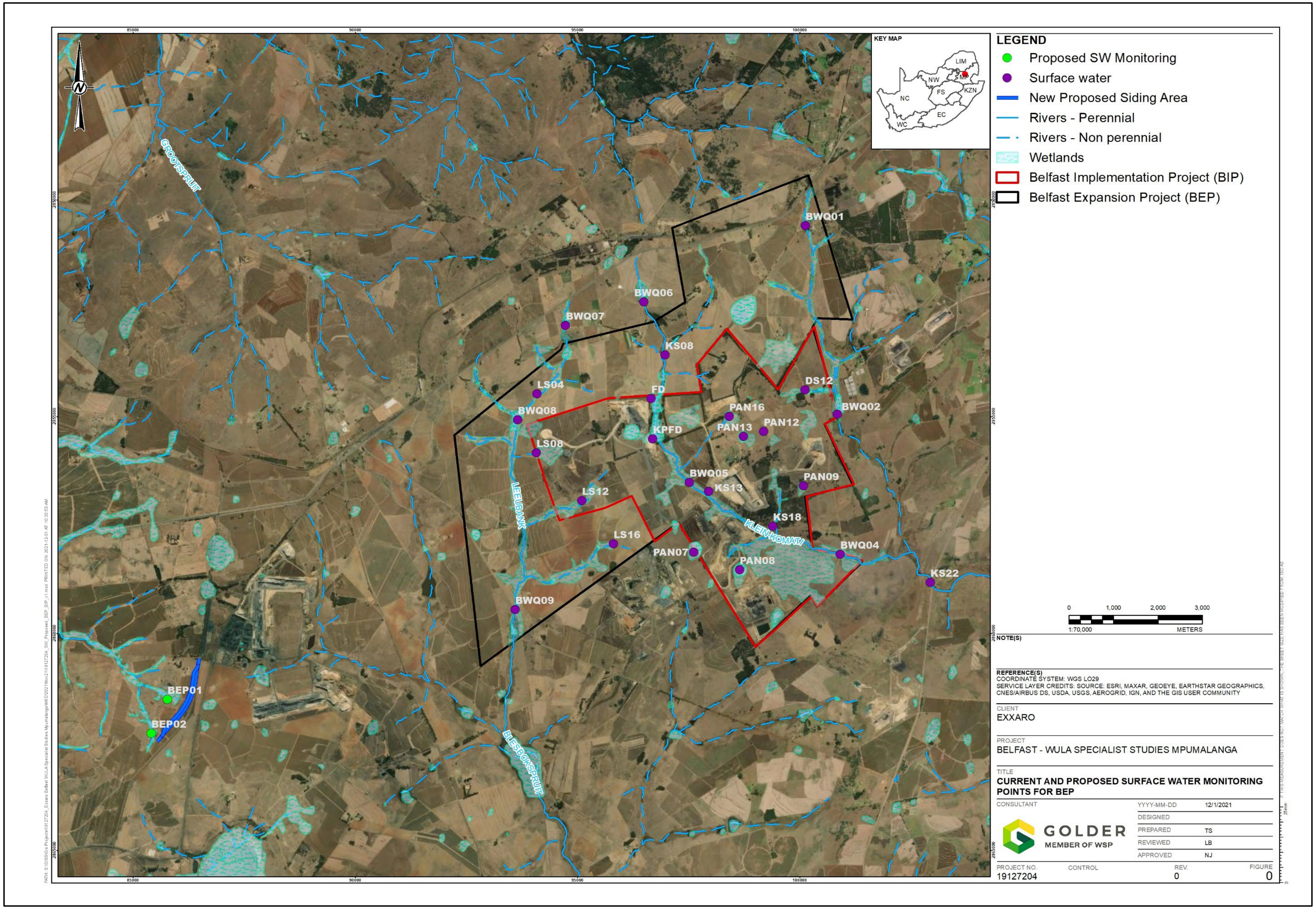


Figure 80: Belfast SW monitoring points showing additional proposed points

12.6 Operational and rehabilitation water management

- All dams should be operated to comply with regulation GN 704 to ensure that the proposed WTP has adequate processing capacity to manage the excess water from the operations.
- Concurrent rehabilitation is recommended to ensure minimisation of contaminated runoff thereby minimising the volume of water requiring treatment.
- Rehabilitation of the MRF and open cast pits should be conducted based on industry best practices. Rehabilitation should ensure adequate sloping and landform development to prevent ponding and pooling and allow for the drainage of clean runoff from the site.
- The following operational monitoring is recommended:
  - Flow monitoring.
  - Pit water levels.
  - Pit water quality (TDS, SO_4, F, Mn, Ca, Fe and pH to be monitored) at the area of the discard facility and of the rehabilitated spoils.
  - Continue with the surface water quality sampling.
  - Erosion around the developing discard facility to be conducted weekly.
  - Monthly Inspection of storm water channels.
  - Monthly monitoring of the rehabilitated area to ensure free draining and good vegetation growth.
  - Discharge water quality to be monitored for TDS, SO_4, F, Mn, Ca, Fe and pH at the outlet of the WTP prior to discharge into the environment on a weekly basis.
  - Performance of Water Treatment Plant that is implemented during operation and post closure (as recommended by the WTP contractor).
  - Daily water level in the dams.

12.7 Post closure water management

- Monitoring of pit water levels during decant is imperative to ensure adequate management of pit water at a certain environmentally safe level (below decant).
- The integrated (BIP and BEP) groundwater modelling has been commissioned. This will confirm total post closure inflows and timing of decant and hence the post closure water treatment requirement. The integrated BIP/BEP surface water balance is to be updated once the results of the integrated groundwater model are available.
- Adequate infrastructure is to be available to ensure the pit water is captured prior to decant and managed (treated and discharged).
- Ongoing monitoring of pit water quality treated water quality, quality of water discharged and water quality of the resource.

13.0 CONCLUSION AND RECOMMENDATIONS

The proposed mining activity being planned for this project will not alter or impede the flow of surrounding non-perennial rivers or surrounding tributaries within the study area. However, water quality, habitat quality and quantity are all major determinants of aquatic community structure. Changes in the biological community in a river may be linked to changes in water quality, habitat availability, habitat integrity or a combination of these. When naturally vegetated landscapes are transformed for industrial/mining/agricultural uses, physical and biological relationships with adjacent streams are affected resulting in impacts such as stream bank erosion, increased sedimentation which will in turn result in changes to the aquatic community structure. Therefore, it was imperative that the above identified direct/indirect impacts concerning the surface water and were identified, mitigated and managed to ensure protection of the downstream receiving rivers.

14.0 SPECIALISTS

This Surface Water report was prepared by Nivi Juggath from Golder. The senior review was done by Lee Boyd, also of Golder. The details of the specialist qualifications and experience are provided in Table 24 below:

Table 38: Qualifications and experience of the specialists

Role	Name	Qualifications and Experience
Report compilation and specialist work	Nirvishee Juggath	■ BSc Chemical Engineering; and ■ MBA (Wits).
Strategic Advisor and Reviewer	Lee Boyd	■ BSc (Biological Sciences) ■ BSc Honours (Microbiology) ■ MSc (Water Utilisation)
Storm water management specialist	Johan Jordaan	■ PrEng BSc Eng (Civil) MSAICE MWISA

Neither Golder nor the specialists that prepared this report have any vested interest in the proposed project other than fair remuneration for professional services rendered. The findings presented in this specialist report are those of the specialists, without influence from any other parties.

15.0 PROFESSIONAL OPINION OF SPECIALIST

It is the professional opinion of the Surface Water Specialist that the BEP should go ahead provided that the recommendations, mitigation and monitoring measures as set out in this report are adhered to and included in the Environmental Monitoring Plan.

16.0 REFERENCES

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APPENDIX A

Surface water quality results

Table A1: 2020 Q1 Stream Water Samples vs IWUL Limits

Water Quality Constituent	Units	IWUL Limit	BWQ4			BWQ5			BWQ9			DS12			BWQ2		
			Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20
Temperature	°C			20.10	21.60	22.60	20.30		18.80	21.70	20.30	22.20	24.40	20.30	21.20	23.50	24.70
pH	pH units	6,5 - 7,8		7.08	7.53	6.25	6.89		6.83	7.61	7.98	6.31	7.29	7.68	6.49	7.12	7.27
Total Dissolved Solids (TDS)	mg/l	450		110.00	151.00	104.00	164.00		110.00	114.00	149.00	138.00	88.00	108.00	63.00	86.00	80.00
Electrical conductivity (EC)	mS/m	40		17.20	21.70	13.70	23.00		16.20	18.30	23.80	14.70	9.90	13.40	8.60	10.40	9.20
Suspended Solids	mg/l	25		5.00	5.00	5.00	5.00		27.00	5.00	5.00	5.00	10.00	37.00	5.00	5.00	37.00
Dissolved Oxygen	mg/l	> 6		7.00	6.00	5.00	4.00		8.00	0.50	4.00	7.00	3.00	1.00	6.00	6.00	6.00
Sulphate as SO_4^{2-}	mg/l	150		5.90	2.10	17.60	6.60		14.20	3.10	0.80	17.40	5.10	2.90	3.50	3.70	2.00
Sodium as Na	mg/l	20		13.90	14.90	8.70	17.50		10.90	10.20	11.00	7.80	7.70	8.60	6.90	7.30	6.30
Chloride as Cl^-	mg/l	55		29.70	35.80	21.60	41.90		16.60	13.80	14.80	15.10	11.00	17.50	11.60	10.00	9.40
Boron as B	mg/l	0,15		0.01	0.01	0.02	0.01		0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Turbidity	NTU	5		3.80	4.80	39.00	2.60		18.80	4.20	4.50	2.90	2.10	5.20	18.90	8.80	20.10
Alkalinity as $CaCO_3$	mg/l	120		21.00	35.00	20.00	28.00		48.00	55.00	86.00	18.00	20.00	30.00	36.00	22.00	209.00
Iron as Fe	mg/l	2		0.24	0.39	0.13	0.28		0.37	0.48	1.04	0.10	1.83	0.85	0.16	0.46	2.16
Aluminium as Al	mg/l	0,7		0.04	0.06	0.00009	0.01		0.00011	0.01	0.01	0.00011	0.08	0.01	0.00001	0.01	0.02
Manganese as Mn	mg/l	0,5		0.04	0.33	0.00	0.04		0.04	0.07	0.61	0.04	0.09	0.12	0.01	0.09	0.04
Ammoniacal Nitrogen as NH_3	mg/l	0,007		0.26	0.59	0.10	0.41		1.50	1.50	0.45	0.05	0.23	0.24	0.06	1.50	0.22
Ammoniacal Nitrogen as NH_4^+	mg/l	1		0.28	0.62	0.11	0.43		1.50	1.50	0.48	0.05	0.24	0.25	0.06	1.50	0.23
Nitrite as NO_2^-	mg/l	2		0.003	0.003	0.010	0.064		0.010	0.003	0.003	0.010	0.079	0.003	0.010	0.003	0.003
Nitrate as NO_3^-	mg/l	2		0.03	0.03	0.10	0.07		0.60	0.03	0.07	23.40	0.09	0.03	0.10	0.03	0.03
Orthophosphate as PO_4^{3-}	mg/l	0,05		0.03	0.03	0.03	0.02		0.03	0.05	0.03	0.03	0.02	0.08	0.03	0.03	0.04
Faecal Coliforms	CFU/100ml	0		-	-	-	-		60	550	-	-	-	-	-	-	-

Table A2: 2020 Q1 Stream Water Samples vs IWUL Limits

Water Quality Constituent	Units	IWUL Limit	DS14			LS03			LS04			KS13			LS13			KS11		
			Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20
Temperature (Field)	°C		19.80	21.90	26.30	19.20	18.30	22.70	17.40	18.20	21.00		23.10	26.60		22.70	28.60	19.40	19.10	25.40
pH	pH units	6,5 - 7,8	6.48	7.31	7.53	6.70	7.18	7.54	5.62	7.24	7.67		7.30	7.62		7.08	7.35	6.55	7.24	7.21
Total Dissolved Solids (TDS)	mg/l	450	88.00	52.00	82.00	288.00	196.00	177.00	118.00	138.00	153.00		163.00	162.00		74.00	81.00	216.00	196.00	219.00
Electrical Conductivity (EC)	mS/m	40	9.10	9.30	9.70	20.10	19.70	22.20	15.70	26.20	25.40		21.80	24.20		13.00	13.50	35.10	27.20	36.20
Suspended Solids	mg/l	25	5.00	5.00	5.00	90.00	5.00	5.00	11.00	15.00	17.00		15.00	5.00		5.00	5.00	5.00	5.00	60.00
Dissolved Oxygen	mg/l	> 6	7.00	6.00	6.00	3.00	5.00	4.00	7.00	5.00	3.00		7.00	4.00		4.00	2.00	4.00	5.00	0.50
Sulphate as SO_4^{2-}	mg/l	150	4.70	3.40	1.70	5.50	2.80	2.90	13.60	2.50	0.25		7.50	3.60		2.60	2.20	14.90	5.30	1.70
Sodium as Na	mg/l	20	6.90	6.90	6.50	16.90	18.00	20.70	17.00	20.00	18.10		16.10	16.60		9.30	9.40	27.60	19.20	31.00
Chloride as Cl^-	mg/l	55	11.00	9.70	9.20	38.60	37.80	44.10	37.20	48.70	41.20		38.50	41.40		21.60	23.90	72.50	51.60	78.50
Boron as B	mg/l	0,15	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01		0.01	0.01		0.01	0.01	0.01	0.01	0.01
Turbidity	NTU	5	2.40	3.10	5.40	205.00	72.40	18.70	10.40	12.10	8.10		4.30	7.20		3.00	1.90	4.00	1.80	26.00
Alkalinity as $CaCO_3$	mg/l	120	36.00	33.00	26.00	46.00	221.00	20.00	16.00	26.00	46.00		27.00	34.00		19.00	15.00	38.00	32.00	31.00
Iron as Fe	mg/l	2	0.21	0.55	0.70	0.35	0.32	0.26	0.41	0.79	2.12		0.20	0.32		3.04	1.74	0.31	0.63	2.02
Aluminium as Al	mg/l	0,7	0.00	0.01	0.01	0.00030	0.22	0.05	0.00019	0.07	0.03		0.01	0.01		0.05	0.02	0.00001	0.01	0.03
Manganese as Mn	mg/l	0,5	0.03	0.05	0.19	0.03	0.03	0.03	0.07	0.07	1.00		0.04	0.07		0.06	0.02	0.03	0.03	0.07
Ammoniacal Nitrogen as NH_3	mg/l	0,007	0.04	1.50	0.31	3.92	1.83	0.11	0.08	1.50	0.51		1.50	1.50		1.50	0.36	0.49	1.50	0.29
Ammoniacal Nitrogen as NH_4^+	mg/l	1	0.04	1.50	0.33	4.15	1.94	0.12	0.08	1.50	0.54		1.50	1.50		1.50	0.38	0.52	1.50	0.31
Nitrite as NO_2^-	mg/l	2	0.010	0.003	0.003	0.010	0.091	0.003	0.010	0.003	0.003		0.003	0.003		0.003	0.003	0.230	0.003	0.003
Nitrate as NO_3^-	mg/l	2	0.10	0.03	0.03	0.10	0.18	0.25	0.10	0.03	0.09		0.03	0.16		0.03	0.03	3.60	0.03	0.03
Orthophosphate as PO_4^{3-}	mg/l	0,05	0.03	0.03	0.03	0.03	0.05	0.08	0.03	0.02	0.08		0.02	0.08		0.04	0.08	0.11	0.08	0.04
Faecal Coliforms	CFU/100ml	0	-	-	-	-	-	-	-	-	-		-	-		-	-	-	-	-

Table A3: 2020 Q1 Stream Water Samples vs IWUL Limits

Water Quality Constituent	Units	IWUL Limit	KS09			KS08			KS22			KS14			KS15			DS13		
			Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20
Temperature (Field)	˚C			22.90	22.30		19.30	25.00	18.40	19.90	19.50		23.30			24.00	26.10		24.30	27.20
pH	pH units	6,5 - 7,8		7.06	7.46		7.37	7.71	6.46	7.31	7.68		7.35			7.31	7.68		7.33	7.43
Total Dissolved Solids (TDS)	mg/l	450		87.00	165.00		114.00	112.00	76.00	86.00	114.00		135.00			136.00	171.00		64.00	141.00
Electrical Conductivity (EC)	mS/m	40		8.60	7.90		19.40	21.10	7.40	11.40	14.10		22.00			22.00	23.90		10.70	10.50
Suspended Solids	mg/l	25		12.00	22.00		13.00	40.00	33.00	5.00	5.00		5.00			5.00	5.00		5.00	22.00
Dissolved Oxygen	mg/l	> 6		0.50	0.50		6.00	4.00	7.00	6.00	6.00		6.00			7.00	7.00		0.50	0.50
Sulphate as $SO4^{2-}$	mg/l	150		1.00	0.25		2.80	1.10	8.00	3.80	0.80		7.80			7.70	1.90		5.00	4.60
Sodium as Na	mg/l	20		2.40	3.10		15.00	14.50	6.30	7.90	8.50		16.50			16.00	16.00		6.10	7.20
Chloride as Cl^-	mg/l	55		5.70	4.70		36.80	36.00	9.00	14.20	14.70		38.50			38.30	40.60		10.00	11.30
Boron as B	mg/l	0,15		0.01	0.01		0.01	0.01	0.01	0.01	0.01		0.01			0.01	0.01		0.01	0.01
Turbidity	NTU	5		5.20	21.60		13.60	13.90	31.40	9.20	9.00		4.30			6.30	4.10		2.50	2.20
Alkalinity as $CaCO_3$	mg/l	120		24.00	26.00		24.00	32.00	36.00	23.00	40.00		32.00			25.00	39.00		24.00	20.00
Iron as Fe	mg/l	2		2.38	1.76		0.39	10.18	0.42	0.18	0.73		0.14			0.10	0.21		0.55	1.03
Aluminium as Al	mg/l	0,7		0.19	0.10		0.01	0.03	0.00012	0.01	0.01		0.01			0.01	0.01		0.05	0.02
Manganese as Mn	mg/l	0,5		0.10	0.09		0.07	0.38	0.06	0.03	0.20		0.01			0.01	0.11		0.04	0.02
Ammoniacal Nitrogen as NH_3	mg/l	0,007		1.50	0.36		1.50	0.25	0.07	1.50	0.17		1.50			1.50	1.50		1.50	0.13
Ammoniacal Nitrogen as NH_4^+	mg/l	1		1.50	0.38		1.50	0.27	0.07	1.50	0.18		1.50			1.50	1.50		1.50	0.14
Nitrite as NO_2^-	mg/l	2		0.003	0.003		0.067	0.003	0.010	0.043	0.003		0.003			0.003	0.003		0.003	0.003
Nitrate as NO_3^-	mg/l	2		0.03	0.03		0.03	0.07	0.10	0.03	0.03		0.03			0.03	0.03		0.03	0.07
Orthophosphate as PO_4^{3-}	mg/l	0,05		0.05	0.03		0.08	0.03	0.03	0.03	0.08		0.08			0.02	0.08		0.04	0.03
Faecal Coliforms	CFU/100ml	0		-	-		-	-	80	190	-		-			-	-		-	-

Table A4: 2020 Q1 Stream Water Samples vs IWUL Limits

Water Quality Constituent	Units	IWUL Limit	RAP WTP			Workshop			LS16		LS08		
			Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20
Temperature (Field)	˚C		19.90	19.50	24.40	17.00	19.50	21.30	18.90		21.10	17.80	
pH	pH units	6,5 -7,8	7.44	7.71	7.94	7.36	7.37	7.85	7.18		6.28	7.24	
Total Dissolved Solids (TDS)	mg/l	450	516.00	371.00	414.00	227.00	277.00	236.00	17.50		107.00	107.00	
Electrical Conductivity (EC)	mS/m	40	91.80	62.20	71.90	27.90	21.60	24.00	7.40		9.90	10.60	
Suspended Solids	mg/l	25	200.00	37.00	287.00	13.00	137.00	5.00	27.00		150.00	18.00	
Dissolved Oxygen	mg/l	> 6	1.00	0.50	0.50	2.00	0.50	0.50	7.00		6.00	5.00	
Sulphate as SO_4^{2-}	mg/l	150	67.70	47.70	53.40	0.25	4.90	1.50	0.60		11.70	5.60	
Sodium as Na	mg/l	20	93.50	51.10	75.20	29.00	21.30	21.00	4.70		2.90	5.70	
Chloride as Cl^-	mg/l	55	65.90	32.60	50.00	7.70	4.40	4.50	3.80		7.90	8.20	
Boron as B	mg/l	0,15	0.03	0.02	0.03	0.14	0.33	0.33	0.01		0.01	0.01	
Turbidity	NTU	5	195.00	30.60	118.00	14.90	207.00	32.20	13.70		196.00	147.00	
Alkalinity as $CaCO_3$	mg/l	120	270.00	201.00	197.00	142.00	88.00	100.00	28.00		18.00	26.00	
Iron as Fe	mg/l	2	0.25	0.36	0.34	5.19	4.18	2.88	0.59		0.06	0.07	
Aluminium as Al	mg/l	0,7	0.00005	0.05	0.03	0.00010	0.09	0.05	0.03		0.00010	0.01	
Manganese as Mn	mg/l	0,5	0.07	0.24	0.22	0.82	0.61	0.61	0.05		0.09	0.07	
Ammoniacal Nitrogen as NH_3	mg/l	0,007	31.29	23.61	12.80	2.88	1.76	2.55	1.50		0.08	1.50	
Ammoniacal Nitrogen as NH_4^+	mg/l	1	33.14	25.01	13.56	3.05	1.86	2.70	1.50		0.08	1.50	
Nitrite as NO_2^-	mg/l	2	0.010	0.247	0.094	0.010	0.003	0.003	0.003		0.010	0.064	
Nitrate as NO_3^-	mg/l	2	0.10	0.03	0.03	0.10	0.03	0.03	0.03		9.80	0.43	
Orthophosphate as PO_4^{3-}	mg/l	0,05	16.64	0.22	2.87	3.03	0.03	0.35	0.08		0.03	0.08	
Faecal Coliforms	CFU/100ml	0	-	-	-	-	-	-	-		-	-	

Note: Orange highlighted cell – value exceeds limit; grey cells: monitoring site was dry / not accessible.

Table A5: 2019 Dam Water Samples vs IWUL Limits

Water Quality Constituent	Units	IWUL Limit	BWQ01 n=10			BWQ06 n=12			BWQ07 n=12			BWQ08 n=12			FD n=11			KFPD n=11		
			Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Temperature (Field)	°C		15.50	28.70	21.42	15.10	25.20	20.54	16.20	27.30	21.40	14.40	31.60	20.60	15.80	26.70	20.66	14.00	24.00	19.94
pH	pH units	6.5 – 8.5	5.79	7.30	6.67	6.20	9.28	7.67	6.77	7.80	7.34	7.21	7.69	7.46	6.82	7.41	7.18	7.09	7.72	7.34
TDS	mg/l	450	64.00	122.00	87.70	17.50	324.00	240.71	199.00	285.00	241.75	17.50	187.00	134.88	104.00	213.00	153.82	107.00	215.00	176.27
Electrical Conductivity	mS/m	40	8.10	15.90	10.88	36.50	787.00	142.14	34.80	550.00	124.62	22.20	305.00	84.96	21.00	320.00	75.98	25.90	340.00	79.98
Suspended Solids	mg/l	25	12.00	165.00	63.20	5.00	2681.00	241.42	5.00	228.00	47.08	5.00	87.00	16.42	5.00	171.00	27.00	5.00	191.00	46.55
Dissolved oxygen	mg/l	> 6	0.50	8.00	3.60	0.50	10.50	4.21	1.00	17.50	5.75	0.50	9.00	5.85	0.50	8.00	4.45	0.50	8.00	4.32
Sulphate as SO_4^{2-}	mg/l	150	3.02	21.60	9.99	0.70	5.40	3.28	2.10	13.90	4.41	1.30	12.13	3.24	0.60	5.10	2.39	1.00	14.50	4.90
Sodium as Na	mg/l	20	4.50	14.40	8.50	16.00	28.90	21.19	30.30	53.90	38.64	17.60	26.70	20.67	2.30	30.90	20.70	22.40	30.10	24.96
Chloride as Cl-	mg/l	55	7.70	30.00	17.37	61.00	114.50	76.88	70.80	123.80	92.33	45.30	57.90	49.64	42.00	69.80	56.65	52.00	85.00	64.40
Boron as B	mg/l	0.15	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01
Turbidity	NTU	5	3.80	74.40	29.81	0.10	129.00	16.99	1.60	118.00	30.98	1.00	31.10	6.00	1.80	197.00	25.33	2.00	156.00	32.48
Alkalinity as $CaCO_3$	mg/l	120	1.50	30.00	12.70	71.00	105.00	83.50	36.00	67.00	51.67	28.00	58.00	35.92	21.00	29.00	24.55	19.00	34.00	27.45
Iron as Fe	mg/l	2	0.05	3.88	1.21	0.03	0.26	0.09	0.03	0.73	0.28	0.13	0.90	0.32	0.06	0.69	0.24	0.06	1.01	0.37
Aluminium as Al	mg/l	0.7	0.01	0.15	0.03	0.01	0.02	0.01	0.01	0.06	0.02	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.07	0.02
Manganese as Mn	mg/l	0.5	0.01	0.75	0.20	0.00	0.23	0.05	0.00	0.06	0.03	0.00	0.04	0.01	0.00	0.21	0.05	0.00	0.95	0.15
Ammoniacal Nitrogen as NH3	mg/l	0.007	0.02	1.50	0.51	0.02	3.19	0.82	0.02	1.50	0.56	0.10	1.50	0.69	0.05	1.50	0.59	0.04	1.50	0.63
Ammoniacal Nitrogen as NH_4^+	mg/l	1	0.02	1.50	0.51	0.02	3.38	0.79	0.02	1.50	0.54	0.09	1.50	0.68	0.05	1.50	0.57	0.03	1.50	0.62
Nitrite as NO_2-	mg/l	2	0.03	0.20	0.04	0.03	0.29	0.05	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.05	0.03
Nitrate as NO_3	mg/l	2	0.03	0.36	0.06	0.03	0.41	0.06	0.03	0.38	0.09	0.03	0.07	0.03	0.03	0.36	0.06	0.03	0.36	0.07
Orthophosphate as PO_4	mg/l	0.05	0.02	0.11	0.04	0.02	55.00	4.62	0.02	0.13	0.04	0.02	0.08	0.03	0.02	0.08	0.03	0.02	0.09	0.03
Faecal Coliforms	CFU/100ml	0	0.00	5 600.00	1 134.40	0.00	1 170.00	257.80	35.00	112.00	81.25	-	-	-	-	-	-	-	-	-

Table A6: 2019 Dam water samples vs IWUL

Water Quality Constituent	Units	IWUL Limit	BWQ2 n=12			PCD 2 n=3			PCD 4 n=4			IN PIT 7 n=3			IN PIT 5 n=7		
			Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Temperature (Field)	°C		9.10	23.70	19.20	-	-	-	-	-	-	-	-	-	15.40	17.80	16.60
pH	pH units	6.5 – 8.5	6.71	7.91	7.30	7.70	7.77	7.74	7.53	7.71	7.62	5.83	7.18	6.38	5.13	7.37	6.49
TDS	mg/l	450	17.50	86.00	51.25	229.00	255.00	239.67	190.00	268.00	212.00	17.50	184.00	116.50	100.00	260.00	179.86
Electrical Conductivity	mS/m	40	6.90	99.00	23.28	32.50	426.00	260.50	33.20	458.00	219.63	4.00	342.00	122.13	19.00	418.00	126.67
Suspended Solids	mg/l	25	5.00	73.00	18.00	5.00	5.00	5.00	5.00	5.00	5.00	117.00	135.00	126.00	5.00	217.00	50.29
Dissolved oxygen	mg/l	> 6	0.50	8.50	5.08	2.50	8.00	5.17	6.00	13.50	8.63	6.00	8.00	6.67	7.00	9.00	7.86
Sulphate as SO_4^{2-}	mg/l	150	0.25	5.90	2.06	10.90	23.10	15.20	6.30	104.40	31.45	11.40	69.30	44.23	20.90	143.00	85.41
Sodium as Na	mg/l	20	4.40	8.30	6.63	25.80	28.40	26.73	22.30	31.00	26.60	3.00	8.80	5.47	1.70	24.90	19.60
Chloride as Cl-	mg/l	55	5.10	16.40	11.14	48.90	70.50	56.93	40.50	65.40	56.48	2.70	5.00	3.67	7.00	15.40	10.71
Boron as B	mg/l	0.15	0.01	0.01	0.01	0.02	0.03	0.02	0.01	0.03	0.02	0.01	0.03	0.02	0.01	0.02	0.01
Turbidity	NTU	5	2.90	12.50	7.33	2.80	145.00	50.57	2.70	73.60	20.90	357.00	12240.00	4525.67	3.10	2918.00	575.61
Alkalinity as $CaCO_3$	mg/l	120	9.00	34.00	21.58	44.00	64.00	57.33	35.00	52.00	46.25	1.50	49.00	26.83	1.50	26.00	16.64
Iron as Fe	mg/l	2	0.28	1.80	0.90	0.01	0.16	0.10	0.02	0.19	0.09	0.01	0.48	0.17	0.01	0.03	0.01
Aluminium as Al	mg/l	0.7	0.01	0.02	0.01	0.02	0.07	0.04	0.01	0.03	0.02	0.01	1.34	0.45	0.01	0.15	0.03
Manganese as Mn	mg/l	0.5	0.00	0.19	0.07	0.00	0.01	0.01	0.00	0.21	0.05	0.02	0.48	0.23	0.11	0.90	0.46
Ammoniacal Nitrogen as NH3	mg/l	0.007	0.04	1.50	0.69	1.50	1.50	1.50	0.70	1.50	1.30	0.21	3.63	1.38	0.04	1.50	0.56
Ammoniacal Nitrogen as NH_4+	mg/l	1	0.03	1.50	0.69	1.50	1.50	1.50	0.74	1.50	1.31	0.22	3.84	1.46	0.03	1.50	0.51
Nitrite as NO_2-	mg/l	2	0.03	0.03	0.03	0.01	0.05	0.03	0.03	0.16	0.06	0.02	0.35	0.13	0.02	0.07	0.04
Nitrate as NO_3	mg/l	2	0.03	0.47	0.11	0.16	0.36	0.24	0.03	1.72	0.55	0.50	13.03	4.78	0.41	6.08	2.66
Orthophosphate as PO_4	mg/l	0.05	0.02	0.15	0.04	0.03	0.08	0.05	0.03	0.08	0.05	0.04	0.05	0.04	0.02	0.08	0.03
Faecal Coliforms	CFU/100 ml	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table A7: 2019 Dam water samples vs IWUL

Water Quality Constituent	Units	IWUL Limit	PCD 3 n=1			RAP-WTP n=8		
			Min	Max	Mean	Min	Max	Mean
Temperature (Field)	°C		-	-	-	14.00	19.00	16.57
pH	pH units	6.5 – 8.5	7.79	7.79	7.79	7.32	8.14	7.68
TDS	mg/l	450	192.00	192.00	192.00	416.00	702.00	542.50
Electrical Conductivity	mS/m	40	35.00	35.00	35.00	86.60	1 083.00	305.50
Suspended Solids	mg/l	25	5.00	5.00	5.00	5.00	80.00	42.13
Dissolved oxygen	mg/l	> 6	7.00	7.00	7.00	0.50	17.50	4.69
Sulphate as SO42-	mg/l	150	5.30	5.30	5.30	53.70	134.50	78.96
Sodium as Na	mg/l	20	27.80	27.80	27.80	81.90	165.90	114.41
Chloride as Cl-	mg/l	55	61.10	61.10	61.10	39.00	176.70	66.90
Boron as B	mg/l	0.15	0.02	0.02	0.02	0.02	0.05	0.03
Turbidity	NTU	5	6.20	6.20	6.20	8.20	107.00	49.44
Alkalinity as $CaCO_3$	mg/l	120	53.00	53.00	53.00	211.00	334.00	264.00
Iron as Fe	mg/l	2	0.07	0.07	0.07	0.15	1.10	0.34
Aluminium as Al	mg/l	0.7	0.05	0.05	0.05	0.03	0.53	0.10
Manganese as Mn	mg/l	0.5	0.00	0.00	0.00	0.05	0.22	0.11
Ammoniacal Nitrogen as NH3	mg/l	0.007	1.50	1.50	1.50	22.30	62.74	35.83
Ammoniacal Nitrogen as NH4+	mg/l	1	1.50	1.50	1.50	18.78	44.46	29.51
Nitrite as NO_2-	mg/l	2	0.03	0.03	0.03	0.03	0.03	0.03
Nitrate as NO_3	mg/l	2	0.03	0.03	0.03	0.03	2.03	0.34
Orthophosphate as PO_4	mg/l	0.05	3.91	3.91	3.91	2.44	25.20	8.43
Faecal Coliforms	CFU/100 ml	0	-	-	-	-	-	-

Table A8: 2020 Q1 Dam Water Samples vs IWUL Limits

Water Quality Constituent	Units	IWUL Limit	BWQ01			BWQ06			BWQ07			BWQ08			FD			KFPD		
			Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20
Temperature (Field)	°C		21.31	17.80	29.10	22.20	22.10	24.30		18.80	24.90	20.10	19.50	22.50			24.00	21.30	26.80	23.30
pH	pH units	6,5 – 8,5	6.29	7.14	7.40	7.42	8.38	7.71		7.24	7.69	6.55	7.81	7.66			7.66	7.32	6.57	7.65
TDS	mg/l	450	96.00	58.00	63.00	289.00	271.00	266.00		173.00	199.00	171.00	135.00	143.00			174.00	182.00	189.00	165.00
Electrical Conductivity	mS/m	40	12.50	8.20	10.00	46.70	40.80	44.30		30.30	33.30	26.10	19.00	22.40			27.40	26.00	28.20	25.80
Dissolved Oxygen	mg/l	> 6	5.00	4.00	6.00	1.00	4.00	7.00		5.00	4.00	5.00	5.00	5.00			6.00	3.00	3.00	5.00
Sulphate as SO_4^{2-}	mg/l	200	23.70	5.40	2.20	0.25	10.40	5.70		6.50	3.30	3.80	4.30	2.10			2.40	8.60	21.10	3.40
Chloride as Cl	mg/l	100	11.70	8.60	13.60	82.40	65.00	62.80		58.50	59.40	51.70	33.40	38.70			48.20	47.40	54.00	44.70
Nitrate as NO_3	mg/l	2	0.10	0.03	0.03	0.10	0.09	0.03		0.03	0.03	0.10	0.03	0.03			0.11	0.03	0.10	0.03
Aluminium as Al	mg/l	0,7	0.00007	0.07	0.01	0.00001	0.01	0.01		0.01	0.01	0.00001	0.01	0.02			0.01	0.01	0.00001	0.01
Manganese as Mn	mg/l	0,5	0.05	0.05	0.02	0.03	0.01	0.16		0.05	0.03	0.01	0.02	0.04			0.06	0.05	0.03	0.05
Sodium as Na	mg/l	70	6.80	5.00	7.50	23.10	18.40	16.70		23.70	22.50	21.40	15.00	16.30			18.70	19.50	22.00	17.20
Magnesium as Mg	mg/l	30	3.40	2.60	3.00	24.00	18.90	19.60		10.60	11.80	8.80	6.00	7.30			8.80	8.00	9.50	8.40
Calcium as Ca	mg/l	32	6.20	6.40	6.90	23.10	19.00	17.80		12.40	13.30	9.70	8.60	8.40			10.00	10.20	10.40	9.40
Turbidity	NTU	5	15.30	16.40	4.60	8.20	0.90	1.60		4.40	1.80	9.70	2.60	1.00			2.10	0.80	7.10	1.70
Faecal Coliforms	CFU/100ml	0	-	470	-	35	1	-		20	-	-	-	-			-	-	-	-

Note: Orange highlighted cell – value exceeds limit; grey cells: monitoring site was dry / not accessible.

Table A9: 2020 Q1 PCD Water Samples vs IWUL

Water Quality Constituent	Units	IWUL Limit	PCD 2			PCD 4			IN PIT 5		
			Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20
Temperature (Field)	°C		21.60	20.40	22.70	21.50	20.00	23.30			27.60
pH	pH units	6,5 – 8,5	6.54	7.49	7.54	6.59	7.59	7.62			6.14
TDS	mg/l	450	304.00	336.00	476.00	343.00	315.00	368.00			869.00
Electrical Conductivity	mS/m	40	44.20	51.80	63.50	33.10	51.80	61.10			108.80
Dissolved Oxygen	mg/l	> 6	6.00	7.00	6.00	7.00	7.00	7.00			7.00
Sulphate as SO_4^{2-}	mg/l	200	134.20	245.90	234.20	91.00	208.00	189.80			524.80
Chloride as Cl	mg/l	100	17.50	7.50	5.50	22.90	12.40	11.40			4.40
Nitrate as NO_3	mg/l	2	20.00	0.93	0.97	3.40	4.52	6.17			0.47
Aluminium as Al	mg/l	0,7	0.00001	0.01	0.01	0.00001	0.01	0.03			0.04
Manganese as Mn	mg/l	0,5	0.20	0.57	0.35	0.19	0.19	0.04			7.09
Sodium as Na	mg/l	70	10.20	7.00	12.50	12.20	10.10	12.70			12.60
Magnesium as Mg	mg/l	30	15.10	23.00	25.60	11.40	20.30	21.40			66.40
Calcium as Ca	mg/l	32	49.60	48.60	48.70	32.40	46.20	44.00			63.60
Turbidity	NTU	5	24.60	580.00	138.00	529.00	9.90	2.00			0.80
Faecal Coliforms	CFU/100ml	0	-	-	-	-	-	-			-

Table A10: 2019 Pan Water Sample vs IWUL Limits

Water Quality Constituent	Units	IWUL Limit	Pan05 n=6			Pan06 n=5			Pan07 n=11			Pan08 n=11			Pan13 n=12		
			Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Temperature (Field)	°C		12.90	22.80	18.10	10.30	18.40	15.95	14.70	21.50	18.50	13.50	27.00	19.37	6.20	31.20	20.65
pH	pH units	6.5 – 7.8	6.10	7.84	6.73	6.32	6.80	6.63	6.53	7.74	7.15	6.34	7.55	7.09	6.70	8.63	7.58
TDS	mg/l	450	71.00	720.00	256.50	65.00	170.00	109.60	94.00	384.00	212.64	100.00	278.00	172.45	202.00	1 566.00	699.50
Electrical Conductivity	mS/m	40	2.20	55.70	24.25	6.00	9.90	7.34	8.70	393.00	52.35	16.10	385.00	82.93	25.60	2 800.00	439.97
Dissolved Oxygen	mg/l	> 6	0.50	11.50	2.58	0.50	6.00	2.10	0.50	12.50	2.82	0.50	17.50	5.32	0.50	15.50	3.92
Sulphate as SO_4^{2-}	mg/l	150	0.25	1.90	0.53	0.25	6.00	2.36	0.25	17.50	5.25	0.25	4.20	1.16	0.25	187.28	20.72
Chloride as Cl^-	mg/l	55	1.80	45.20	21.90	3.20	9.30	6.34	5.90	78.40	22.23	16.40	68.60	34.81	24.00	711.90	229.84
Nitrate as NO_3	mg/l	2	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.36	0.06	0.03	0.36	0.06	0.03	0.38	0.06
Nitrite as NO_2^-	mg/l	2	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.35	0.06	0.03	0.15	0.04
Orthophosphate as PO_4	mg/l	0.05	0.02	0.06	0.03	0.02	0.03	0.02	0.02	0.09	0.04	0.02	0.16	0.05	0.02	0.15	0.05
Ammoniacal Nitrogen as NH_3	mg/l	0.007	0.17	2.08	0.90	0.22	0.87	0.58	0.05	1.68	0.85	0.04	1.50	0.55	0.06	1.50	0.75
Ammoniacal Nitrogen as NH_4^+	mg/l	1	0.14	1.71	0.78	0.18	0.71	0.47	0.04	1.78	0.81	0.03	1.50	0.52	0.05	1.50	0.73
Alkalinity as $CaCO_3$	mg/l	120	12.00	175.00	72.50	10.00	39.00	18.80	22.00	88.00	52.82	36.00	73.00	48.18	50.00	273.00	152.17
Aluminium as Al	mg/l	0.7	0.01	0.12	0.04	0.01	0.06	0.04	0.01	0.12	0.04	0.01	0.03	0.01	0.01	0.46	0.09
Boron as B	mg/l	0.15	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.05	0.02	0.01	0.02	0.01	0.01	0.06	0.02
Iron as Fe	mg/l	2	0.23	5.42	3.10	0.25	1.62	0.59	0.10	8.06	2.19	0.03	2.08	0.54	0.51	4.25	1.74
Manganese as Mn	mg/l	0.5	0.01	3.05	0.77	0.02	0.15	0.10	0.00	1.65	0.38	0.00	0.30	0.08	0.03	1.16	0.27
Sodium as Na	mg/l	20	1.80	29.60	14.27	3.20	9.00	6.14	4.60	55.40	17.34	15.00	44.00	25.24	22.90	349.00	132.69
Suspended Solids	mg/l	25	9.50	1 532.00	319.97	3.40	189.00	74.26	9.70	372.00	111.92	5.00	332.00	74.78	6.30	648.00	151.16
Turbidity	NTU	5	35.00	257.00	87.28	4.60	111.00	40.32	2.50	202.00	48.99	2.90	57.40	17.45	5.00	338.00	82.37

Table A11: 2019 Pan Water Sample vs IWUL Limits

Water Quality Constituent	Units	IWUL Limit	Pan09 n=5			Pan12 n=2		
			Min	Max	Mean	Min	Max	Mean
Temperature (Field)	°C		15.70	30.30	22.44	19.80	24.60	22.20
pH	pH units	6.5 – 7.8	5.41	6.06	5.63	5.84	6.18	6.01
TDS	mg/l	450	17.50	50.00	34.40	248.00	290.00	269.00
Electrical Conductivity	mS/m	40	2.50	4.70	3.44	12.30	15.40	13.85
Dissolved Oxygen	mg/l	> 6	2.00	14.50	7.60	0.50	3.00	1.75
Sulphate as SO_4^{2-}	mg/l	150	0.25	0.25	0.25	0.25	0.25	0.25
Chloride as Cl^-	mg/l	55	3.60	5.00	4.16	5.20	26.60	15.90
Nitrate as NO_3	mg/l	2	0.03	0.06	0.03	0.03	0.03	0.03
Nitrite as NO_2^-	mg/l	2	0.03	0.03	0.03	0.03	0.03	0.03
Orthophosphate as PO_4	mg/l	0.05	0.02	0.02	0.02	0.02	0.11	0.06
Ammoniacal Nitrogen as NH_3	mg/l	0.007	0.13	1.50	0.63	0.09	0.16	0.13
Ammoniacal Nitrogen as NH_4^+	mg/l	1	0.11	1.50	0.57	0.08	0.13	0.11
Alkalinity as $CaCO_3$	mg/l	120	4.00	8.00	5.60	8.00	31.00	19.50
Aluminium as Al	mg/l	0.7	0.05	0.40	0.14	0.16	0.35	0.25
Boron as B	mg/l	0.15	0.01	0.01	0.01	0.01	0.02	0.01
Iron as Fe	mg/l	2	0.46	11.26	3.03	1.73	4.51	3.12
Manganese as Mn	mg/l	0.5	0.01	0.19	0.06	0.36	1.06	0.71
Sodium as Na	mg/l	20	3.80	8.50	5.00	5.20	7.80	6.50
Suspended Solids	mg/l	25	26.30	223.00	138.66	27.60	204.00	115.80
Turbidity	NTU	5	5.60	213.00	67.44	28.70	74.00	51.35

Table A12: 2020 Q1 Pan Water Sample vs IWUL Limits

Water Quality Constituent	Units	IWUL Limit	Pan09			Pan06			Pan08			Pan12			Pan13		
			Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20	Dec-19	Jan-20	Feb-20
Temperature (Field)	°C				24.50			24.70	23.50	18.60	23.50			24.40		22.50	23.90
pH	pH units	6,5 - 7,8			6.67			7.37	6.83	7.13	7.58			6.86		7.36	8.04
TDS	mg/l	450			74.00			121.00	138.00	114.00	151.00			151.00		642.00	518.00
Electrical Conductivity	mS/m	40			3.10			8.90	21.90	21.30	18.60			6.40		87.50	63.70
Dissolved Oxygen	mg/l	> 6			2.00			0.50	3.00	0.50	2.00			0.50		0.50	0.50
Sulphate as SO_4^{2-}	mg/l	150			1.00			0.25	0.25	2.30	0.25			0.25		2.60	1.40
Chloride as Cl^-	mg/l	55			3.20			5.70	29.50	26.70	23.80			5.40		145.10	68.20
Nitrate as NO_3	mg/l	2			0.03			0.03	0.10	0.03	0.03			0.03		0.03	0.03
Nitrite as NO_2^-	mg/l	2			0.003			0.003	0.010	0.003	0.003			0.003		0.003	0.003
Orthophosphate as PO_4	mg/l	0,05			0.08			0.02	0.14	0.02	0.02			0.08		0.05	0.05
Ammoniacal Nitrogen as NH_3	mg/l	0,007			1.50			0.21	0.42	0.40	1.50			0.67		1.50	1.50
Ammoniacal Nitrogen as NH_4^+	mg/l	1			1.50			0.22	0.45	0.42	1.50			0.71		1.50	1.50
Alkalinity as $CaCO_3$	mg/l	120			6.00			28.00	76.00	50.00	44.00			13.00		176.00	179.00
Aluminium as Al	mg/l	0,7			0.09			0.02	0.00001	0.06	0.01			0.05		0.18	0.09
Boron as B	mg/l	0,15			0.01			0.01	0.02	0.01	0.01			0.02		0.01	0.02
Iron as Fe	mg/l	2			0.86			1.61	0.13	1.19	0.43			1.18		3.45	1.36
Manganese as Mn	mg/l	0,5			0.05			0.19	0.08	0.50	0.03			0.24		0.45	0.45
Sodium as Na	mg/l	20			4.00			4.60	22.60	21.50	19.00			4.40		102.90	67.00
Suspended Solids	mg/l	25			73.00			5.00	5.00	13.00	25.00			5.00		20.00	15.00
Turbidity	NTU	5			37.30			7.00	2.80	3.80	3.50			6.10		6.90	Document Limitations Surface water quality results4.70

Table A13: Rivers data for the period January 2021 to May 2021

Monitoring point	Date	Alkalinity, Total as $CaCO_3$	Aluminum	Ammonia as NH_3	Ammonia as NH_4	Boron	Calcium	Chloride	Dissolved Oxygen	Electrical Conductivity	Iron	Magnesium	Manganese	Nitrate as N	Nitrite as N	Ortho Phosphate as PO_4	pH	Potassium	Silicon	Sodium	Sulphate	Total Ammonia as N	Total Dissolved Solids	Total Suspended Solids	Turbidity
Unit		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU
WUL Limit		**120**	**0.7**	**0..007**	**1**	**0.15**		**55**	**6**	**40**	**2**		**0.5**	**2**		**0.05**	**6.5 – 7.8**			**20**	**150**		**450**	**25**	**5**
Proposed limit		**120**	**0.7**	**16**	**1.7**	**0.15**		**55**	**6**	**40**	**2**		**0.5**	**2**		**0.1**				**20**	**150**		**450**	**120**	**150**
KS08	21-Jan	10.2	0.01	0.45	0.45	0.01	6.178	58	6.43	23.5	0.01	6.149	0.04	0.35	0.01	0.03	6.55	4.316	1.95	20.7	3.59	0.45	105.09	236	195
	17-Feb	21.8	0.04	0.45	0.45	0.01	5.96	36	6.33	19.1	0.41	6.244	0.01	0.35	0.01	0.03	6.72	4.149	1.66	12.1	4.83	0.45	82.81	1.2	4.3
	17-Mar	28.4	0.04	0.45	0.45	0.01	6.75	39.22	6.66	20.7	1.42	7.89	0.01	0.51	0.01	0.03	6.96	4.28	1.62	12.6	4.25	0.45	95.88	348	191
	21-Apr	21.8	0.01	0.45	0.45	0.01	6.19	42.1	7.15	21.6	0.15	7.872	0.01	0.35	0.01	0.03	7.18	2.82	0.1	13.5	4.71	0.45	90.64	9.6	9.27
	20-May	16.3	0.01	0.45	0.45	0.01	7.12	48.02	6.24	21.6	0.19	8.94	0.01	0.35	0.01	0.03	6.57	2.92	1.71	14.1	5.69	0.45	96.77	69.6	48.4
KS10	16-Feb	9.6	0.17	0.45	0.45	0.01	2.2	9.61	5.48	6.56	0.34	1.74	0.01	0.35	0.01	0.03	6.04	1.6	2.24	4.21	3.39	0.45	29.02	1.6	1.58
	21-Jan	21.4	0.17	0.45	0.45	0.01	10.5	99.8	6.85	39.6	0.36	12.5	0.01	0.35	0.01	0.03	6.97	11.3	0.1	34.1	2.46	0.45	184.03	78	47.8
	17-Feb	35.8	0.01	0.45	0.45	0.01	12.5	62.7	6.29	32.1	0.39	10.2	0.01	0.35	0.01	0.03	6.57	7.6	1.9	21.5	6.98	0.45	143.36	21.2	12.3
	17-Mar	48	0.01	0.45	0.9	0.01	13.219	86.83	5.55	40.6	1.46	10.97	0.1	0.35	0.01	0.21	6.55	15.156	1.24	29.5	3.9	0.9	193.46	55.6	30.6
	21-Apr	22.2	0.03	0.45	0.45	0.01	10.4	76.1	6.89	32.6	0.53	8.52	0.03	0.35	0.01	0.03	6.61	7.59	0.1	26.1	5.08	0.45	147.97	94	45.6
	19-May	49.4	0.04	0.45	0.45	0.01	9.196	83.5	6.58	39.1	0.28	16.466	0.01	0.35	0.01	0.03	6.43	17.475	0.31	29.8	4.29	0.45	190.827	107	5.26
KS11	19-May	28.6	0.02	0.45	0.45	0.01	12.9	43.8	6.31	29.4	0.51	12.2	0.01	0.35	0.01	0.03	6.82	4.49	1.49	14	31.8	0.45	137.03	14	5.54
KS12	19-May	28.6	0.02	0.45	0.45	0.01	12.9	43.8	6.31	29.4	0.51	12.2	0.01	0.35	0.01	0.03	6.82	4.49	1.49	14	31.8	0.45	137.03	14	5.54
KS13	20-Jan	17.4	0.07	0.45	0.45	0.01	4.21	26.4	5.48	13.43	1.64	3.88	0.24	0.35	0.01	0.03	6.53	2.5	0.37	9.6	3.35	0.45	62.33	116	33
	18-Feb	48.8	0.06	0.45	0.48	0.01	11.6	27.7	6.35	20.7	0.968	7.45	0.05	0.35	0.01	0.03	6.52	3.59	2.26	12.3	8.87	0.48	102.93	416	181
	18-Mar	40.2	0.01	0.45	0.45	0.01	8.463	36.4	5.53	21.5	1.83	8.272	1.2	0.35	0.01	0.03	6.7	4.939	1.37	10.98	5.01	0.45	101.42	131	48.2
	22-Apr	34.2	0.12	0.45	0.45	0.01	8.78	40.7	6.91	23	0.65	8.37	0.02	0.35	0.01	0.03	6.87	4.03	0.1	13.3	6.26	0.45	102.96	8.8	12.2
	20-May	27.2	0.09	0.45	0.45	0.01	11.1	41.2	6.45	26.7	0.42	11.1	0.01	0.35	0.01	0.03	6.92	3.91	1.12	13.4	27	0.45	124.67	3.6	3.15
KS14	20-Jan	17.6	0.29	0.45	0.45	0.01	4.81	23.4	6.75	12.21	1.18	3.73	0.01	0.35	0.01	0.03	6.79	1.16	0.24	8.55	2.82	0.45	56.5	100	29.5
	18-Feb	42.8	0.04	0.45	0.45	0.01	10.6	33.3	6.59	22	4.09	7.88	0.55	0.35	0.01	0.03	6.42	4.25	1.96	11.5	2.4	0.45	101.65	329	151
	18-Mar	36.6	0.05	0.45	0.45	0.01	9.13	36.3	6.27	20.8	0.71	8.014	0.01	0.35	0.01	0.03	7	4.308	1.54	10.768	2.41	0.45	93.82	2.8	4.28
	22-Apr	33.6	0.03	0.45	0.45	0.01	7.84	40.6	7.2	22.4	0.57	9.062	0.01	0.35	0.01	0.03	6.98	3.97	0.1	13.1	4.99	0.45	100.68	2.4	5.96
	20-May	25.3	0.1	0.45	0.45	0.01	11	39.3	6.29	25.8	0.32	10.8	0.01	0.35	0.01	0.03	6.99	3.79	1	13.4	26.9	0.45	120.93	0.4	2.67
KS15	20-Jan	37.4	0.16	0.45	0.45	0.01	7.44	22.9	6.33	17.57	1.01	6.02	0.01	0.35	0.01	0.03	7.18	1.76	0.1	13.6	6.53	0.45	81.86	7.2	12.5
	18-Feb	32.8	0.08	0.45	0.45	0.01	8.94	34.9	6.29	20.7	0.28	7.27	0.01	0.35	0.01	0.03	6.7	4.5	1.32	11.9	7.45	0.45	95	6	3.09
	18-Mar	42.2	0.16	0.45	0.45	0.01	9.925	36.73	6.58	21.9	0.62	8.599	0.02	0.35	0.01	0.03	7.05	4.499	0.81	11.314	3.267	0.45	100.64	18.8	10
	22-Apr	36.8	0.08	0.45	0.45	0.01	8.22	40.5	7.11	22.9	0.16	9.253	0.01	0.35	0.01	0.03	7.17	3.76	0.1	13.3	4.66	0.45	102.21	0.4	3.42
	20-May	26.7	0.01	0.45	0.45	0.01	11.6	41.6	6.44	26.5	0.05	11	0.01	0.35	0.01	0.03	6.88	3.93	0.77	13.7	27.8	0.45	125.83	0.4	20
KS20	18-Feb	39.4	0.09	0.45	0.45	0.01	10.2	34	6.78	20.8	0.11	7.75	0.01	0.35	0.01	0.03	6.68	4.657	1.56	11.7	5.83	0.45	98.08	16.4	12
	22-Apr	7	0.06	0.45	0.45	0.01	1.52	10	6.67	5.38	2.07	1.28	0.21	0.35	0.01	0.03	5.82	0.34	0.1	3.04	1.46	0.45	24.59	149	69.2
	20-May	4.31	0.054	0.45	0.45	0.01	2.299	15.1	6.38	7.12	0.075	3.437	0.034	0.35	0.01	0.03	5.98	1.076	2.93	3.91	2.89	0.45	31.461	66.4	16.1
KS22	22-Jan	33.9	0.155	0.45	0.505	0.01	4.675	11.65	6.615	12.425	1.65	4.38	0.015	0.35	0.01	0.03	7.195	1.54	2.2	8.155	4.05	0.51	56.96	272.6	80.75
	18-Feb	22.4	0.055	0.45	0.45	0.01	10.537	15.15	6.3	21.5	0.6985	9.65	0.015	0.5	0.01	0.03	6.885	2.34	3.335	8.19	42.45	0.45	103.96	29.6	20.1
	19-Mar	38.1	0.065	0.45	0.45	0.01	5.973	13.35	6.64	13.5	1.69	5.872	0.01	0.35	0.01	0.03	6.905	1.6325	4.11	6.133	4.261	0.45	61.97	15.8	24.9
	22-Apr	35.4	0.01	0.45	0.45	0.01	5.16	13.35	7.005	12.35	0.98	5.3525	0.01	0.35	0.01	0.03	6.93	1.31	2.645	6.765	3.135	0.45	57.56	6.8	9.44
	20-May	25.125	0.035	0.45	0.45	0.01	4.8385	21.3	6.525	13.1	0.69	7.1215	0.01	0.35	0.01	0.03	6.72	1.3775	4.1155	6.945	4.697	0.45	62.19	6.6	12.185
LS03	21-Jan	14.4	0.64	0.45	0.45	0.01	1.823	46.4	6.48	19.83	0.336	3.48	0.01	0.35	0.01	0.04	6.92	15.4	2.63	17.2	2.742	0.45	96.78	28	46.1
	17-Feb	18.4	0.944	0.45	0.45	0.01	1.99	41.2	6.82	18.8	1.412	3.66	0.01	0.35	0.01	0.03	6.7	9.287	4.59	16.5	2.78	0.45	88.81	22.8	39.3
	17-Mar	16.8	2.22	0.45	0.45	0.01	2	48.4	6.81	21	2.77	4.22	0.01	0.35	0.01	0.03	6.64	8.15	4.36	17.5	4.06	0.45	99.54	9.2	17.3
	21-Apr	12.6	0.02	0.45	0.45	0.01	2.54	50.2	7.11	20.3	0.56	4.932	0.01	0.35	0.01	0.03	6.72	8.15	0.1	19.9	3.31	0.45	97.54	9.6	11.8
	19-May	10.5	1.67	0.45	0.45	0.01	1.88	48.9	6.23	20.4	1.46	4.67	0.01	0.35	0.01	0.03	6.53	6.05	3.21	17.6	2.08	0.45	90.81	6.4	20.5
LS04	21-Jan	36.8	0.06	0.45	0.45	0.01	10.1	49.8	6.25	24.3	1.8	10.1	0.04	0.35	0.01	0.03	7.01	0.65	4.96	16.8	1.32	0.45	112.75	42.4	36.2

Monitoring point	Date	Alkalinity, Total as $CaCO_3$	Aluminum	Ammonia as NH_3	Ammonia as NH_4	Boron	Calcium	Chloride	Dissolved Oxygen	Electrical Conductivity	Iron	Magnesium	Manganese	Nitrate as N	Nitrite as N	Ortho Phosphate as PO_4	pH	Potassium	Silicon	Sodium	Sulphate	Total Ammonia as N	Total Dissolved Solids	Total Suspended Solids	Turbidity
Unit		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU
	17-Feb	29.8	0.08	0.45	0.45	0.01	8.52	43.9	6.77	22.2	0.67	7.444	0.01	0.35	0.01	0.03	6.69	2.565	2.98	15.5	4.22	0.45	100.77	83.2	43.1
	17-Mar	30.8	0.06	0.45	0.45	0.01	8.782	45	6.77	22.6	0.55	7.993	0.01	0.35	0.01	0.03	6.94	2.86	3.74	15.74	4.5	0.45	104.08	79.2	38.9
	21-Apr	22.8	0.01	0.45	0.45	0.01	6.89	45.5	7.09	20.6	0.46	7.175	0.01	0.35	0.01	0.03	6.67	2.56	1.98	15.9	3.72	0.45	96.21	258	148
	19-May	15.2	0.15	0.45	0.45	0.01	6.413	48.8	6.46	21.2	0.43	6.5	0.01	0.35	0.01	0.03	6.59	2.272	4.04	16.2	1.68	0.45	91.66	2	3.77
LS08	21-Jan	134	0.01	0.00744	0.59256	0.01	446.7	8.49	6.63	242	0.01	168	1.611	0.35	0.08	0.03	7.54	11.371	0.41	8.737	1538	0.6	2264.08	140	118
	17-Feb	22	0.39	0.45	0.45	0.01	12.6	9.9	6.54	16.9	0.53	4.95	0.01	0.35	0.01	0.03	6.76	0.01	3.13	7.7	31.4	0.45	80.67	1.2	10.6
	17-Mar	176	0.03	0.45	0.73	0.01	96.4	14.9	6.62	83.4	0.14	47.3	0.1	0.35	0.01	0.03	7.3	1.35	1.14	8.95	263	0.73	538.86	187	78.3
LS12	18-Feb	22.6	0.12	0.45	0.45	0.01	5.95	30.6	6.24	16.5	3.5	4.69	0.01	0.35	0.01	0.03	6.86	5.39	3.66	10.1	3.8	0.45	77.8	8.4	7.55
	18-Mar	26.6	0.06	0.45	0.83	0.01	5.159	29.9	6.44	16.8	3.13	5.117	0.01	0.35	0.01	0.03	6.64	4.769	3.22	8.765	3.862	0.83	77.96	13.2	7.03
	18-Apr	11.4	0.11	0.45	0.45	0.01	4.97	33.1	6.5	15.6	0.8	4.714	0.04	0.35	0.01	0.03	6.48	4.84	0.53	10.1	7.06	0.45	72.75	60	24.6
LS16	22-Apr	26.6	0.01	0.45	0.45	0.01	3.86	8.48	6.63	8.55	0.82	2.822	0.01	0.35	0.01	0.03	6.6	0.55	2.73	5.96	1.1	0.45	39.88	137	68.8

Exceeds current WUL limit

Exceeds both current WUL and proposed limit

Table A-14: Dams data for the period January 2021 to May 2021

Monitoring point	Date	Alkalinity, Total as $CaCO_3$	Aluminum	Ammonia as NH_3	Ammonia as NH_4	Boron	Calcium	Chloride	Dissolved Oxygen	Electrical Conductivity	Iron	Magnesium	Manganese	Nitrate as N	Nitrite as N	Ortho Phosphate as PO_4	pH	Potassium	Silicon	Sodium	Sulphate	Total Ammonia as N	Total Dissolved Solids	Total Suspended Solids	Turbidity
Unit		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU
WUL Limit		120	0.7	0..007	1	0.15		55	6	40	2		0.5	2		0.05				20	150		450	25	5
Proposed limit		120	0.7	16	1.7	0.15		55	6	40	2		0.5	2		0.1				20	150		450	120	150
BWQ1	22-Jan	24.5	0.01	0.45	0.45	0.01	3.855	15.1	6.755	11.075	1.89	3.945	0.01	0.35	0.01	0.03	6.605	1.67	1.58	5.92	2.125	0.45	49.21	80	47.6
	19-Feb	26.6	0.055	0.45	0.63	0.01	3.65	17.15	6.605	15.41	4.38	3.41	0.05	0.35	0.01	0.03	6.29	6.3415	3.04	7.33	7.46	0.625	67.92	95.1	29.15
	18-Mar	9.7	0.025	0.45	0.45	0.01	1.8	16.95	6.255	9.215	4.45	1.98	0.025	0.35	0.01	0.03	6.15	1.685	1.51	6.505	7.175	0.45	46.58	55.6	26.55
	21-Apr	23.2	0.08	0.45	0.45	0.01	3.07	17.3	5.5	15	2.92	3.486	0.03	0.35	0.01	0.03	6.49	1.6	0.1	7.27	3.57	0.45	53.43	123	82.1
	22-Apr	10.4	0.01	0.45	0.45	0.01	3.19	16.2	6.57	9.77	0.88	2.75	0.01	0.35	0.01	0.03	6.4	1.7	0.1	6.72	6.64	0.45	44.51	96.4	26
	18-May	9.77	0.01	0.45	0.45	0.01	3.254	19.27	6.54	10.95	1.05	4.488	0.03	0.35	0.01	0.03	6.32	1.3245	1.195	7.135	9.1865	0.45	51.69	203.8	78.65
BWQ2	19-Jan	19.6	0.01	0.45	0.45	0.01	3.906	13	6.38	9.27	0.25	3.12	0.01	0.35	0.01	0.03	6.95	1.934	0.1	5.91	2.15	0.45	42.03	13.2	356
	16-Feb	16.8	0.19	0.45	0.45	0.01	2.84	12.1	5.39	9.15	1.42	2.65	0.01	0.35	0.01	0.21	6.52	2.06	3.56	6.36	4.29	0.45	42.63	2	7.91
	16-Mar	21.2	0.28	0.45	0.45	0.01	2.96	11.8	6.63	9.63	1.54	2.78	0.01	0.35	0.01	0.03	6.66	1.92	3.3	6.13	3.66	0.45	43.93	27.2	9.82
	20-Apr	23.6	0.03	0.45	0.45	0.01	2.98	13.3	6.15	9.64	2.55	3.34	0.01	0.35	0.01	0.03	6.79	1.46	1.75	6.25	2.82	0.45	47.13	6.8	41.5
	20-May	22.4	0.02	0.45	0.45	0.01	2.809	11.6	6.31	9.03	1.04	3.36	0.01	0.35	0.01	0.03	6.7	1.967	2.223	5.703	1.74	0.45	41.77	15.2	8.02
BWQ4	19-Jan	35.8	0.61	0.45	0.45	0.01	6.41	15.2	6.67	15.25	0.85	4.55	0.01	0.35	0.01	0.03	7.24	1.15	0.1	12.3	9.29	0.45	71.84	40	24.1
	16-Feb	18.4	0.57	0.45	0.45	0.01	20.1	17.3	6.75	32	0.61	16.8	0.01	0.62	0.01	0.03	6.66	3.51	2.8	10.3	96.12	0.45	179.09	6.8	11.9
	16-Mar	41.4	0.07	0.45	0.45	0.01	17.479	28.9	6.8	30.9	0.43	15.239	0.01	0.35	0.01	0.03	7.03	3.551	1.41	11.44	56.8	0.45	158.90	12.4	6.75
	20-Apr	41.8	0.05	0.45	0.45	0.01	10	36.6	6.92	22.9	0.45	9.49	0.01	0.35	0.01	0.03	7.12	2.49	0.1	13.3	8.58	0.45	106.37	2	6.6
	20-May	23.7	0.07	0.45	0.45	0.01	10.74	40.2	6.68	23.9	0.28	9.56	0.01	0.35	0.01	0.03	6.85	2.53	1.6	13.3	21.8	0.45	112.8	4.4	5.09
BWQ5	20-Jan	17.6	0.05	0.45	0.45	0.01	3.66	21.1	6.45	11.36	1.65	3.66	0.01	0.35	0.01	0.03	6.37	1.94	0.59	7.66	2.65	0.45	52.93	28.4	17.6
	18-Feb	48	0.03	0.45	0.45	0.01	12.9	16.8	6.29	21	0.25	8.89	0.01	0.35	0.01	0.03	6.73	2.79	2.51	8.63	17.2	0.45	96.41	28	3.66
	18-Mar	36.6	0.02	0.45	0.45	0.01	9.212	37.5	6.81	21.3	1.07	8.229	0.07	0.35	0.01	0.06	6.79	4.713	1.72	11.024	3.755	0.45	97.90	5.6	7.38
	22-Apr	34.6	0.01	0.45	0.45	0.01	8.88	43.1	7.13	22.9	0.69	8.98	0.01	0.35	0.01	0.03	7.04	4.51	0.1	13.7	6.82	0.45	107.72	2	6.69
	18-May	28.2	0.02	0.45	0.45	0.01	12.2	42.8	6.45	27.6	0.42	12	0.01	0.35	0.01	0.03	6.68	4.37	0.91	14	30.4	0.45	133.24	2	3.27
BWQ6	22-Jan	92.5	0.01	0.007	1.08	0.01	22.7	95.05	6.585	52.25	0.245	27.5055	0.045	0.35	0.01	0.06	7.155	11.0125	0.1	20.6475	3.27	1.09	237.51	134.8	41
	18-Feb	89.4	0.01	0.45	0.8	0.01	24.7	46.75	6.145	42.85	1.71	17.05	0.045	0.35	0.01	0.03	6.875	6.68	0.795	11.8	7.945	0.8	171.61	195.2	55.65
	23-Apr	85.8	0.045	0.45	0.45	0.01	21.75	47.8	6.725	34.55	0.33	17.75	0.06	0.35	0.01	0.03	6.965	4.615	0.1	9.73	11.53	0.45	165.32	114.5	57.85
	20-May	67.4	0.01	0.45	0.45	0.01	17	48.3	6.32	32.3	0.14	17.4	0.01	0.35	0.01	0.03	6.77	3.85	0.1	9.08	9.86	0.45	146.23	11.2	18.4
	21-May	68.7	0.01	0.45	0.45	0.01	17.4	47.3	6.58	32.5	0.07	18.9	0.01	0.35	0.01	0.03	7.03	4.07	0.1	9.33	9.75	0.45	148.2	10.4	11
BWQ7	22-Jan	44.8	0.01	0.45	0.45	0.01	13.05	87.65	6.035	40.05	0.38	16.9	0.01	0.35	0.01	0.03	7.385	3.6	0.1	31.95	3.8	0.45	184.21	0.4	2.21
	18-Feb	46.2	0.025	0.45	0.515	0.01	14.25	62.115	6.495	33.05	2.42	11.45	0.01	0.35	0.01	0.03	6.89	4.865	2.275	22.4	7.935	0.515	153.61	182.6	62.5
	23-Apr	68	0.045	0.45	0.45	0.01	17.9	80.8	6.87	42.35	1.4	16.9	0.01	0.35	0.01	0.03	6.97	6.93	0.1	24.8	3.64	0.45	193.82	66.2	57.85
	20-May	73.415	0.27	0.45	0.81	0.01	19	82.05	6.37	61.65	1.4	18.75	0.02	0.61	0.01	0.03	6.805	8.435	0.205	24.6	3.37	0.81	205.05	262	142
BWQ8	21-Jan	31.8	0.02	0.45	0.45	0.01	10.88	50.7	6.75	23.8	0.19	8.39	0.01	0.35	0.01	0.03	8.81	2.31	0.1	16.8	2.18	0.45	110.55	4.8	4.58
	17-Feb	29.4	0.07	0.45	0.45	0.01	7.58	36.5	6.29	20.1	1.44	6.62	0.01	0.35	0.01	0.03	6.86	3.47	2.92	13.3	4.47	0.45	91.09	8	5.59
	17-Mar	35.4	0.01	0.45	0.45	0.01	9.41	41.7	6.82	21.9	0.52	8.917	0.01	0.35	0.01	0.03	6.94	3.427	2.76	14.304	3.49	0.45	103.79	3.6	2.58
	21-Apr	35.2	0.11	0.45	0.45	0.01	8.82	44.9	7.2	22.9	0.74	8.777	0.01	0.35	0.01	0.03	7.08	3.24	1.04	15.3	4.88	0.45	108.07	36.4	46.4
	09-May	32.9	0.01	0.45	0.45	0.01	8.2	43.8	6.35	22.7	0.16	8.71	0.01	0.35	0.01	0.03	6.98	2.7	2.93	14.7	2.47	0.45	100.57	8	10
BWQ9	22-Jan	71	0.07	0.45	0.575	0.01	14.35	18.4	6.295	21.4	0.505	9.99	0.01	0.35	0.01	0.03	7.395	0.47	5.14	8.775	3.56	0.574	99.17	44.6	25.05
	18-Feb	45.9	0.05	0.45	0.45	0.01	9.68	22.55	6.475	18.4	0.86	6.98	0.01	0.36	0.01	0.03	7.5	1.97	4.455	10.15	4.8	0.45	85.39	2.4	4.305
	18-Mar	53.2	0.065	0.45	0.45	0.01	10.687	26.005	6.805	19.95	1.29	8.3765	0.01	0.35	0.01	0.03	7.33	2.224	4.59	10.1405	2.675	0.45	93.69	3	13.84
	22-Apr	51.4	0.09	0.45	0.45	0.01	9.78	24.9	7.14	18.7	0.83	7.9675	0.015	0.35	0.01	0.03	7.36	1.645	3.405	10.55	2.855	0.45	89.66	1.4	6.52
	20-May	45.48	0.065	0.45	0.45	0.01	8.975	25.53	6.395	18.75	0.855	8.265	0.02	0.5725	0.01	0.826	7.115	1.47	5.945	10.35	0.5	0.45	87.19	0.4	6.74
Farm Dam	20-Jan	22	0.01	0.45	0.45	0.01	9.74	78.6	6.59	33.7	0.01	11.1	0.01	0.35	0.01	0.03	7.4	7.78	0.1	26.5	6.03	0.45	152.95	124	94.6
	18-Feb	36.4	0.06	0.45	0.45	0.01	12.6	43.3	6.76	25.4	1.08	8.82	0.01	0.35	0.01	0.03	6.42	5.52	1.61	14.3	6.02	0.45	113.54	71.6	32.2

Monitoring point	Date	Alkalinity, Total as $CaCO_3$	Aluminum	Ammonia as NH_3	Ammonia as NH_4	Boron	Calcium	Chloride	Dissolved Oxygen	Electrical Conductivity	Iron	Magnesium	Manganese	Nitrate as N	Nitrite as N	Ortho Phosphate as PO_4	pH	Potassium	Silicon	Sodium	Sulphate	Total Ammonia as N	Total Dissolved Solids	Total Suspended Solids	Turbidity
Unit		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU
	18-Mar	40	0.01	0.45	0.49	0.01	9.47	42.3	6.75	23.9	1.2	8.87	0.01	0.35	0.01	0.31	6.81	5.83	0.87	13.5	3.69	0.49	110.61	4.8	3.55
	22-Apr	30	0.04	0.45	0.45	0.01	8.46	46.5	6.88	22.7	0.29	9.212	0.01	0.35	0.01	0.03	7.02	3.95	0.1	14.2	4.15	0.45	105.01	84.8	47.4
	18-May	22.2	0.01	0.45	0.45	0.01	7.14	46.6	6.38	22.9	0.13	8.93	0.01	0.35	0.01	0.03	6.69	3.99	0.22	14	5.98	0.45	100.21	35.6	2.74
KP Farm Dam	20-Jan	37.8	0.01	0.45	0.45	0.01	10.7	65.9	6.35	33.1	0.05	11.2	0.01	0.35	0.01	0.03	8.5	8.48	0.1	22.8	6.6	0.45	148.41	2.8	4.83
	18-Feb	46	0.11	0.45	1.17	0.01	10.4	39.5	6.68	25.8	1.12	8.239	0.24	0.35	0.01	0.07	6.59	6.866	1.71	13.4	5.77	1.17	116.10	16.4	13.4
	18-Mar	35.4	0.05	0.45	0.45	0.01	8.06	40.4	6.79	22.9	3.24	8.17	0.01	0.35	0.01	0.03	7	5.8	1.48	11.3	6.83	0.45	105.27	2.4	4.43
	22-Apr	36	0.01	0.45	0.45	0.01	9.22	43	7.09	24.6	2.06	9.3	0.01	0.35	0.01	0.03	7.22	5.23	0.1	13.3	7.23	0.45	111.20	7.6	6.9
	20-May	34.8	0.01	0.45	0.45	0.01	16.6	41.5	6.45	31.8	0.53	13.9	0.01	0.35	0.01	0.03	6.93	5.01	1.19	13.5	43.5	0.45	155.55	2	38

Exceeds current WUL limit

Exceeds both current WUL and proposed limit

Table A-15: Pans data for the period January 2021 to May 2021

Monitoring point	Date	Alkalinity, Total as $CaCO_3$	Aluminum	Ammonia as NH_3	Ammonia as NH_4	Boron	Calcium	Chloride	Dissolved Oxygen	Electrical Conductivity	Iron	Magnesium	Manganese	Nitrate as N	Nitrite as N	Ortho Phosphate as PO_4	pH	Potassium	Silicon	Sodium	Sulphate	Total Ammonia as N	Total Dissolved Solids	Total Suspended Solids	Turbidity
Unit		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU
WUL Limit		**120**	**0.7**	**0.007**	**1**	**0.15**		**55**	**6**	**40**	**2**		**0.5**	**2**		**0.05**	**6.5 - 7.8**			**20**	**150**		**450**	**25**	**5**
Proposed limit		**154**	**0.7**	**5.2**	**5.5**	**0.15**		**700**	**1**	**280**	**6.8**		**2**	**10**		**0.05**				**350**	**305**		**1800**	**1800**	**130**
PAN06	18-Mar	15.2	0.053	0.45	0.45	0.01	0.55	6.52	6.33	6.23	3.59	0.92	0.038	0.35	0.01	0.03	6.06	0.29	2.69	6.25	2.25	0.45	29.815	68	35.6
	22-Apr	13.2	0.08	0.45	0.45	0.01	0.434	6.25	6.61	5.89	3.14	0.72	0.08	0.35	0.01	0.03	6.09	0.22	0.1	5.757	3.14	0.45	28.11032	450	181
	21-May	19.11	0.11	0.45	0.45	0.01	0.69	9.03	6.63	7.25	4.69	0.97	0.13	0.35	0.01	0.03	5.94	0.6	2.91	6.28	3.1	0.45	37.236	202	67.8
PAN07	20-Jan	30.6	0.01	0.45	0.52	0.01	5.11	8.95	6.35	12.21	1.49	3	0.17	0.35	0.01	0.03	6.51	7.03	0.65	5.01	7.72	0.52	57.5208	331	80.9
	18-Mar	28.8	0.11	0.45	0.76	0.01	4.24	7.24	6.15	10.1	7.55	2.23	0.13	0.35	0.01	0.03	6.02	2.61	8.11	3.54	14.31	0.76	60.6964	114	23.6
	22-Apr	14.4	0.02	0.45	0.45	0.01	2.94	5.82	6.21	6.81	0.29	2	0.05	0.35	0.01	0.03	5.82	0.3	0.25	4.41	1.81	0.45	27.43932	260	87.3
	20-May	29.37	0.07	0.45	0.45	0.01	4.36	13	6.5	11.4	2.97	3.51	0.07	0.35	0.01	0.03	6.04	4.54	3.91	6.05	2.02	0.45	54.776	400	105
PAN08	20-Jan	55	0.03	0.45	0.93	0.01	9.14	39.9	6.29	25.7	2.07	7.16	0.04	0.35	0.01	0.03	6.58	1.8	0.1	26.2	4.54	0.93	125.0797	193	63.3
	18-Feb	42.8	0.02	0.45	0.45	0.01	6.98	20.9	6.38	16.1	3.49	4.07	0.01	0.35	0.01	0.03	6.51	2.58	5.13	12.9	1.09	0.45	77.94	22.8	10.5
	18-Mar	30.4	0.01	0.45	0.53	0.01	4.27	24.5	6.15	15.1	2.56	3.44	0.02	0.35	0.01	0.03	6.33	2.51	3.08	12	0.5	0.53	68.4437	118	36.7
	22-Apr	23.4	0.02	0.45	0.45	0.01	2.99	19.7	6.14	11.9	1.86	2.63	0.06	0.35	0.01	0.03	6.21	2.06	0.1	12.5	1.43	0.45	58.51932	140	74.2
	20-May	28.16	0.02	0.45	0.45	0.01	2.647	21.8	6.48	14.1	0.44	5.621	0.05	0.35	0.01	0.03	6.16	2.848	1.66	12.8	2.71	0.45	66.032	190	57.4
PAN12	16-Feb	24.8	0.12	0.45	1.59	0.01	4.04	10.3	6.48	10.8	1.57	2.03	0.73	0.35	0.01	0.16	5.93	6.77	4.67	3.77	4.5	1.59	52.2123	190	58.3
	16-Mar	19	0.1	0.45	0.79	0.01	2.5	12.18	6.12	9.75	5.81	1.87	0.85	0.35	0.01	0.03	6.21	6.25	6.53	3.25	14.63	0.79	60.2191	38.4	13.7
	20-Apr	10.2	0.04	0.45	0.45	0.01	1.245	13.9	6.12	8.71	2.89	1.82	0.1	0.35	0.01	0.03	5.98	5.8	2	4.425	3.59	0.45	40.44932	532	174
	20-May	8.04	0.06	0.45	0.45	0.01	1.67	16.5	6.21	9.67	1.21	1.95	0.08	0.35	0.01	0.03	5.7	6.49	6.16	4.78	2.5	0.45	40.314	129	56.1
PAN13	16-Feb	70.8	0.18	0.015	1.58	0.01	9.11	47.8	6.28	31	1.86	6.74	0.77	0.35	0.01	0.21	7.36	22.8	4.34	24.3	6.64	1.6	166.6587	115	17
	16-Mar	99.4	0.45	0.006	2.22	0.01	11.5	68.3	5.13	43.3	5.37	9.48	0.37	0.35	0.01	0.45	6.78	37.6	7.11	31.9	10.76	2.23	241.1482	336	115
	20-Apr	76.4	0.01	0.45	0.45	0.01	7	69.4	6.23	41.4	1.4	8.79	0.02	0.35	0.01	0.03	6.98	35.8	3.14	33.1	0.5	0.45	201.7893	60	17.5
	20-May	120.72	0.01	0.45	0.45	0.01	12.1	83.2	6.37	53.3	1.49	11.6	0.03	0.35	0.01	0.03	6.7	46.8	5.36	43.5	1.1	0.45	272.662	97.6	23.9

Exceeds current WUL limit

Exceeds both current WUL and proposed limit

APPENDIX B

Sub-catchment input parameters

Table B.1: BEP Opencast Mine sub-catchment input parameters

Name	Area (ha)	Flow Length (m)	Slope (%)	Precipitation (mm)
S_P1a	52.058	840	4.50	118
S_P1b	57.938	483	4.48	118
S_P1c	200.752	873	4.24	118
S_P1d	104.377	1044	3.89	118
S_P1e	116.250	969	3.61	118
S_P2a	67.787	411	3.22	118
S_P2b	65.952	528	3.88	118
S_P2c	60.796	486	2.78	118
S_P2d	43.415	724	3.13	118
S_P2e	27.168	445	2.52	118
S_P2f	58.902	640	2.85	118
S_P2g	8.977	176	2.43	118
S_P2h	39.392	563	2.57	118
S_P3a	37.112	212	2.84	118
S_P3b	69.603	324	2.77	118
S_P3c	20.964	411	1.67	118
S_P3d	7.127	95	1.16	118
S_P3e	49.211	547	2.75	118
S_P4a	14.186	284	2.55	118
S_P4b	23.667	473	2.27	118
S_P4c	42.559	294	2.39	118
S_P4d	10.522	234	1.69	118

APPENDIX C

Channel input parameters

Table C.1: Channel Input Parameters

Name	Phase	Length (m)	Height (m)	Bottom width (m)	Left side-slope	Right side-slope	Slope (m/m)
C1	P1	156.1	1.6	2	1.5	1.5	0.011
C10	P1	129.9	1.6	2	1.5	1.5	0.040
C11	P1	288.8	1.6	2	1.5	1.5	0.050
C111	P1	562.0	1.6	2	1.5	1.5	0.033
C112	P1	271.4	1.6	2	1.5	1.5	0.042
C12	P1	100.9	1.6	2	1.5	1.5	0.041
C123	P1	551.8	1.6	2	1.5	1.5	0.030
C2	P1	138.7	1.6	2	1.5	1.5	0.042
C3	P1	71.7	1.6	2	1.5	1.5	0.099
C36	P1	441.9	1.6	2	1.5	1.5	0.029
C37	P1	314.8	1.6	2	1.5	1.5	0.006
C40	P1	162.5	1.6	2	1.5	1.5	0.011
C41	P1	98.0	1.6	2	1.5	1.5	0.074
C42	P1	220.1	1.6	2	1.5	1.5	0.010
C43	P1	145.9	1.6	2	1.5	1.5	0.005
C44	P1	186.1	1.6	2	1.5	1.5	0.013
C45	P1	234.7	1.6	2	1.5	1.5	0.022
C46	P1	265.3	1.6	2	1.5	1.5	0.035
C5	P1	262.6	1.6	2	1.5	1.5	0.013
C6	P1	218.7	1.6	2	1.5	1.5	0.014
C63	P1	363.5	1.6	2	1.5	1.5	0.006
C7	P1	104.3	1.6	2	1.5	1.5	0.004
C8	P1	214.7	1.6	2	1.5	1.5	0.009
C85	P1	166.2	1.6	2	1.5	1.5	0.016
C9	P1	349.9	1.6	2	1.5	1.5	0.003
C109	P2	301.5	1.5	1.5	1.5	1.5	0.043
C113	P2	210.0	1.5	1.5	1.5	1.5	0.015
C114	P2	241.5	1.5	1.5	1.5	1.5	0.015
C115	P2	240.1	1.5	1.5	1.5	1.5	0.038

Name	Phase	Length (m)	Height (m)	Bottom width (m)	Left side-slope	Right side-slope	Slope (m/m)
C116	P2	154.0	1.5	1.5	1.5	1.5	0.025
C124	P2	107.8	1.5	1.5	1.5	1.5	0.035
C125	P2	177.4	1.5	1.5	1.5	1.5	0.003
C126	P2	148.4	1.5	1.5	1.5	1.5	0.010
C13	P2	83.9	1.5	1.5	1.5	1.5	0.026
C134	P2	499.0	1.5	1.5	1.5	1.5	0.012
C14	P2	153.9	1.5	1.5	1.5	1.5	0.025
C140	P2	63.9	1.5	1.5	1.5	1.5	0.016
C142	P2	31.2	1.5	1.5	1.5	1.5	0.072
C15	P2	136.5	1.5	1.5	1.5	1.5	0.009
C16	P2	141.9	1.5	1.5	1.5	1.5	0.009
C17	P2	259.9	1.5	1.5	1.5	1.5	0.004
C18	P2	202.8	1.5	1.5	1.5	1.5	0.007
C19	P2	113.4	1.5	1.5	1.5	1.5	0.011
C20	P2	189.0	1.5	1.5	1.5	1.5	0.006
C21	P2	122.0	1.5	1.5	1.5	1.5	0.003
C22	P2	151.5	1.5	1.5	1.5	1.5	0.003
C35	P2	326.9	1.5	1.5	1.5	1.5	0.047
C38	P2	179.8	1.5	1.5	1.5	1.5	0.014
C39	P2	200.5	1.5	1.5	1.5	1.5	0.017
C4	P2	183.5	1.5	1.5	1.5	1.5	0.006
C47	P2	238.5	1.5	1.5	1.5	1.5	0.020
C51	P2	222.4	1.5	1.5	1.5	1.5	0.005
C52	P2	219.9	1.5	1.5	1.5	1.5	0.003
C53	P2	129.3	1.5	1.5	1.5	1.5	0.008
C54	P2	88.1	1.5	1.5	1.5	1.5	0.011
C55	P2	83.1	1.5	1.5	1.5	1.5	0.017
C56	P2	123.6	1.5	1.5	1.5	1.5	0.053
C60	P2	143.7	1.5	1.5	1.5	1.5	0.013
C61	P2	135.5	1.5	1.5	1.5	1.5	0.003

Name	Phase	Length (m)	Height (m)	Bottom width (m)	Left side-slope	Right side-slope	Slope (m/m)
C62	P2	95.5	1.5	1.5	1.5	1.5	0.006
C84	P2	300.2	1.5	1.5	1.5	1.5	0.068
C87	P2	148.7	1.5	1.5	1.5	1.5	0.021
C88	P2	210.0	1.5	1.5	1.5	1.5	0.036
C89	P2	287.2	1.5	1.5	1.5	1.5	0.020
C90	P2	323.4	1.5	1.5	1.5	1.5	0.034
C94	P2	177.1	1.5	1.5	1.5	1.5	0.032
C95	P2	112.2	1.5	1.5	1.5	1.5	0.061
C98	P2	223.3	1.5	1.5	1.5	1.5	0.013
C99	P2	207.3	1.5	1.5	1.5	1.5	0.053
C100	P3	200.0	1.5	1.5	1.5	1.5	0.003
C101	P3	252.3	1.5	1.5	1.5	1.5	0.003
C102	P3	266.9	1.5	1.5	1.5	1.5	0.002
C103	P3	178.7	1.5	1.5	1.5	1.5	0.001
C104	P3	235.8	1.5	1.5	1.5	1.5	0.001
C108	P3	490.8	1.5	1.5	1.5	1.5	0.039
C110	P3	705.8	1.5	1.5	1.5	1.5	0.026
C127	P3	144.6	1.5	1.5	1.5	1.5	0.017
C128	P3	118.0	1.5	1.5	1.5	1.5	0.024
C129	P3	196.0	1.5	1.5	1.5	1.5	0.025
C130	P3	133.1	1.5	1.5	1.5	1.5	0.050
C131	P3	109.3	1.5	1.5	1.5	1.5	0.034
C135	P3	178.2	1.5	1.5	1.5	1.5	0.015
C136	P3	238.5	1.5	1.5	1.5	1.5	0.001
C137	P3	212.3	1.5	1.5	1.5	1.5	0.008
C138	P3	84.4	1.5	1.5	1.5	1.5	0.029
C139	P3	94.9	1.5	1.5	1.5	1.5	0.032
C141	P3	57.2	1.5	1.5	1.5	1.5	0.016
C143	P3	26.3	1.5	1.5	1.5	1.5	0.041
C23	P3	132.1	1.5	1.5	1.5	1.5	0.028

Name	Phase	Length (m)	Height (m)	Bottom width (m)	Left side-slope	Right side-slope	Slope (m/m)
C24	P3	159.2	1.5	1.5	1.5	1.5	0.022
C25	P3	147.8	1.5	1.5	1.5	1.5	0.006
C26	P3	156.7	1.5	1.5	1.5	1.5	0.005
C27	P3	241.5	1.5	1.5	1.5	1.5	0.009
C28	P3	207.4	1.5	1.5	1.5	1.5	0.009
C29	P3	166.3	1.5	1.5	1.5	1.5	0.008
C30	P3	33.2	1.5	1.5	1.5	1.5	0.020
C31	P3	100.6	1.5	1.5	1.5	1.5	0.004
C32	P3	74.4	1.5	1.5	1.5	1.5	0.007
C33	P3	72.6	1.5	1.5	1.5	1.5	0.006
C34	P3	233.2	1.5	1.5	1.5	1.5	0.022
C48	P3	206.0	1.5	1.5	1.5	1.5	0.003
C49	P3	184.4	1.5	1.5	1.5	1.5	0.008
C64	P3	101.0	1.5	1.5	1.5	1.5	0.007
C65	P3	338.7	1.5	1.5	1.5	1.5	0.005
C66	P3	287.6	1.5	1.5	1.5	1.5	0.021
C67	P3	315.1	1.5	1.5	1.5	1.5	0.017
C68	P3	274.5	1.5	1.5	1.5	1.5	0.025
C69	P3	174.0	1.5	1.5	1.5	1.5	0.012
C70	P3	80.5	1.5	1.5	1.5	1.5	0.006
C71	P3	200.2	1.5	1.5	1.5	1.5	0.007
C83	P3	220.0	1.5	1.5	1.5	1.5	0.025
C96	P3	134.6	1.5	1.5	1.5	1.5	0.014
C97	P3	58.2	1.5	1.5	1.5	1.5	0.006
C105	P4	424.4	1.0	1.2	1.5	1.5	0.019
C106	P4	564.5	1.0	1.2	1.5	1.5	0.008
C107	P4	625.4	1.0	1.2	1.5	1.5	0.023
C117	P4	257.4	1.0	1.2	1.5	1.5	0.012
C118	P4	172.9	1.0	1.2	1.5	1.5	0.012
C119	P4	220.6	1.0	1.2	1.5	1.5	0.011

Name	Phase	Length (m)	Height (m)	Bottom width (m)	Left side-slope	Right side-slope	Slope (m/m)
C120	P4	79.2	1.0	1.2	1.5	1.5	0.009
C121	P4	176.9	1.0	1.2	1.5	1.5	0.004
C122	P4	200.9	1.0	1.2	1.5	1.5	0.013
C132	P4	54.7	1.0	1.2	1.5	1.5	0.032
C133	P4	118.6	1.0	1.2	1.5	1.5	0.044
C50	P4	597.7	1.0	1.2	1.5	1.5	0.021
C57	P4	178.3	1.0	1.2	1.5	1.5	0.026
C58	P4	172.6	1.0	1.2	1.5	1.5	0.016
C59	P4	183.9	1.0	1.2	1.5	1.5	0.012
C72	P4	161.4	1.0	1.2	1.5	1.5	0.017
C73	P4	179.0	1.0	1.2	1.5	1.5	0.014
C74	P4	59.5	1.0	1.2	1.5	1.5	0.020
C75	P4	72.9	1.0	1.2	1.5	1.5	0.018
C76	P4	162.3	1.0	1.2	1.5	1.5	0.019
C77	P4	311.7	1.0	1.2	1.5	1.5	0.023
C78	P4	309.8	1.0	1.2	1.5	1.5	0.021
C79	P4	165.1	1.0	1.2	1.5	1.5	0.008
C80	P4	321.2	1.0	1.2	1.5	1.5	0.003
C82	P4	197.4	1.0	1.2	1.5	1.5	0.021
C86	P4	246.7	1.0	1.2	1.5	1.5	0.014
C91	P4	302.2	1.0	1.2	1.5	1.5	0.010
C92	P4	329.3	1.0	1.2	1.5	1.5	0.019
C93	P4	83.6	1.0	1.2	1.5	1.5	0.026

APPENDIX D

Sub-catchment model results

Table D.1: Sub-catchment Model Results

Name	Infiltration (mm)	Runoff Depth (mm)	Runoff Volume (ML)	Peak Runoff (m³/s)	Runoff Coefficient
S_P1a	49.37	68.67	35.75	4.2	0.582
S_P1b	44.79	73.27	42.45	7.01	0.621
S_P1c	50.05	67.99	136.48	15.38	0.576
S_P1d	52.37	65.65	68.53	6.74	0.556
S_P1e	51.97	66.06	76.79	7.73	0.56
S_P2a	44.82	73.25	49.65	8.18	0.621
S_P2b	45.98	72.07	47.53	7.12	0.611
S_P2c	46.66	71.39	43.4	6.18	0.605
S_P2d	49.69	68.35	29.67	3.42	0.579
S_P2e	46.35	71.7	19.48	2.84	0.608
S_P2f	48.97	69.07	40.68	4.91	0.585
S_P2g	40.81	77.32	6.94	1.72	0.655
S_P2h	48.26	69.78	27.49	3.49	0.591
S_P3a	41.31	76.81	28.51	6.65	0.651
S_P3b	43.73	74.35	51.75	9.43	0.63
S_P3c	47.39	70.66	14.81	2	0.599
S_P3d	39.83	78.32	5.58	1.6	0.664
S_P3e	47.7	70.34	34.62	4.57	0.596
S_P4a	43.16	74.93	10.63	2.05	0.635
S_P4b	47.29	70.76	16.75	2.28	0.6
S_P4c	43.57	74.51	31.71	5.87	0.631
S_P4d	43.23	74.85	7.88	1.51	0.634

APPENDIX E

Channel model results

Table E.1: Channel Model Results

Name	Phase	Max. |Flow| (m^3/s)	Max. |Velocity| (m/s)	Max/Full Depth (%)
C5	P1	5.60	2.40	0.47
C6	P1	5.59	1.94	0.55
C7	P1	5.59	1.82	0.57
C8	P1	5.58	1.70	0.61
C9	P1	5.73	1.67	0.68
C10	P1	19.02	5.18	0.65
C11	P1	19.01	5.23	0.64
C12	P1	19.01	5.04	0.66
C40	P1	11.98	3.69	0.59
C41	P1	11.98	3.66	0.60
C42	P1	11.97	2.36	0.81
C43	P1	11.97	2.46	0.78
C44	P1	11.97	3.14	0.66
C45	P1	11.97	3.80	0.58
C46	P1	11.97	2.98	0.69
C63	P1	11.95	2.11	0.90
C85	P1	25.84	3.86	0.97
C36	P1	5.20	2.28	0.47
C37	P1	5.20	1.85	0.53
C111	P1	5.97	3.51	0.37
C112	P1	5.97	3.70	0.35
C123	P1	9.40	3.74	0.49
C1	P1	3.29	2.29	0.32
C2	P1	3.28	3.47	0.23
C3	P1	3.28	4.17	0.20
C13	P2	6.53	3.24	0.51
C14	P2	6.53	2.61	0.59
C15	P2	6.53	2.20	0.66
C16	P2	6.52	1.86	0.74

Name	Phase	Max. |Flow| (m³/s)	Max. |Velocity| (m/s)	Max/Full Depth (%)
C17	P2	6.52	1.74	0.77
C18	P2	6.52	2.14	0.67
C19	P2	6.51	2.14	0.67
C20	P2	6.51	1.68	0.79
C21	P2	6.50	1.48	0.85
C22	P2	6.49	1.96	0.74
C35	P2	13.41	4.45	0.67
C60	P2	4.87	1.70	0.65
C61	P2	4.87	1.49	0.71
C62	P2	4.86	2.18	0.61
C84	P2	13.91	3.58	0.79
C47	P2	2.67	2.43	0.35
C89	P2	3.85	2.78	0.39
C90	P2	3.84	3.08	0.36
C94	P2	3.84	2.76	0.39
C98	P2	2.74	2.43	0.33
C99	P2	2.73	2.69	0.37
C113	P2	4.89	2.41	0.51
C114	P2	4.88	2.83	0.46
C115	P2	4.88	3.20	0.42
C116	P2	4.87	2.61	0.48
C56	P2	5.63	4.05	0.39
C109	P2	4.22	2.58	0.44
C39	P2	2.67	2.44	0.33
C124	P2	2.67	2.57	0.31
C125	P2	2.25	1.31	0.45
C126	P2	2.25	1.79	0.36
C38	P2	2.24	1.97	0.34
C87	P2	1.42	2.11	0.22
C88	P2	1.42	2.55	0.19

Name	Phase	Max. |Flow| (m^3/s)	Max. |Velocity| (m/s)	Max/Full Depth (%)
C95	P2	1.42	2.84	0.18
C134	P2	3.85	2.17	0.46
C140	P2	2.24	2.04	0.33
C142	P2	7.42	4.88	0.42
C4	P2	5.63	1.89	0.66
C53	P2	5.63	2.14	0.61
C54	P2	5.63	2.99	0.48
C51	P2	5.65	1.53	0.77
C55	P2	5.64	2.17	0.61
C52	P2	5.64	1.84	0.68
C23	P3	5.49	3.08	0.47
C24	P3	5.49	2.31	0.57
C25	P3	5.47	1.72	0.69
C26	P3	5.46	1.82	0.67
C27	P3	5.46	2.10	0.61
C28	P3	5.44	2.03	0.62
C29	P3	5.43	2.33	0.56
C30	P3	5.43	2.01	0.62
C31	P3	5.43	1.72	0.69
C32	P3	5.43	1.91	0.64
C33	P3	5.42	2.23	0.6
C34	P3	6.96	2.83	0.58
C65	P3	7.55	2.25	0.72
C66	P3	7.53	3.00	0.59
C67	P3	7.53	3.10	0.58
C68	P3	7.52	2.90	0.61
C69	P3	7.51	2.25	0.72
C70	P3	7.50	2.06	0.76
C71	P3	7.49	2.55	0.68
C83	P3	9.08	3.59	0.59

Name	Phase	Max. |Flow| (m³/s)	Max. |Velocity| (m/s)	Max/Full Depth (%)
C100	P3	0.00	0.00	0.00
C101	P3	0.00	0.00	0.00
C102	P3	0.00	0.00	0.00
C103	P3	0.00	0.00	0.00
C104	P3	0.00	0.00	0.00
C108	P3	1.57	1.74	0.28
C110	P3	0.00	0.00	0.19
C64	P3	7.58	1.90	0.81
C96	P3	0.00	0.00	0.12
C97	P3	3.60	1.98	0.47
C127	P3	3.59	2.52	0.40
C128	P3	3.59	2.67	0.38
C129	P3	3.59	3.02	0.35
C130	P3	3.59	3.27	0.33
C131	P3	3.59	3.03	0.35
C48	P3	1.33	1.00	0.38
C49	P3	1.32	1.49	0.28
C135	P3	1.32	1.73	0.25
C136	P3	1.57	0.92	0.45
C137	P3	1.57	1.71	0.28
C138	P3	1.57	2.37	0.22
C139	P3	3.59	2.64	0.38
C141	P3	1.32	1.76	0.24
C143	P3	4.58	3.48	0.37
C72	P4	1.79	1.91	0.49
C73	P4	1.79	1.97	0.48
C74	P4	1.79	2.07	0.46
C75	P4	1.79	2.03	0.46
C76	P4	1.79	2.13	0.45
C77	P4	1.79	2.20	0.44

Name	Phase	Max. |Flow| (m³/s)	Max. |Velocity| (m/s)	Max/Full Depth (%)
C78	P4	1.78	1.86	0.5
C79	P4	1.78	1.41	0.74
C80	P4	1.77	1.19	0.67
C82	P4	1.77	1.23	0.67
C50	P4	1.20	2.01	0.38
C91	P4	1.21	1.58	0.42
C92	P4	1.21	1.93	0.36
C105	P4	4.71	2.45	0.86
C106	P4	4.64	2.20	0.86
C107	P4	4.62	3.27	0.65
C57	P4	1.65	1.97	0.45
C58	P4	1.64	1.80	0.48
C59	P4	1.64	1.73	0.49
C117	P4	1.64	1.73	0.49
C118	P4	1.63	1.68	0.5
C119	P4	1.63	1.59	0.52
C120	P4	1.62	1.41	0.59
C121	P4	1.62	0.98	0.73
C122	P4	1.65	1.81	0.48
C93	P4	1.20	2.12	0.33
C132	P4	1.20	2.33	0.31
C133	P4	1.20	2.20	0.33
C86	P4	1.17	1.05	0.55

APPENDIX F

Water use memo for dust suppression water use

TECHNICAL MEMORANDUM

DATE 10 February 2022

Project No. 19127204_Mem17_Rev1

TO Delia Mare, Golder Associates Africa (Pty) Ltd.

CC

FROM Nivi Juggath

EMAIL njuggath@golder.co.za

SUMMARY OF DUST SUPPRESSION REQUIREMENTS FOR EXXARO BELFAST: BIP AND BEP

1.0 INTRODUCTION

For the new BEP project, Exxaro will be submitting a new Water Use Licence (WUL) to the Department of Water and Sanitation (DWS). One of the water uses to be applied for is dust suppression (in terms of Section 22(g) water uses) for the BEP operation.

This document provides a summary of the current dust suppression usage at the BIP area and a discussion of what is required for BEP.

2.0 CURRENT BIP AUTHORISATION

The BIP operation is currently authorised (WUL 05/X11D/ABCFGIJ/2613 dated 26 September 2014) to use the following volumes of water for dust suppression:

- Dust suppression Disposal 126 m^3/day
- Dust suppression Disposal 126 m^3/day
- Dust suppression Disposal 30 m^3/day

Total current authorised - 282 m^3/day

3.0 CURRENT BIP USAGE

BIP Dust suppression is currently supplied to the following areas:

- Primary and secondary crusher dust suppression.
- Link haul road.
- ME haul road
- Discard link road.
- Discard bin road.
- Tip road.
- ROM stockpile.

Water from the BIP pits is used for dust suppression at the pits and any excess water is dewatered to Dam 2 and is used for dust suppression at various areas as indicated above.

Initial BIP water demands are presented in Table 1. The total dust suppression volume for roads as stated here is 262 m^3/d (excluding Plant wash water requirement and discard dump dust suppression requirement) and specified in the GCS report, 2019, is 200 m^3/d for the RoM stockpile.

The measured 2020 – 2021 volumes range from 500 m^3/d to 1 200 m^3/d (as provided by BIP for the water balance consolidation) where the maximum amount actually being applied for roads is 832 m^3/d.

A range of dust suppression rates increasing during Life of Mine (LoM) from 500 m^3/d to 2 000 m^3/d has been applied in the water balance model (this allows for the BIP and BEP usage until LOM). The increase is to allow for increasing stockpile, spoils and rehabilitated area as the mining progresses within both BIP and BEP mining areas.

Table 1: Current BIP Process water demands

Use	Current BIP rate [m^3/d]	Start date	End date
Primary Crusher dust suppression	230	July 2016	LoM
Mining Haul Roads dust suppression	72	Jan 2017	LoM
In Pit Haul roads dust suppression	150	Jan 2017	LoM
Discards dust suppression	120	Jan 2017	LoM
Washbay	18	Jan 2017	LoM
Dust suppression roads	40	Jan 2017	LoM

4.0 BEP OPENCAST USAGE

The LoM plan for the BIP and BEP opencast mining as well as underground mining follows each other with short overlaps of the years. Below is the LoM dates for the respective mining operation:

- 2020 – 2031: BIP East and West;
- 2031 – 2039: BEP East and West; and
- 2037 – 2042: BEP underground.

Additional facilities requiring dust suppression will be the new Discard Facility as well as backfilled and rehabilitated pits as per mining progression. The haul roads, Run of Mine (RoM) maximum stockpile footprint and the product area footprint is not expected to change.

Therefore, the maximum total dust suppression usage of 2 000 m^3/d has been applied in the model for LoM usage (BIP and BEP included). The additional dust suppression usage due to the BEP opencast operation is 1 168 m^3/d.

5.0 BEP UNDERGROUND

Dust suppression requirement for the RoM stockpile area and the haul roads is sourced from the Flood Protection and Dewatering Dam, BEP PCD as well as the Process Water Tank. All internal shaft roads will be dust treated.

The Flood Protection and Dewatering Dam supplies the underground mining operations with the water required for dust suppression and for the continuous miners of 150 m^3/d. The Flood Protection Dam also supplies the conveyor transfer stations wash water and dust suppression requirements. The BEP PCD supplies the shaft area with dust suppression of 20 m^3/d and the Process Water Tank supplies the BEP underground wash water requirements of 30 m^3/d and dust suppression make-up of 30 m^3/d.

The total BEP underground requirement is 230 m^3/d.

6.0 CONCLUSION

Based on the discussion in this document, the maximum additional dust suppression volume that is required to be applied for is as part of the BEP WULA is as follow:

- BEP open cast – 1 168 m^3/day; and
- BEP underground – 230 m^3/day.

Giving a total of 1 398 m^3/d to be authorised for dust suppression use for BEP.

However, in order to bridge the deficit of the dust suppression volume authorised in the BIP WUL an additional volume of 550 m^3/d should be included in the authorisation volume. Therefore, Exxaro should apply for a total dust suppression volume of 1 948 m^3/day as part of the BEP WULA (unless a separate WULA is applied for the BIP area).

Golder Associates Africa (Pty) Ltd.

Delia Maré
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https://golderassociates.sharepoint.com/sites/112768/project files/7 correspondence/memo/17 dust suppression/19127204_mem0017_dustsuppressionvolumes_bip_bep_final_100222.docx

APPENDIX G

Water use memo for mine dewatering water use

TECHNICAL MEMORANDUM

DATE 10 February 2022 **Project No.** 19127204_Mem018

TO Delia Mare, Golder Associates Africa (Pty) Ltd.

CC

FROM Nivi Juggath **EMAIL** njuggath@golder.co.za

EXXARO: BEFAST EXPANSION PROJECT: DEWATERING OPENCAST PIT VOLUMES FOR WATER USE LICENCE AUTHORISATION

1.0 INTRODUCTION

For the new BEP project, Exxaro will be submitting a new Water Use Licence (WUL) to the Department of Water and Sanitation (DWS). One of the water uses to be applied for is dewatering from the BEP openpit and underground mining operations.

2.0 BEP OPENCAST DEWATERING

The operation philosophy of the open cast pit generally adopted / accepted by Exxaro is to size the pumping system to dewater the pit for the for the 5-year rainfall event (67 mm). The average workings, prestrip, spoils, levelled and topsoiled areas will be used in calculating the 5-year runoff volume for each pit.

For higher than the 5-year rainfall event, the water volume in the pit will not be allowed to increase greater than 50 000 m^3. Based this philosophy, the maximum dewatering rate applied to the BEP opencast workings is shown in Table 1. The maximum daily dewatering volume required to be authorised is 10 300 m^3/d.

Table 1: Maximum dewatering pumping rates

Pits number	Opencast void	Pit workings (m^3/d)	Backfilled spoils (m^3/d)	Total (m^3/d)
Pit 8	West	1 500	800	2 300
Pit 9	West	1 500	800	2 300
Pit 10	East	1 500	400	1 900
Pit 11	East	1 500	400	1 900
Pit 12	East	1 500	400	1 900
Total		**7 500**	**2 800**	**10 300**

3.0 BEP UNDERGROUND

The maximum dewatering rate applied for the underground BEP operation is 1 800 m^3/d.

4.0 CONCLUSION

Based on the discussion in this document, the maximum daily dewatering volume to be applied for as part of the BEP WULA is as follow:

- BEP open cast – 10 300 m^3/day
- BEP underground – 1 800 m^3/day

Giving a maximum of 12 100 m^3/d to be authorised for dewatering at BEP.

Golder Associates Africa (Pty) Ltd.

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APPENDIX H

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