Dorstfontein East Mine – Surface Water Specialist Study

Report Prepared for

Exxaro Coal (Pty) Ltd

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Report Prepared by

srk consulting

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Executive Summary

SRK Consulting Limited, (SRK) has been appointed by Exxaro Coal (Pty) Ltd (Exxaro) to undertake the surface water specialist study to support the authorisation application. The Dorstfontein East Mine (DEM) is located to the east of Kriel in the Mpumalanga Province of South Africa.

Principal objectives

The objectives of the surface water study are to conduct a:

- Stormwater management plan.
- Water balance.
- Baseline study.
- Impacts assessment.

Work programme

The work programme included:

- Site visit in June 2016;
- Updating the surface water hydrology for the site;
- Determination of the 1:100 and 1:50-year flood lines for unnamed tributary;
- Preparation of water balance scenarios;
- Sizing of clean and dirty water stormwater channels.

Conclusions and Recommendations

The surface water specialist study provides an indication of the steps and processes required in order to meet the Regulation 704 criteria in terms of the National Water Act (Act No. 36 of 1998). These include the:

- Separation of clean and dirty water streams and the release and containment of each stream respectively.
- The impact of Mean Annual Runoff (MAR) changes on the local and quaternary catchment level.
- The potential impact on infrastructure by the 1:100-year flood event; and
- Operating water balance for the pit extension

The pit extension requires a clean water cut off canal to the south west to prevent the situation of surface runoff from entering the pit extension during rainfall events. The canal will discharge the water to the west and east as it straddles a high point in the middle of the canal.

The nature of a pit excavation results in a reduced likelihood of dirty water, generated at the pit extension, from flowing into the environment. A sump has been indicated for the pit extension as a means of creating a point from which to pump the water out and to a suitable containment and treatment location. The pit extension means that the current infrastructure need only be extended in order to facilitate the requirement set out above.

The pit extension will affect the MAR by approximately 5% on a local scale and by 0.2% on a quaternary scale.

The pipeline extension between the DEM and Dorstfontein West Mine (DWM) has been conceptually drawn at a distance of no closer than 100 m from a water course where possible. However, due to the topography of the area being relatively flat, the 1:100-year flood line exceeds the 100 m buffer. This is primarily at the pipeline origin point at DWM, where the pipeline crosses the conveyor section, travelling east, before turning north for a distance. It is recommended that the pipeline be rerouted to skirt the current office area as much as possible, thereby avoiding the area of inundation. A second point of interest in the floodline results is approximately midway between DEM and DWM. The pipeline crosses a defined watercourse. The 1:100-year floodline extent has been calculated for this position. The infrastructure required for the pipeline should be located outside of this zone as far as possible, with the pipeline crossing above the water course. Exact design levels were not considered in this investigation.

The impact assessment results are provided below.

Pipeline

Nature of the impact		Significance		Mitigation Measures	Significance		degree of mitigation (%)
Pre-Construction Phase							
Increased solids transport due to clearing/grubbing	-	**32**	**Moderate**	Construct in dry season and install silt bunds	**4**	**Low**	87.5
Increased runoff requiring retention on site	-	**32**	**Moderate**	Limit footprint and install retardation structures	**4**	**Low**	87.5
Accidental hazardous substance spillages during construction phase	-	**32**	**Moderate**	Operate using best practises	**4**	**Low**	87.5
Construction Phase							
Impeding flow while under construction	-	**48**	**Moderate**	Construct in dry season. Protect with gabions & mattresses. Remove litter & debris to stop blocking.	**6**	**Low**	87.5
Accidental spillages of hazardous substances from construction vehicles used during construction of the crossings.	-	**44**	**Moderate**	Control site access; Control refuelling areas; Restrict vehicular access to stream; Clean spillages immediately they occur and remediate as necessary.	**6**	**Low**	86.4
Contamination of runoff by poor materials/waste handling practices	-	**44**	**Moderate**	Park vehicles on hard standing with sump; Store hydrocarbons and other contaminants responsibly; Bund fuel storage areas; Store and dispose of waste responsibly.	**6**	**Low**	86.4
Debris from poor handling of materials and/or waste blocking watercourse	-	**8**	**Low**	Operate using best practises in separating waste streams and disposing of the waste correctly.	**6**	**Low**	25.0
Operational Phase							
Debris from upstream blocking watercourse at pipes/canals/culverts	-	**22**	**Low**	Operate using best practises in separating waste streams and disposing of the waste correctly.	**4**	**Low**	81.8
Closure/Rehabilitation Phase							
Debris blocking watercourses if road continues to be used by the community.	-	**8**	**Low**	Community needs to remove litter & debris to prevent blocking.	**8**	**Low**	0.0

Impeding flow while under demolition	-	8	Low		8	Low	0.0
Increased turbidity due to demolition.	-	8	Low	Demolish during dry season, limit the disturbed footprint.	8	Low	0.0
Accidental spillages of hazardous substances from construction vehicles used during demolition.	-	8	Low	Operate using best practises.	8	Low	0.0
Post-Closure Phase							
Flooding caused by extreme rainfall event.	-	16	Low	Warning signs to discourage crossing if pipes/culverts are submerged.	10	Low	37.5
Damage to the crossings themselves.	-	14	Low	Regular periodic inspections by successor in title and remediation as necessary.	7	Low	50.0

Pit Extension

Nature of the impact		Significance		Mitigation Measures	Significance		degree of mitigation (%)
Pre-Construction Phase							
Water runoff requiring retention on site	-	32	Moderate	Construct in dry season;	4	Low	87.5
				Limit footprint.	4	Low	87.5
Accidental hazardous substance spillages during construction phase	-	32	Moderate	Operate using best practises by storing hazardous substances in an adequately sized bunded area, with appropriate safety equipment.	4	Low	87.5
Construction Phase							
Impeding flow while under construction	-	30	Moderate	Construct in dry season Protect with gabions & mattresses. Remove litter & debris to stop blocking.	6	Low	80.0
Accidental spillages of hazardous substances from construction vehicles used during construction of the crossings.	-	44	Moderate	Control site access. Control refuelling areas. Restrict vehicular access to stream. Clean spillages immediately they occur and remediate as necessary.	6	Low	86.4
Contamination of runoff by poor materials/waste handling practices.	-	44	Moderate	Park vehicles on hard standing with sump. Store hydrocarbons and other contaminants responsibly. Bund fuel storage areas. Store and dispose of waste responsibly.	6	Low	86.4
Separate clean and dirty water streams	-	70	High	Construct diversion drains timeously.	40	Moderate	42.9
Operational Phase							
Pump failure will result in dirty water accumulation in the pit.	-	12	Low	Undertake regular structural inspections of pumps and pipes exiting pit. Ensure groundwater investigation is done to understand groundwater levels.	8	Low	33.3
Dirty water entering wetland.	-	65	High		55	Moderate	15.4
High rate of ground water ingress.	-	11	Low		8	Low	33.3
Closure/Rehabilitation Phase							
Pit extension reaching capacity and overflowing to the environment.	-	16	Low	Understand groundwater in the area.	8	Low	0.0
Post-Closure Phase							

Water quality changes downstream.	-	**52**	**Moderate**	Maintain stormwater collection system and monitoring.	**44**	**Moderate**	15.4

Extension of diversion canals

Nature of the impact		Significance		Mitigation Measures	Significance		degree of mitigation (%)
Pre-Construction Phase							
Dirty water runoff requiring retention on site.	-	**32**	**Moderate**	Construct in dry season.	**4**	**Low**	87.5
				Limit footprint.	**4**	**Low**	87.5
Accidental hazardous substance spillages during construction phase.	-	**32**	**Moderate**	Operate using best practises.	**4**	**Low**	87.5
Construction Phase							
Impeding flow while under construction.	-	**30**	**Moderate**	Construct in dry season Protect with gabions & mattresses and Remove litter & debris to stop blocking.	**6**	**Low**	80.0
Contamination of runoff by spillages.	-	**44**	**Moderate**	Control site access. Control refuelling areas. Restrict vehicular access to stream. Clean spillages immediately they occur and remediate as necessary.	**6**	**Low**	86.4
Contamination of runoff by poor materials/waste handling practices.	-	**44**	**Moderate**	Park vehicles on hard standing with sump. Store hydrocarbons and other contaminants responsibly. Bund fuel storage areas. Store and dispose of waste responsibly.	**6**	**Low**	86.4
Operational Phase							
Debris from upstream blocking watercourse at pipes/canals/culverts.	-	**16**	**Low**	Operate using best practises.	**8**	**Low**	50.0
Closure/Rehabilitation Phase							
Debris from upstream blocking watercourse at pipes/canals/culverts.	-	**8**	**Low**	Community needs to remove litter & debris to prevent blocking.	**4**	**Low**	50.0
Post-Closure Phase							
Water quality changes downstream.	-	**52**	**Moderate**	Warning signs to discourage crossing if pipes/culverts are submerged.	**22**	**Low**	57.7

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List of Abbreviations

DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EMP	Environmental Management Plan
MRPDA	Mineral and Petroleum Resources Development Act
NEMA	National Environmental Management Act
NWA	National Water Act
PCD	Pollution Control Dam
SWD	Storm Water Dam
SWMP	Storm Water Management Plan
WMA	Water Management Area
WULA	Water Use Licence Application

1 Introduction

SRK Consulting was appointment by Exxaro Coal (Pty) Ltd to undertake environmental studies and associated authorisation application processes at the Dorstfontein East Mine (DEM). The DEM is located to the east of Kriel in the Mpumalanga Province of South Africa.

Dorstfontein Coal Mines (Pty) Ltd (DCM) is a joint venture between Exxaro Coal Central (Pty) (Ltd) (Exxaro) and Mmakau Mining (Pty) Ltd. DCM plans to expand the opencast mining of Pit 1 at their Dorstfontein East Mine in a North Western direction of approximately 85 Hectares. This will ensure a constant Run of Mine (RoM) of 3 mega tonnes per annum (mtpa). In addition to this, DCM would like to construct a pipeline from the Dorstfontein West Mine to the Dorstfontein East Mine of approximately 11 kilometres (km) for the transportation of process water which will be recycled.

DCM holds 2066 Hectares of coal rights and 1230 Hectares of surface rights, which make up the DCM operations. All of these farms lie within the eMalahleni Local Municipality and Nkangala District Municipality. The proposed project is located near the town of Ga-Nala and approximately 30 km northwest of Bethal and 25 km north east of Secunda.

Opencast techniques are currently employed to mine the DCM reserves. The remainder of the deeper reserves will be mined by conventional mechanised underground bord and pillar mining methods. Opencast mining activities currently targets the No. 2 and 4 seam lower reserves, however all seams thicker than 0.5 m are considered during mining operations, where treatment of coal seams only occurs where studies show a negative value add component on the production and beneficiation costs incurred (Exxaro Coal Central (Pty) Ltd B, 2017).

Initial mining started with the removal of the top soil. Excavated material is placed on pre-determined dumps. Waste from the mining will be backfilled into the voids post mining, during rehabilitation.

Originally the tonnage mined at DCM was set at 300 000 tonnes per month. This target was achieved. The current target for the Pit 1 expansion project is aimed at 180 000 tonnes per month. The Life of Mine for the opencast operations is 7 years, whereby underground mining will commence on the remainder of the coal reserves.

DCM plan to expand the opencast mining of Pit 1 at their Dorstfontein East mine in a North Western direction of approximately 85 Ha, ensuring a constant RoM of 3 mtpa. In addition to this, DCM would like to construct a pipeline from the Dorstfontein West Mine to the Dorstfontein East Mine of approximately 11 km for the transportation of process water, which will be recycled. The exploitation of the Pit 1 expansion area will run concurrently with the DCM operations.

The additional environmental studies and authorisation applications are required for the extension of the East Pit (Pit 1). The extension will be in the order of 0.85 km^2 towards the west. A new water pipeline from Dorstfontein West to Dorstfontein East, around the pit extension, will also require authorisation.

This report outlines the stormwater and water balance for the pit but does not include the site wide water balance.

2 Scope of Work

The scope of work for the investigation at DEM included the following:

- Stormwater management plan
  - Determination of catchment characteristics (catchment boundaries, water bodies, slope and drainage directions).
  - Determination of impact on Mean Annual Runoff (MAR).

- Determination of storm water flows (m^3/s) and volumes (m^3) for the 1:50 and the 1:100-year return period event for the clean and dirty water areas.
- Determination of longer duration storm events for the purposes of storm water containment.
- Delineation of clean and dirty water areas on a drawing.
- Confirmation of the indicated placement of berms, channels and pollution control dams (PCD) to divert clean water around the dirty water areas as well as infrastructure required for the dirty water system, in line with Regulation 704 of the National Water Act (Act No. 36 of 1998) (NWA).
- Development of a plan/map for water diversion berms and conveyances for infrastructure.
- Layout of the stormwater management plan.
- Floodlines for the 1:50 and the 1:100 peak flow events for any rivers near proposed infrastructure.

- Water balance
  - Annual average, wet and dry scenarios.
  - Determination of water requirements for any excess water that will need to be absorbed into the mine.
- Baseline study
  - Collect the surface topography maps and survey from the client and collect maps from the authorities, as necessary.
  - Site visit and description of water bodies.
  - Maps from the hydrology study will be used to indicate the catchment areas and any strategic points.
  - The Mean Annual Runoff (MAR), peak flow rates and volumes will be estimated for these catchments using WR2005 data.
- Impacts assessment
  - All surface water impacts will be described and mitigation measures will then be proposed as normally required for the Environmental Impact Assessment/Environmental Management Plan (EIA/EMP), for the construction, operation, decommissioning and post closure phases.
  - During this phase, refinements will be made to the stormwater management plan to improve the mitigation measures.
  - The water balance will assist this phase by quantifying impacts and effects of the mitigation measures (where data are available).

3 Study Area

3.1 Location

The DEM is located east of the town of Kriel, in the Mpumalanga Province of South Africa (26°11'35.6"S 29°21'14.8"E). The study area focuses on the DEM, specifically the East Pit extension and the new water pipeline route. The location of the mine relative to the town of Kriel and its positioning in South Africa is shown in Figure 3-1. A layout of the proposed site infrastructure is also indicated.

3.2 Topography

The catchment consists of moderately hilly to flat areas. The Dorstfontein West Mine (DWM) is bordered by a small stream in the south, flowing in a westerly direction, away from the DWM. No other significant and defined water courses are to be found in close proximity to DWM and DEM.

3.3 General description of the Upper Olifants Water Management Area

Dorstfontein East Mine is situated in Quaternary catchments B11B and B11D in the Upper Olifants Water Management Area (WMA) which is situated in the north eastern part of South Africa, in the Mpumalanga Province. The Olifants River originates east of the mine flows in a northerly direction. The Steenkoolspruit is located west of the mine. These two rivers converge north of the mine, from which point the river is called the Olifants River.

Climate over the Upper Olifants WMA is temperate with frost occurring in winter, and is generally semi-arid. Mean Annual Precipitation (MAP) ranges from 700 mm in the west to >1200 mm in the east, and mainly occurs as summer thunder storms. The potential evaporation, which can be as high as 1 900 mm per year, is well in excess of the rainfall. Vegetation is mainly grassland, with sparse bushveld in patches. The topography is relatively flat with no distinct features. Hilly terrain occurs to the east.

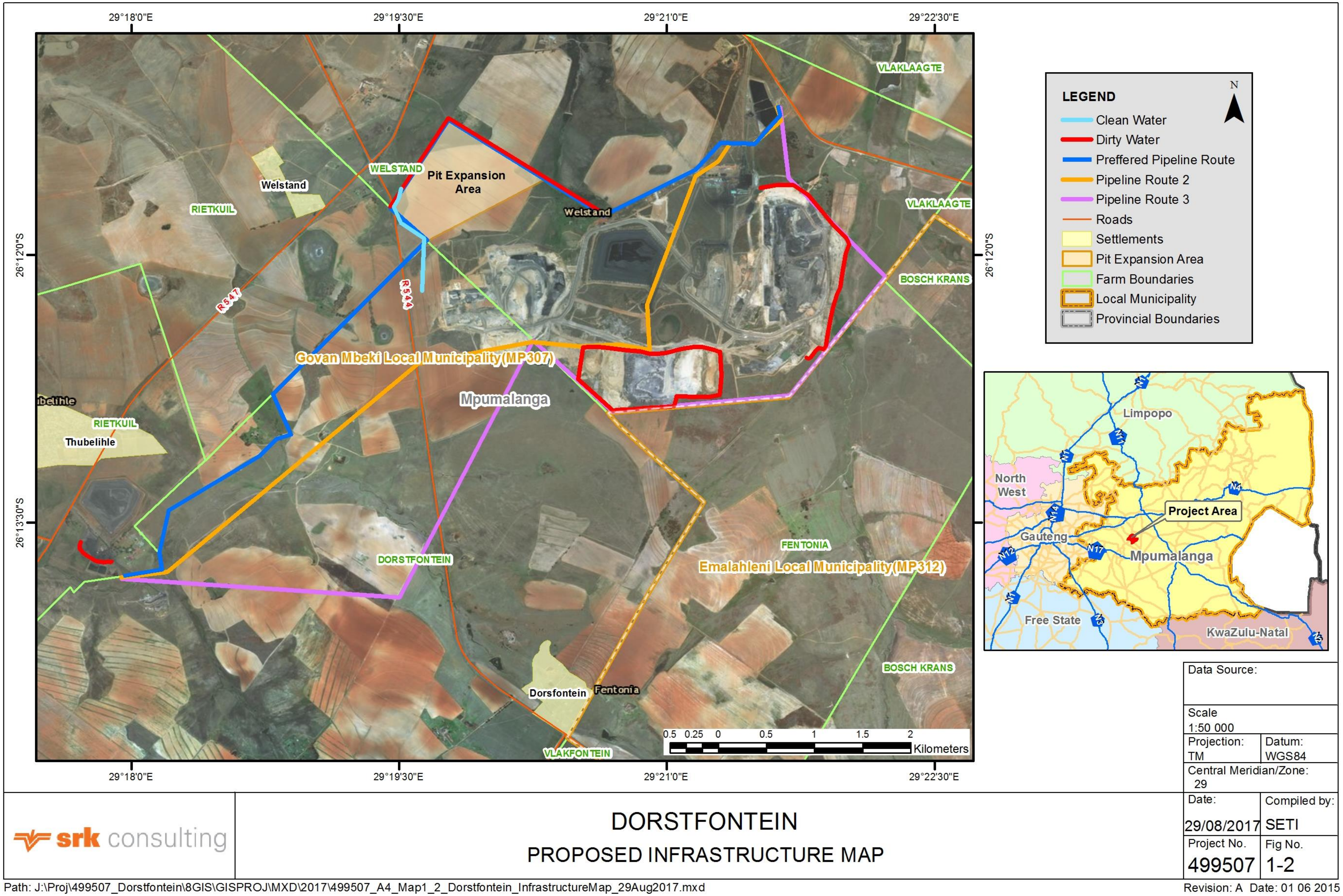

Figure 3-1: Locality map of Dorstfontein East Mine

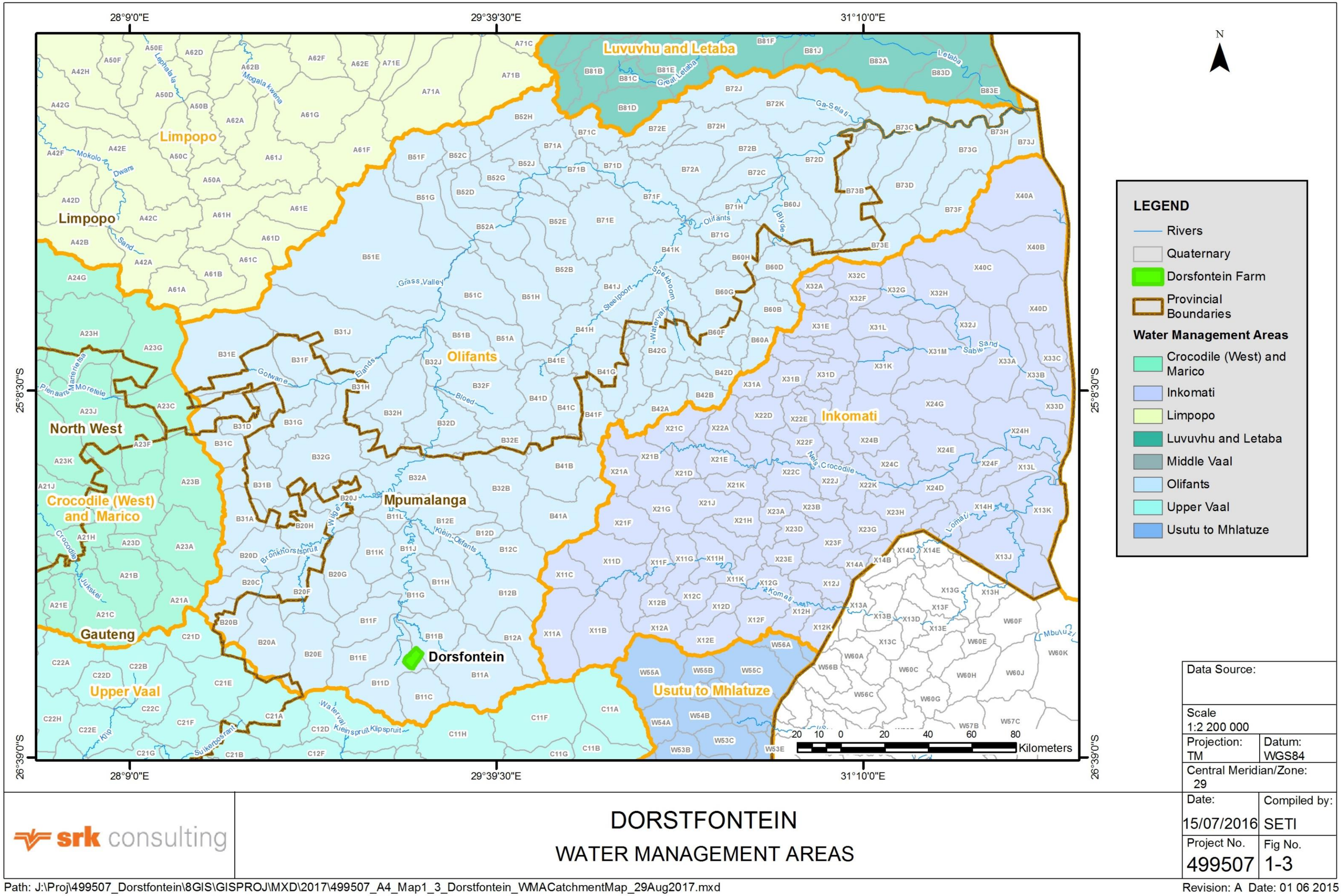

Figure 3-2: Location of Dorstfontein within Olifants River Catchment WMA 4

4 Climate

The rainfall station selected for use at DEM is 0478406_W (Kriel (POL)) for the period 1900 to 2000. The 0478406_W station was selected based on its proximity to the site of interest, its altitude relative to the site of interest as well as the record length available and the reliability of the recorded data. Patched data is included in this record length. A summary of the recorded rainfall is shown in Table 4-1. Table 4-2 shows the design rainfall calculated using the Kriel rainfall station daily data.

Table 4-1: Summary of rainfall data from the Kriel (0478406_W) rainfall station

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Percentile	10%	63.1	33.8	32.5	6.0	0.0	0.0	0.0	0.0	1.5	27.1	58.5	61.4	531.4
	30%	91.8	63.3	54.4	17.9	2.1	0.0	0.0	0.0	7.0	48.3	84.5	88.7	605.5
	50%	115.5	80.3	70.3	32.5	11.4	0.5	0.0	0.9	15.7	80.3	112.5	110.2	686.5
	70%	137.1	104.4	93.2	52.6	22.2	3.2	3.5	12.0	26.6	102.5	142.7	129.6	784.4
	90%	178.5	142.6	127.6	85.3	37.4	20.0	20.4	30.0	63.1	134.9	188.9	189.8	954.8
	98%	220.7	275.6	178.5	125.4	70.2	61.6	60.4	50.2	108.7	187.2	298.3	242.5	1,058.2
Minimum		18.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0	5.3	28.4	25.6	307.2
Average		119.5	91.4	77.3	40.1	18.0	6.4	6.7	9.5	24.3	79.5	121.7	116.6	710.9
Maximum		231.6	317.4	235.5	144.1	184.1	78.3	67.8	66.6	179.7	204.4	458.0	278.2	1,382.3

Table 4-2: Various rainfall depths for return periods from 1:2 to 1:200 year – Kriel rainfall station (0478406_W)

	Return period						
	2	5	10	20	50	100	200
5 m	9	11	14	16	19	21	23
10 m	12	17	20	23	27	30	34
15 m	15	21	24	28	34	38	42
30 m	20	26	31	36	43	48	54
45 m	23	30	36	41	49	55	62
1 h	25	33	40	46	54	61	69
1.5 h	29	39	46	53	63	71	79
2 h	32	43	50	58	69	78	87
4 h	37	50	59	69	82	92	103
6 h	41	55	65	76	90	101	113
8 h	44	59	70	81	96	108	121
10 h	46	62	74	85	101	114	128
12 h	49	65	77	89	106	119	133
16 h	52	70	82	95	113	128	143
20 h	55	73	87	100	119	134	150
24 h	57	77	91	105	125	140	157
1 d	50	66	78	91	108	122	136

	Return period						
	2	5	10	20	50	100	200
2 d	60	81	96	111	132	149	166
3 d	68	91	108	125	148	167	187
4 d	74	99	117	135	161	181	202
5 d	78	105	124	144	171	192	215
6 d	82	111	131	151	180	202	226
7 d	86	115	136	158	187	211	236

Further investigation into rainfall characteristics in the vicinity of the DEM for the summer, rainfall season indicate the 10 wettest seasons for the period 1900 to 2000, as this data was freely available.

Table 4-3: 10 wettest years – Kriel (0478406_W) rainfall station

The wettest years during the years 1900 to 2000 were	Year	Total Rainfall for 6 months (mm)
Wettest Year	1987	1,032.9
2nd wettest	1989	921.3
3rd wettest	1986	865
4th wettest	1955	826
5th wettest	1990	812.4
6th wettest	1997	785.7
7th wettest	1988	773.3
8th wettest	1917	743
9th wettest	1939	732
10th wettest	1909	724.1

The evaporation data is sourced from the quaternary catchment database (B11B) for the 50 year period (1950-1999). The Mean Annual Evaporation (MAE) for the quaternary catchment is 1,541 mm, which greatly exceeds the MAP of the catchment.

5 Stormwater Management Plan

The Department of Water and Sanitation (DWS) (previously known as the Department of Water Affairs and Forestry (DWAF) and then the Department of Water Affairs (DWA)), has produced a range of Best Practice Guidelines (BPGs) for the mining sector with each BPG having particular application to different aspects of the mining process and to different components of the water management system at a mine. BPG G1 (DWAF, 2006) provides four primary principles that need to be applied in the development and implementation of a Storm Water Management Plan (SWMP). The first two principles capture the clean and dirty water separation requirements of Regulation 704. The four principles are as follows:

- Clean water must be kept clean and be routed to a natural watercourse by a system separate from the dirty water system while preventing or minimising the risk of spillage of clean water into dirty water systems. This will limit the reduction in water flow to the receiving water environment/catchment (loss of water to the catchment) and thus increase the water available in the water resource to other users. **Error! Reference source not found.** shows the clean and dirty water areas considered in this SWMP and Regulation 704 audit.
- Dirty water must be collected and contained in a system separate from the clean water system and the risk of spillage or seepage into clean water systems must be minimised. The containment of dirty or polluted water will minimize the impact on the surrounding water environment.
- The SWMP must be sustainable over the life cycle of the site and over different hydrological cycles and must incorporate principles of risk management. Portions of the SWMP, such as those associated with waste management facilities, may have to remain after site closure since management is required until such time that the impact is considered negligible and the risk no longer exists.
- The statutory requirements of various regulatory agencies and the interests of stakeholders must be considered and incorporated.

Based on these principles and the guidelines in BPG G1, a framework for LDM's SWMP was developed.

5.1 Mean annual runoff

The 0.85 km^2 open cast pit extension will reduce runoff generated within the immediate catchment. The catchment in which the pit extension is located is 17.4 km^2. In addition, the DEM is situated in quaternary catchment B11B, which is 435 km^2 (see Figure 3-2 above). The catchments are shown in Figure 5-1.

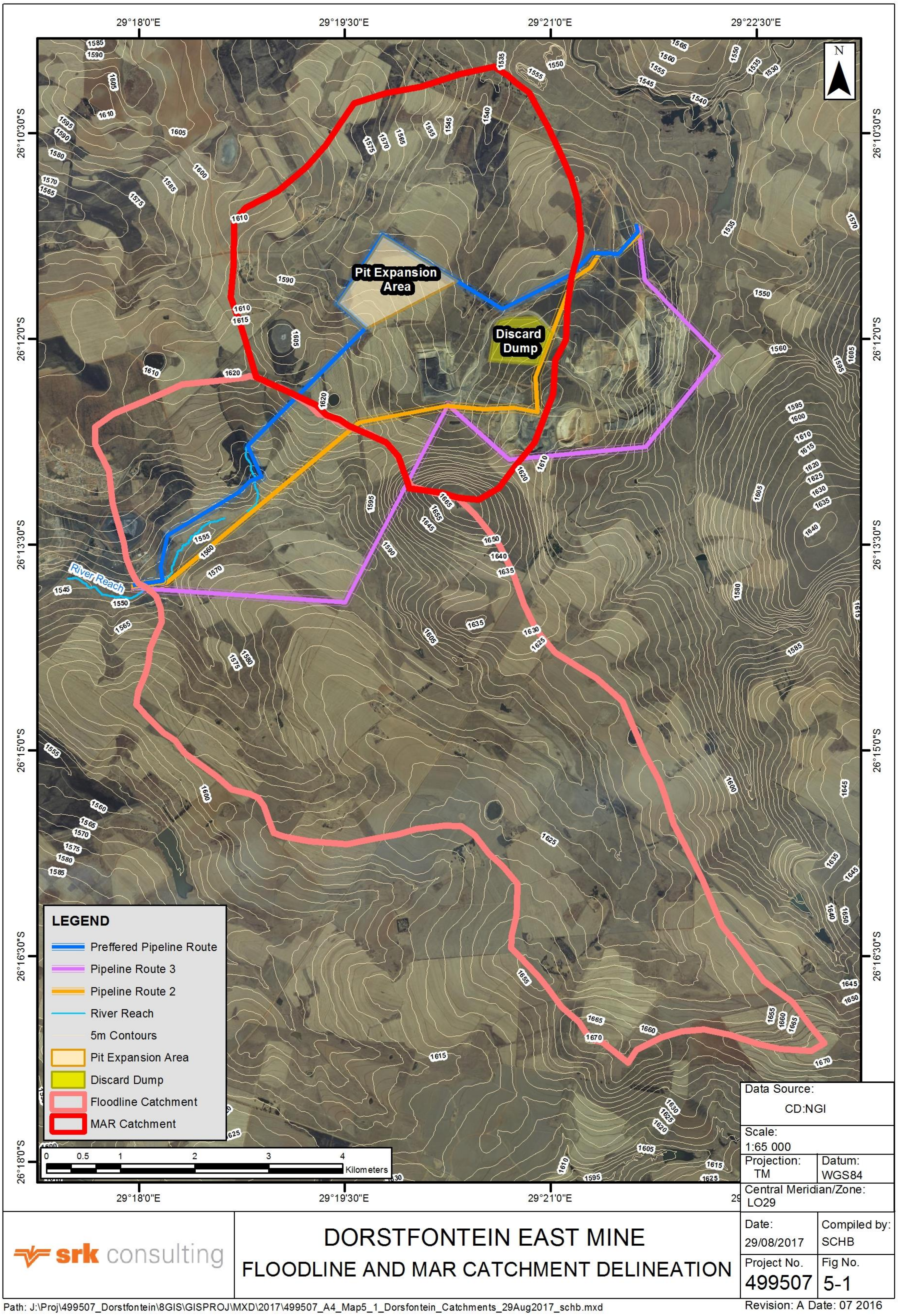

Figure 5-1: Dorstfontein local catchments and river reach along preferred pipeline route

The pipeline falls across two quaternary catchments; B11B and B11D. The pipeline will not have any effect on the MAR. As a result, B11D will not be affected by a change in MAR. The MAR for the unnamed tributary is shown in Table 5-1.

Table 5-1: Natural mean annual runoff (MAR) (from WR2012) at conveyor

Catchment	Area (km^2)	B11D MAR contributing rainfall (mm)	MAR from Pit Catchment (mill m^3)	Dirty water area (km^2)	MAR from dirty water (m^3)	Loss of MAR (%)
Pipeline	34	54	1.84	0	0	0

The effects of mining activity on the catchment MAR in which the pit extension is located, will be a reduction in MAR. The results for the localised investigation are shown in Table 5-2. The captured dirty water will result in a reduction of MAR of 45,900 m^3.

Table 5-2: Natural MAR (from WR2012) and loss of MAR due to dirty water containment

Catchment	Area (km^2)	B11B MAR contributing rainfall (mm)	MAR from Pit Catchment (mill m^3)	Dirty water area (km^2)	MAR from dirty water (m^3)	Loss of MAR (%)
Pit Extension	17.4	54	0.94	0.85	45,900	4.9

In the greater context, the pit extension is located within quaternary catchment, B11B. The catchment area and the associated MAR is presented in Table 5-3

The reduction in MAR included in Table 5-3 was estimated using the runoff depth given in WR2012 (Midgley, Pitman and Middleton, 1994).

Table 5-3: Quaternary natural MAR (from WR2012) and loss of MAR due to dirty water containment

Catchment	B11B Area (km^2)	B11B MAR contributing rainfall (mm)	MAR from B11B (mill m^3)	Dirty water area (km^2)	MAR from dirty water (m^3)	Loss of MAR B11B (%)
B11B	435	54	23.65	0.85	45,900	0.2

5.2 Clean water management

The 0.85 km^2 East Pit extension is positioned mid-slope. The result is that it is a requirement to manage potential ingress of clean water, to the pit. A clean water diversion canal positioned uphill of the pit, will allow for the water to be collected and routed away from the dirty area, for release to the environment.

The clean water area and associated channel sizes are presented in Table 5-4 and Table 5-5, below. The layout can be found in Appendix B.

Table 5-4: East clean water diversion canal

Label	Channel Slope (m/m)	Normal Depth (m)	Left Side Slope (m/m (H:V))	Right Side Slope (m/m (H:V))	Bottom Width (m)	Discharge (m³/s)	Velocity (m/s)	Froude Number
Trapezoidal Channel - 1	0.012	0.16	2	2	1	0.2	0.92	0.81
Trapezoidal Channel - 2	0.042	0.19	2	2	1	0.48	1.85	1.53
Trapezoidal Channel - 3	0.005	0.63	2	2	1	1.72	1.22	0.61
Trapezoidal Channel - 4	0.007	0.83	2	2	1	3.72	1.68	0.75

Table 5-5: West clean water diversion canal

Label	Channel Slope (m/m)	Normal Depth (m)	Left Side Slope (m/m (H:V))	Right Side Slope (m/m (H:V))	Bottom Width (m)	Discharge (m³/s)	Velocity (m/s)	Froude Number
Trapezoidal Channel - 1	0.046	0.12	2	2	1	0.21	1.48	1.51
Trapezoidal Channel - 2	0.005	0.33	2	2	1	0.46	0.86	0.57
Trapezoidal Channel - 3	0.034	0.25	2	2	1	0.72	1.93	1.43
Trapezoidal Channel - 4	0.02	0.83	2	2	1	6.2	2.83	1.27

5.3 Dirty water management

The dirty water at DEM is confined to the open cast pit extension. As per common practice, the edges of the open cast will have a berm built up to prevent ingress of surface water, in addition to the sized and designed clean water canal. The source of water to the open cast section is therefore limited to direct rainfall and ground water seep.

Removal of water from the open cast area requires a localised sump and installed pumping capacity to deal with collected water. The results for the volume of water captured and temporarily stored prior to pumping are shown in Table 5-6.

Table 5-6: Dirty water stormflow volume

Catchment Name	Area (km^2)	1:50 (m^3)	1:100 (m^3)
Pit Extension	0.85	100,755	115,093
Existing Pit	1.83	216,920	247,790
Total	2.68	317,675	362,884

Assumptions made in calculating the water contained in the pit, requiring pumping.

- Existing pit will be backfilled and rehabilitated as the pit extension is opened.
- The pit extension will develop as a continuation of the existing pit.
- Pit extension will be completely open (0.85 km^2).

Rehabilitation will take place on the current pit as the pit extension area is opened, however it is unlikely that the rehabilitation will be completed before the new pit is excavated. This will reduce the area available for direct rainfall to accumulate on the floor of the pit. It is however not known at the rate of backfilling and rehabilitation. Taking this into consideration, for the purposes of the report, the area of the existing pit will be used in the further calculation of direct rainfall accumulation in the pit.

Further, the stance is taken that in the process of opening, operating and closing the pit extension, the complete 0.85 km^2 area will be open and therefore contributing to rainfall volume in the base of the pit. The new values for use in the stormwater management of dirty water are shown in Table 5-7.

Table 5-7: Dirty water stormflow volume for the pit extension

Catchment Name	Area (km^2)	1:50 (m^3)	1:100 (m^3)
Pit Extension	0.85	100,755	115,093

The nature of open cast mine requires a temporary sump to collect the water and allow pumping. The position of the sump will move in relation to the mining operations. For the management of dirty water in the pit at DEM, the sump will be approximately 30 m by 30 m with a depth of approximately 3 m. The sump will provide a holding capacity of 2,700 m^3 which will be sufficient for the more common rainfall events. The 1:50 and the 1:100-year rainfall events are more severe and will require the bottom bench to accumulate water in addition to the sump. The overflow volume and required pumping rate to remove ponded water over three days is shown in Table 5-8.

Table 5-8: Dirty water stormflow volume for the pit extension on reduced open area

Catchment Name	Area (km^2)	1:50	1:100
Pit Extension rainfall (m3)	0.85	100 755	115 093
Sump capacity (m^3)		2 700	2 700
Overflow (m^3)		98 055	112 393
Pumping from sump over 3 days (m^3/h)		1,361.88	1,561.01
Decant rate (m^3/s)		0.38	0.43

The pit extension pumping network will be fitted to the existing pumping infrastructure, used at the existing pit. This approach allows for cost saving at the mine by reducing the length of pipe required to achieve the dewatering process. Pumped water is to be contained in appropriate holding facilities for reuse on the mine where possible. The conceptual setup for the dirty water pumping system for the pit extension is shown in Figure 5-2.

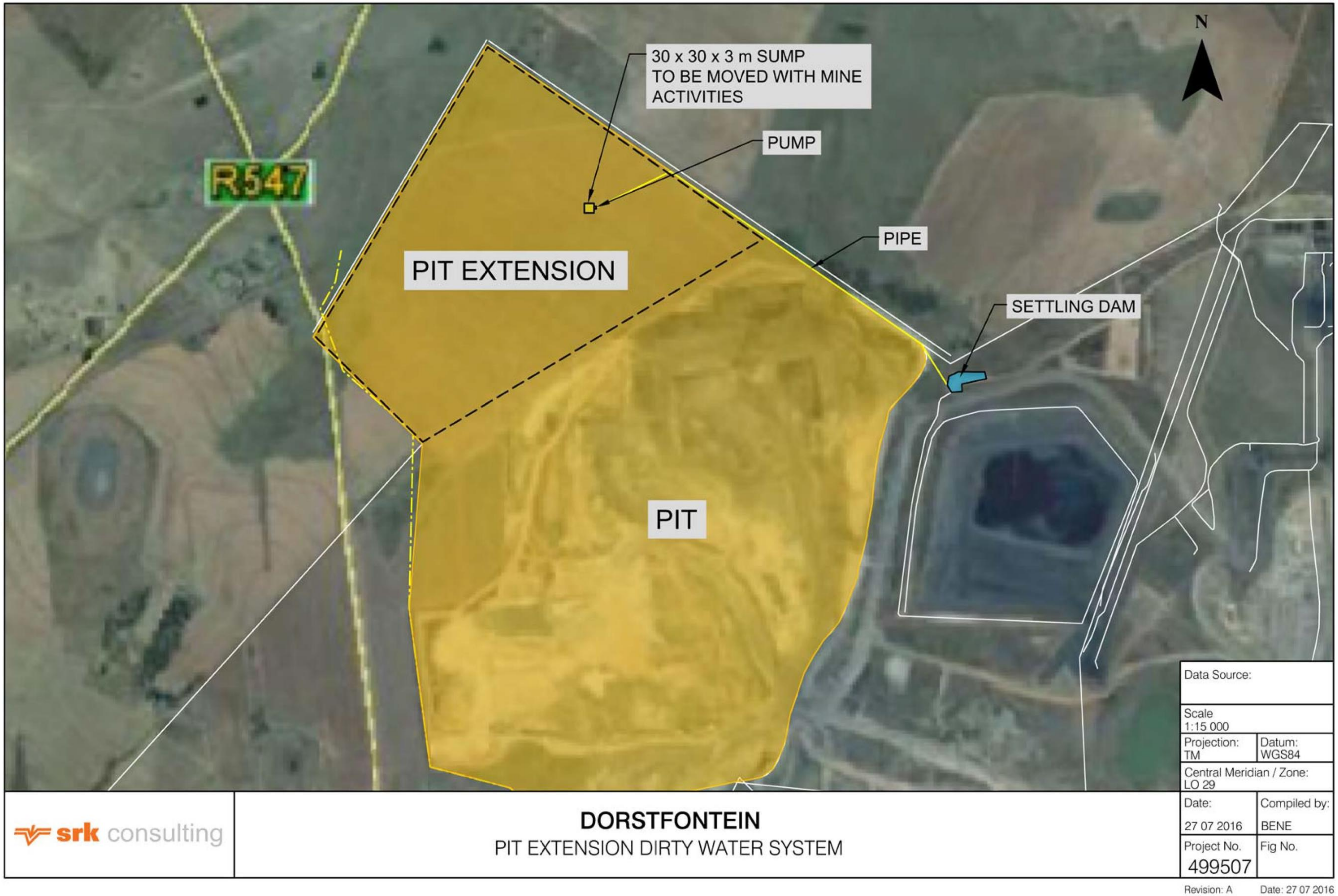

Figure 5-2: Dirty water management

6 Floodlines

The floodlines for the DEM need to be estimated in order to prevent loss and damage to infrastructure, through water damage; namely the pipeline. The estimation of the floodlines is described below. The 1:100-year floodline is shown in Figure 6-1 and the catchment area and peak discharge are shown in Table 6-1.

6.1 Peak flow assessment for Dorstfontein East Mine pipeline

The peak flow assessment of the DEM was undertaken using the Rational method. The Rational method is one of the best-known and widely used methodologies for small to medium catchments and is easy to apply.

The area contributing to the runoff to the unnamed tributary is 34 km^2. The tributary forms part of the Steenkoolspruit which flows north, located west of the mine. The area contributing to the tributary was used in the estimation of the peak discharge for the 1:50 and 1:100-year event as shown in Table 6-1 below.

Table 6-1: Catchment area and peak discharge used for the floodline delineation at pipeline start

Return Period 1:x years	Catchment Area (km^2)	Peak Discharge (m^3/s)
50	34	194
100	34	263

The results are for the existing conveyor bridge, south of the Dorstfontein West complex. The pipeline emanates from the PCD's located west of the conveyor. The pipeline crossed the conveyor obliquely, travelling towards the unnamed tributary. After approximately 410 m, the pipeline turns left at 90º and proceeding a further 195 m before turning to the right. The results in Figure 6-1 indicate that a portion of the section described above will be in the modelled 1:100-year and 1:50-year flood.

The pipeline position is more than 100 m from the stream centreline. However, the requirement states that the infrastructure should be outside the 1:100-year floodline or at least 100 m from the centreline, whichever is greater. In this case, the 1:100-year flood extent is the greater distance and therefore the pipeline position should be done so in accordance with the simulation result.

In addition to the pipeline position south of the Dorstfontein West complex, the proposed pipeline crosses a second identified water course approximately 2,100 m from the Dorstfontein West complex. The area contributing to the crossing forms part of the catchment described above in calculating the peak discharge for the watercourse passing south of the Dorstfontein West complex.

The area contributing to the tributary was used in the estimation of the peak discharge for the 1:50 and 1:100-year event as shown in

Figure 6-2 and the peak discharge used for the floodline simulation are shown in Table 6-2 below.

Table 6-2: Catchment area and peak discharge used for the floodline delineation at watercourse crossing

Return Period 1:x years	Catchment Area (km^2)	Peak Discharge (m^3/s)
50	1.1	4.6
100	1.1	6.3

It must be noted that there are two additional watercourses that no floodlines were prepared for. The watercourse on the western side of the Pit and the watercourse draining the mining area post closure. The current 10m contour intervals were used for the study and this data is insufficient to complete. a hydraulic calculation using mannings was undertaken and compared to the 100 m buffer zone. From the estimation, the 100 m buffer zone is greater than the 100 year floodline and this buffer zone at the two places is indicated on the floodline drawing.

The conceptual design for the preferred pipeline route have not been completed, but will be included for incorporation into the IWULA.

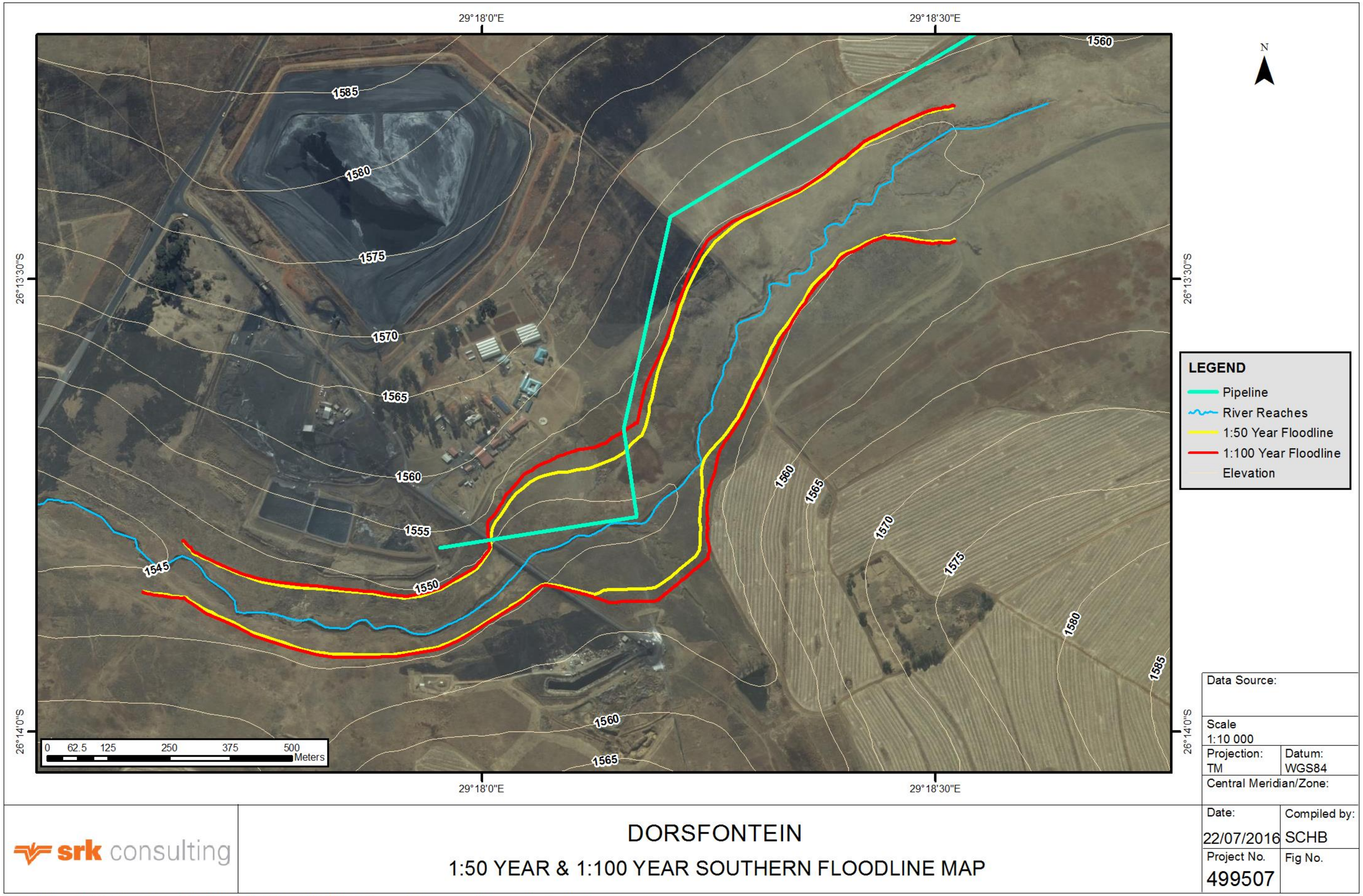

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Figure 6-1: Dorstfontein West complex 1:50 and 1 in 100 year flood line

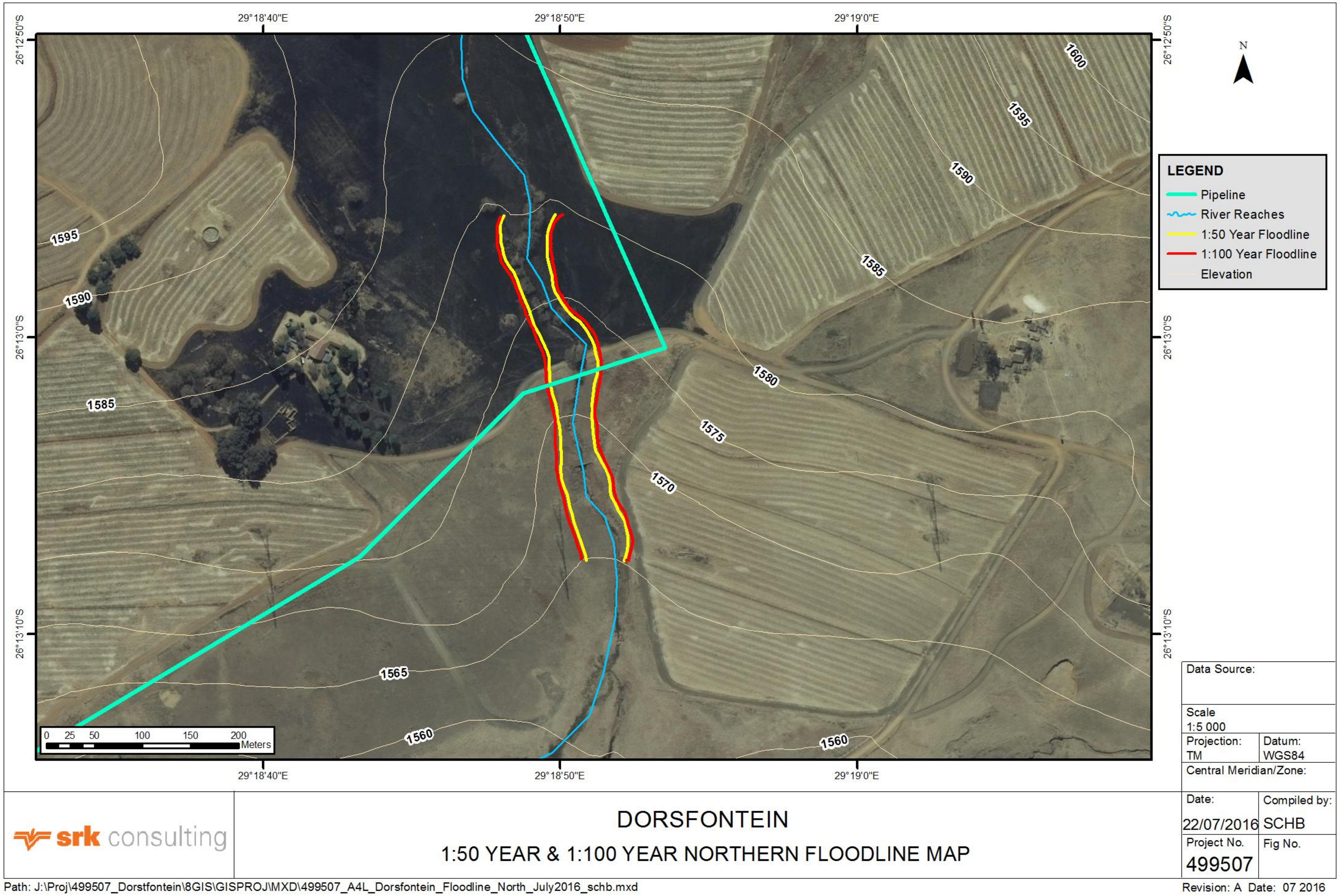

Figure 6-2: Watercourse 1:50 and 1 in 100 year flood line

7 Water Balance

The water is undertaken as prescribed by the Best Practice Guideline G2: Water and Salt Balances by DWAF, 2007.

Included in the study are the workshops, offices and the pit. Information was obtained where possible from DEM. The average annual water balance is shown in Figure 7-1. The wet and dry scenarios are presented in Appendix A (Figures A1 to A2).

7.1 Methodology

A monthly and annual water balance was set up based on GoldSim model. The water balance uses average monthly rainfall and evaporation for the hydrological year. Average rainfall and other rainfall statistics for the various wet and dry rainfall scenarios have been determined from observed long-term rainfall records.

Much of the water use indicated in the water balance is (currently) estimated by calculation because water meter data is not available at all the points and/or is of limited duration as the pit extension is still in a development phase. These assumptions can be modified at any stage and the resulting water balance would be automatically updated. The key parameters used in the water balance are shown in Table 7-1.

Table 7-1: Key parameters used for the water balance

Rainfall	Evaporation	Groundwater	Potable water
Monthly rainfall was used in the water balance	Monthly evaporation data was used in the water balance	Groundwater figures were obtained from the 2015 hydrogeological report (GCS, 2015). A figure of 4000 m^3/day was used.	0.25 m^3 was allocated per person per day.

Part of the role of the water balance is to present to the mine, the options available to decrease firstly the cost to the mine of raw water supply through municipal infrastructure and secondly, to decrease the reliance on the environment for water supply in new raw water use. The mine is able to save on both of the above points by reusing water (dirty water) in their processes.

Groundwater collected in the sump of the pit extension is classed as dirty water and as a result requires containment, treatment and use, where possible. If the mine has an idea of the volume of water likely to be classed as dirty, their reliance on the municipal raw water streams decreases by that amount.

This water balance will need to be incorporated into the overall mine water balance to determine if the mine can accommodate extra mine water from the pump.

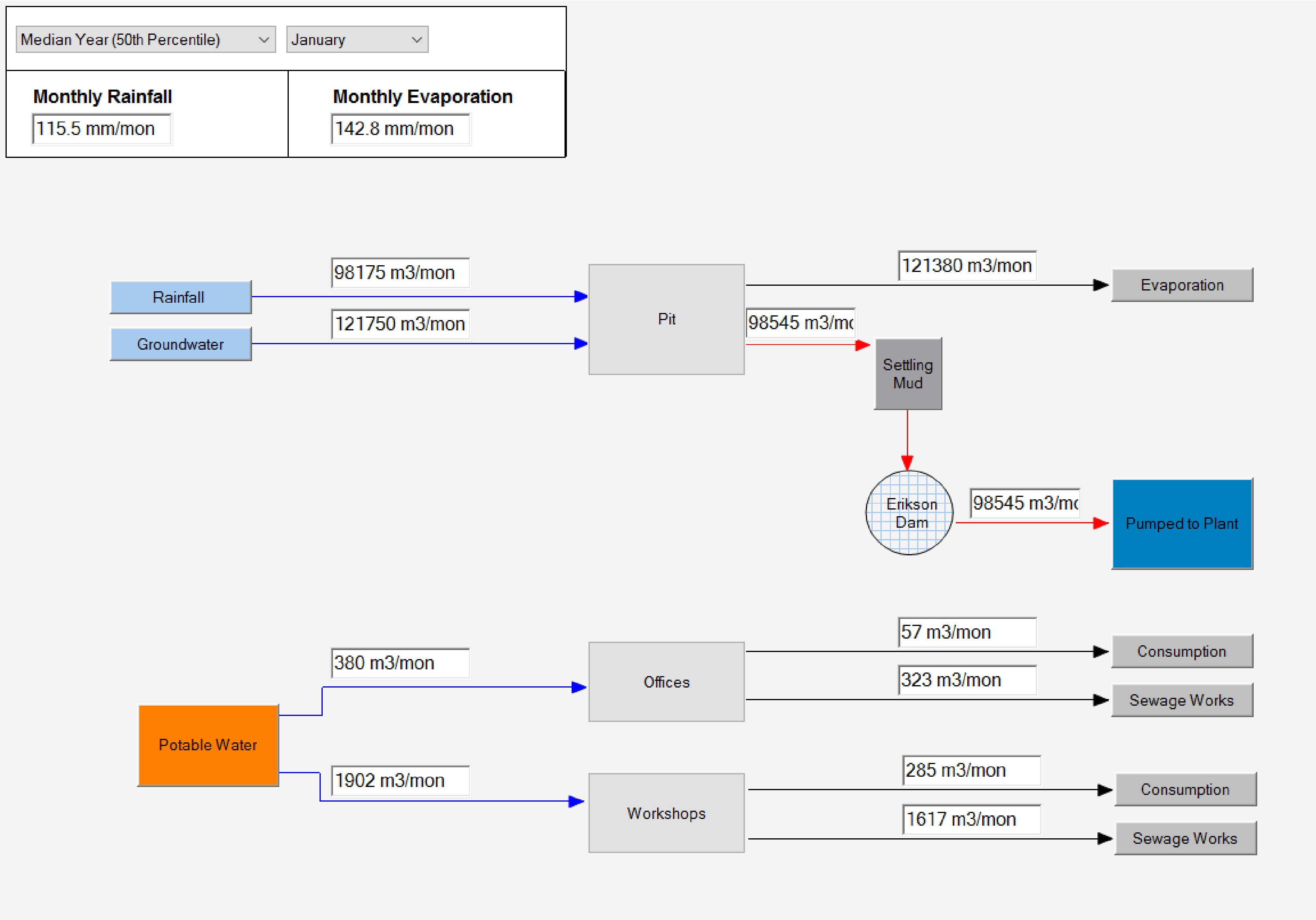

Figure 7-1: Annual average water balance for Pit extension

8 Surface Water Impact Assessment

All specialists are required to assess each potential impact identified according to the following Impact Assessment Methodology as described below.

This Impact Assessment Methodology has been formalised to comply the 2014 EIA Regulations of the NEMA, which states the following:

- *An environmental impact assessment report must contain all information that is necessary for the competent authority to consider the application and to reach a decision, and must include –*
  - *an assessment of each identified potentially significant impact, including –*

  *(i) **cumulative impacts**;*

  *(ii) the **nature, significance and consequence** of the impact and risk;*

  *(iii) the **extent** and **duration** of the impact and risk;*

  *(iv) the **probability** of the impact and risk occurring;*

  *(v) the **degree** to which the impact and risk can be **reversed**;*

  *(vi) the degree to which the impact and risk may **cause irreplaceable loss of resources**; and*

  *(vii) the **degree** to which the impact and risk can be **mitigated**.*

Based on the above, the Impact Assessment Methodology will require that each potential impact identified, is clearly described including whether the potential impact will have a positive or negative outcome on the biophysical and/or social environment (thereby providing the nature of the impact) and be assessed in terms of the following factors:

- **extent** (spatial scale) - will the impact affect the national, regional or local environment, or only that of the site?
- **duration** (temporal scale) - how long will the impact last?
- **magnitude** (severity) - will the impact be of high, moderate or low severity?; and
- **probability** (likelihood of occurring) - how likely is it that the impact may occur?

To enable a scientific approach for the determination of the environmental significance (importance) of each identified potential impact, a numerical value has been linked to each factor.

8.1 Activities to be Rated

Table 8-1 provides the anticipated activities relating to each project and project phase for which potential impacts should be identified and assessed, and mitigation measures provided. Please note that this table is not limited to only the stated activities identified, but should be used as a guideline when determining and identifying activities that could have potential impact on the biophysical and social environment.

Table 8-1: Dorstfontein Project Activities

Project Phase	Activity
Pre-construction	• Site clearing and grubbing of the footprint areas associated with the pit extension, diversion canals, pipeline, and proposed access roads.
Construction	• Excavation of the pit, construction of diversion canals, pipeline, and proposed access roads.
Operation	• Operation, management and maintenance of the pit extension, pipeline, and proposed access roads.
	• Operation, management and maintenance of the river crossings, alterations and crossings associated with the powerlines.

	• Mining of the pit extension area.
Rehabilitation	• The pit extension will be back-filled.
Post-closure	• Demolition of all other project related infrastructure.
	• Removal of all access and haul roads.
	• Handling of potential contaminated soils.
	• Monitoring of groundwater.

The Im

8.2 Project activities with potential to impact surface water resources

Although it is recognised that existing legislation is in place that would not allow a project to be developed that would have a material detrimental impact on surface water resources, there are a number of potential impacts on water resources that can arise from mining activities related to both the volume and quality of water entering, or leaving, water resources which may include some of the following:

- Reduced availability to downstream/down-gradient water users due to changes in water quantity or flow regime;
- Reduced availability of water to downstream water users due to changes in water quality;
- Reduced availability of water to surrounding water users due to physical obstruction from mine infrastructure pit extension, stream and stormwater diversions etc.);
- Linear crossings of the watercourses may cause scouring around the infrastructure in the river;
- Damage to the aquatic ecosystem due to substances contained in releases from the mine;
- Scouring effect on stream banks and bed due to releases from the mine (clean water diversions, storm water drains, road culverts etc.);
- Increased erosion from areas of exposed soils; and
- Increased risk of flooding due to changes in catchment hydrology.

Impacts may be envisaged for the various phases of the pit development, being construction, operational, closure and rehabilitation phases. The general activities that are common to construction and rehabilitation of the pit include the following:

- Removal of the vegetation.
- Removal and stockpiling of the topsoil.
- Earthworks and excavation of foundations for infrastructure e.g. roads, pipelines etc.
- Provision of stormwater management measures.
- Construction of concrete structures, pump stations and laying of pipelines.
- Rehabilitation of disturbed areas after general site construction is completed.
- Operation of the pit, on-going revegetation of berms around pit, water management systems, maintenance and monitoring.
- Decommissioning and closure of the pit once life of pit is reached.
- Rehabilitation of the pit once decommissioning is completed.
- Post Closure including maintenance and monitoring.

8.3 Impacts associated with all activities

The impacts for all activities during the construction, operation and closure of the access roads, extension of diversion canals are discussed in greater detail below. They are detailed in Table 8-2 to **Error! Reference source not found.**.

8.3.1 Pre-construction - site clearing and grubbing of the footprint areas

An increase in erosion from cleared areas, topsoil stockpiles or any other area where there are exposed soils can occur during storm events (direct impact). Increased erosion can result in an increase in turbidity, suspended solids and sedimentation in the unnamed tributary (indirect and cumulative impact). Some level of sedimentation is expected to occur in the unnamed tributary pre-development as runoff is naturally anticipated to pick up environmental debris as it crosses natural areas.

Increased turbidity is reversible and surface water should return to pre-impact turbidity levels once sediment levels entering the watercourse are reduced. Settled sediments should naturally move downstream during periods of high flow flowing storm events.

By minimising the area cleared for construction the potential for erosion will be reduced. Construction of appropriate stormwater controls in the form of clean water diversion bunds upstream of the construction site and paddocks downstream of the working activities will minimise the sediment loads leaving the construction area. Such sediments will be further reduced by temporary erosion prevention berms or similar measures within the path of the diverted clean water.

Rehabilitation of disturbed areas immediately after construction will facilitate re-establishment of vegetation thus reducing the potential for erosion post-construction.

8.3.2 Impacts during closure/rehabilitation

Similar water quality and erosions impacts as in the construction phase have the potential to occur during the demolition of infrastructure and rehabilitation of the pit and associated infrastructure despite the pit becoming a permanent fixture in the landscape. No additional impacts are envisaged as this activity should be restricted to the already disturbed area. These impacts will therefore be addressed in the construction phase.

The pit will be revegetated to manage on-going dust generation and erosion after back-filling. All rehabilitation activities should be monitored until vegetation is well established and no further surface water quality impacts are deemed likely.

8.3.3 Post-closure

The main activity identified during the post-closure phase that has the potential to impact on surface water resources is dispersion of the contaminated groundwater plume which is discussed in the groundwater specialist report.

During the post-closure phase, all infrastructures will have been removed; therefore the surface water quality should not be further impacted by any of the post-closure activities.

8.4 Impacts associated with the pit extension and associated infrastructure (e.g. pipelines, stormwater management)

8.4.1 Construction of the pit extension and associated infrastructure (pipelines)

Changes to surface water hydrology could result due to placement of infrastructure within drainage lines and containment of dirty runoff within the pit footprint Without adequate clean water diversions or suitable grading of areas there is an increased risk of flooding upstream (impedance of flow) which could result in damage to property and infrastructure. The impact will be localised but will remain throughout the life of the mine. The probability that local water courses will be diverted and will not carry the water falling directly on the pit extension and considered dirty water, is definite and the overall significance of the impact is rated as moderate. The impact will affect the flow regime and morphology of the watercourse and thus overall functionality of the local surface water courses. Water course functions are beyond the scope of this study and are described in the Biodiversity.

Appropriately designed and constructed clean water diversion structures and outlets in compliance with Regulation 704 will return clean water runoff generated up gradient of the pit extension to the Olifants River in a manner as close to natural/pre-mining conditions as possible. Energy dissipaters should be constructed at points where there are concentrated discharges of water to the environment that could cause significant erosion and scouring within water channels to reduce the energy and speed of the water flow.

Direct contamination of the unnamed tributary or its tributaries at the pipeline crossings can occur due to spillages and accidental discharges or due to erosion of disturbed areas during construction in the riparian zone. This impact is potentially reversible through a combination of clean-up and assimilation in the watercourse but is considered to be of moderate significance due to the pipeline crossings occurring in the riparian zone.

Appropriately designed and constructed crossing structures and stormwater outlets in compliance with Regulation 704 will reduce the potential for erosion. Erosion protection and energy dissipaters should be constructed at points where there are concentrated, high velocity flows of water to the environment that could cause significant erosion to slow the speed of water. The standard WUL conditions require that construction takes place in the dry season and starts from upstream to downstream with concurrent rehabilitation taking place. Weekly water monitoring is also required during construction and for three months post construction.

8.4.2 Operation of the pit extension

Changes to the hydrology within the Olifants River catchment will continue from the construction phase and no additional mitigation is indicated.

The rainfall water within the designated dirty water area of the pit extension that forms part of the MAR to the local water courses will continue to be removed from the catchment and may continue to reduce the quantity of water available to downstream users.

The potential for contamination of surface water due to releases of dirty water (runoff and return water) remains of moderate significance both pre- and post-mitigation.

Spillages and accidental discharges could result in the contamination of surface water resources. Spillage of return water from the piped transfer systems has the potential to impact directly on the Olifants River via spills in the riparian zone at watercourse crossings or indirectly via runoff. The greatest consequence is for spillage occurring at the watercourse crossings. Should this occur, the functionality of the surface water course will be temporarily reduced, but should continue in a modified way during the period of waste assimilation and recovery. The impact is of high significance but can be mitigated and reversible through a combination of clean-up and assimilation/natural recovery in the watercourse.

Table 8-2: Impact assessment for the pipeline

Nature of the impact		Significance of potential impact BEFORE mitigation							Mitigation Measures	Significance of potential impact AFTER mitigation							degree of mitigation (%)
		Probability	Duration	Extent	Magnitude	Loss of Resources (%)	Significance			Probability	Duration	Extent	Magnitude	Loss of Resources (%)	Significance		
Pre-Construction Phase																	
Increased solids transport due to clearing/grubbing	-	4	1	1	6	1	**32**	**Moderate**	Construct in dry season and install silt bunds	1	1	1	2	1	**4**	**Low**	87.5
Increased runoff requiring retention on site	-	4	1	1	6	1	**32**	**Moderate**	Limit footprint and install retardation structures	1	1	1	2	1	**4**	**Low**	87.5
Accidental hazardous substance spillages during construction phase	-	4	1	1	6	1	**32**	**Moderate**	Operate using best practises by storing hazardous substances in an adequately sized bunded area, with appropriate safety equipment.	1	1	1	2	1	**4**	**Low**	87.5
Construction Phase																	
Impeding flow while under construction	-	4	1	1	10	1	**48**	**Moderate**	Construct in dry season. Protect with gabions & mattresses. Remove litter & debris to stop blocking.	1	1	1	4	1	**6**	**Low**	87.5
Accidental spillages of hazardous substances from construction vehicles used during construction of the crossings.	-	4	1	2	8	1	**44**	**Moderate**	Control site access. Control refuelling areas. Restrict vehicular access to stream. Clean spillages immediately they occur and remediate as necessary.	1	1	1	4	1	**6**	**Low**	86.4
Contamination of runoff by poor materials/waste handling practices	-	4	1	2	8	1	**44**	**Moderate**	Park vehicles on hard standing with sump. Store hydrocarbons and other contaminants responsibly. Bund fuel storage areas. Store and dispose of waste responsibly.	1	1	1	4	1	**6**	**Low**	86.4
Debris from poor handling of materials and/or waste blocking watercourse	-	2	1	1	2	1	**8**	**Low**	Operate using best practises In separating waste streams and disposing of the waste correctly.	1	1	1	4	1	**6**	**Low**	25.0
Operational Phase																	
Pipeline breaking and spillage to river.	-	2	2	1	8	1	**22**	**Low**	Operate using best practises.	1	1	1	2	1	**4**	**Low**	81.8
Closure/Rehabilitation Phase																	
Impeding flow while under demolition	-	2	1	1	2	1	**8**	**Low**		2	1	1	2	1	**8**	**Low**	0.0
Increased turbidity due to demolition.	-	2	1	1	2	1	**8**	**Low**	Demolish during dry season, limit the disturbed footprint.	2	1	1	2	1	**8**	**Low**	0.0
Accidental spillages of hazardous substances from construction vehicles used during demolition.	-	2	1	1	2	1	**8**	**Low**	Operate using best practises.	2	1	1	2	1	**8**	**Low**	0.0
Post-Closure Phase																	
Flooding caused by extreme rainfall event	-	1	5	1	10	1	**16**	**Low**	Warning signs to discourage crossing if pipes/culverts are submerged.	1	5	1	4	1	**10**	**Low**	37.5
Damage to the crossings themselves	-	1	5	1	8	1	**14**	**Low**	Regular periodic inspections by successor in title and remediation as necessary.	1	5	1	1	1	**7**	**Low**	50.0

Table 8-3: Impact assessment for the pit extension

Nature of the impact		Significance of potential impact BEFORE mitigation							Mitigation Measures	Significance of potential impact AFTER mitigation							degree of mitigation (%)
		Probability	Duration	Extent	Magnitude	Loss of Resources (%)	Significance			Probability	Duration	Extent	Magnitude	Loss of Resources (%)	Significance		
Pre-Construction Phase																	
Dirty water leaving site	-	4	1	1	6	2	32	Moderate	Construct in dry season;	1	1	1	2	2	4	Low	87.5
									Limit footprint.	1	1	1	2	2	4	Low	87.5
Accidental hazardous substance spillages during construction phase	-	4	1	1	6	1	32	Moderate	Operate using best practises by storing hazardous substances in an adequately sized bunded area, with appropriate safety equipment.	1	1	1	2	1	4	Low	87.5
Construction Phase																	
Impeding flow while under construction	-	3	1	1	8	2	30	Moderate	Construct in dry season. Protect with gabions & mattresses Remove litter & debris to stop blocking.	1	1	1	4	2	6	Low	80.0
Accidental spillages of hazardous substances from construction vehicles used during construction of the crossings.	-	4	1	2	8	1	44	Moderate	Control site access. Control refuelling areas. Restrict vehicular access to stream. Clean spillages immediately they occur and remediate as necessary.	1	1	1	4	1	6	Low	86.4
Contamination of runoff by poor materials/waste handling practices	-	4	1	2	8	1	44	Moderate	Park vehicles on hard standing with sump. Store hydrocarbons and other contaminants responsibly. Bund fuel storage areas. Store and dispose of waste responsibly.	1	1	1	4	1	6	Low	86.4
Separate clean and dirty water streams	-	5	5	1	8	5	70	High	Construct diversion drains timeously.	5	5	1	2	5	40	Moderate	42.9
Operational Phase																	
Pump failure will result in dirty water accumulation in the pit	-	1	4	2	6	5	12	Low	Undertake regular structural inspections of pumps and pipes exiting pit. Ensure groundwater investigation is done to understand groundwater levels.	1	4	2	2	5	8	Low	33.3
Dirty water entering wetland	-	5	3	4	6	3	65	High		5	3	2	6	3	55	Moderate	15.4
High rate of ground water ingress causing floodline of the pit	-	1	3	2	6	5	11	Low		1	4	2	2	5	8	Low	27.3
Closure/Rehabilitation Phase																	
Pit extension reaching capacity and overflowing to the environment.	-	2	4	2	2	1	16	Low	Understand groundwater in the area.	2	1	1	2	1	8	Low	50.0
Post-Closure Phase																	
Water quality changes downstream	-	4	5	2	6	1	52	Moderate	Maintain stormwater collection system and monitoring.	4	5	2	4	1	44	Moderate	15.4

9 Conclusions and Recommendations

The surface water specialist study provides an indication of the steps and processes required in order to meet the Regulation 704 criteria. These include the;

- Separation of clean and dirty water streams and the release and containment of each stream respectively.
- The impact of MAR changes on the local and quaternary catchment level.
- The potential impact on infrastructure by the 1:100-year flood event and the
- Operating water balance for the pit extension.

The pit extension requires a clean water cut off canal to the south west to prevent the situation of surface runoff from entering the pit extension during rainfall events. The canal will discharge the water to the west and east as it straddles a high point in the middle of the canal.

The nature of a pit excavation results in a reduced likelihood of dirty water, generated at the pit extension, from flowing into the environment. A sump has been indicated for the pit extension as a means of creating a point from which to pump the water out and to a suitable containment and treatment location. The pit extension means that the current infrastructure need only be extended in order to facilitate the requirement set out above.

The pit extension will affect the MAR by approximately 5% on a local scale and by 0.2% on a quaternary scale.

The pipeline extension between the DEM and DWM has been conceptually drawn at a distance of no closer than 100 m from a water course where possible. However, due to the topography of the area being relatively flat, the 1:100-year flood line exceeds the 100 m buffer. This is primarily at the pipeline origin point at DWM, where the pipeline crosses the conveyor section, travelling east, before turning north for a distance. It is recommended that the pipeline be rerouted to skirt the current office area as much as possible, thereby avoiding the area of inundation. A second point of interest in the floodline results is approximately midway between DEM and DWM. The pipeline crosses a defined watercourse. The 1:100-year floodline extent has been calculated for this position. The infrastructure required for the pipeline should be located outside of this zone as far as possible, with the pipeline crossing above the water course. Exact design levels were not considered in this investigation.

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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Appendices

Appendix A: Water Balance Scenarios

Appendix A: Water Balance

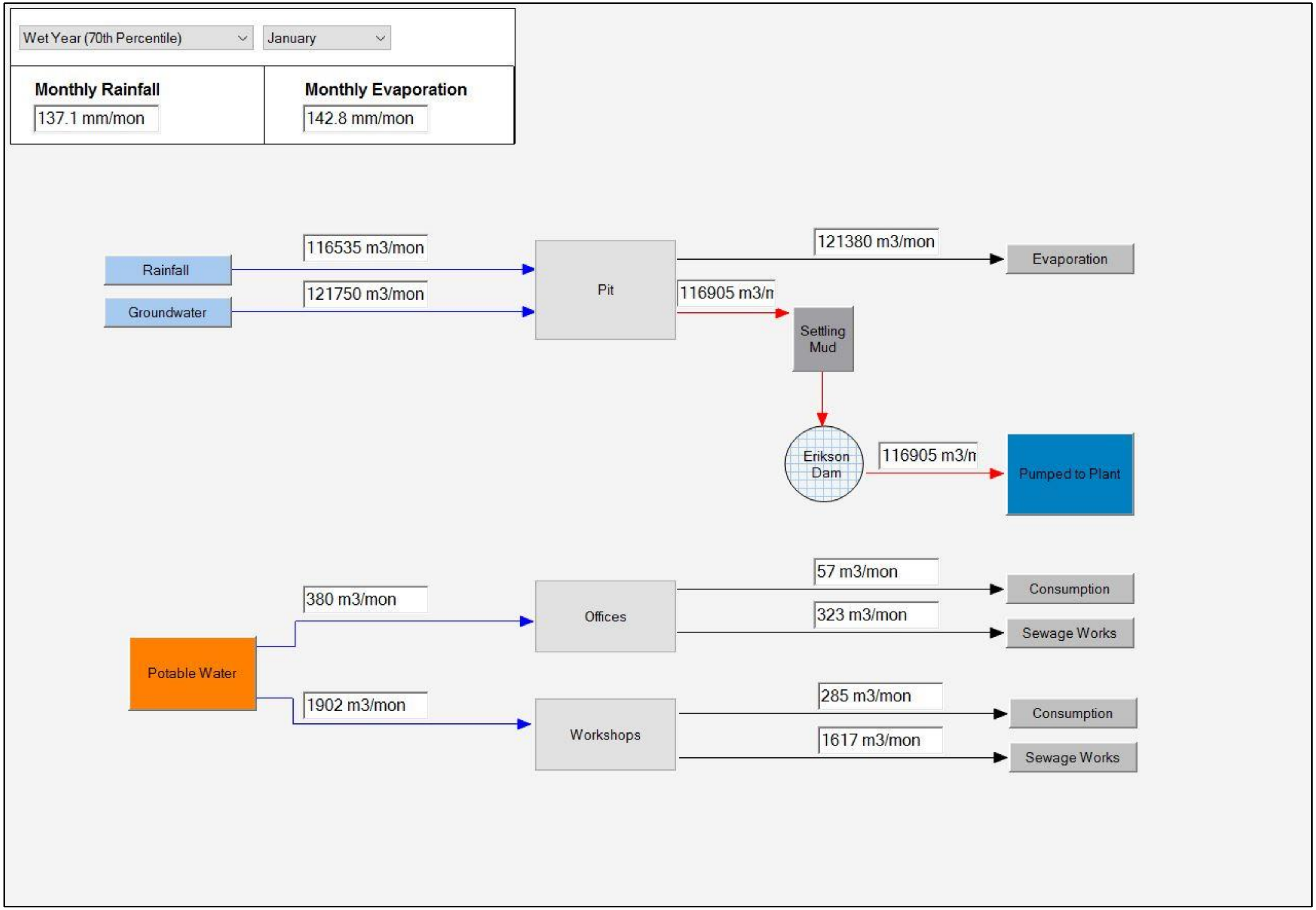

Figure A-1: Wet scenario water balance

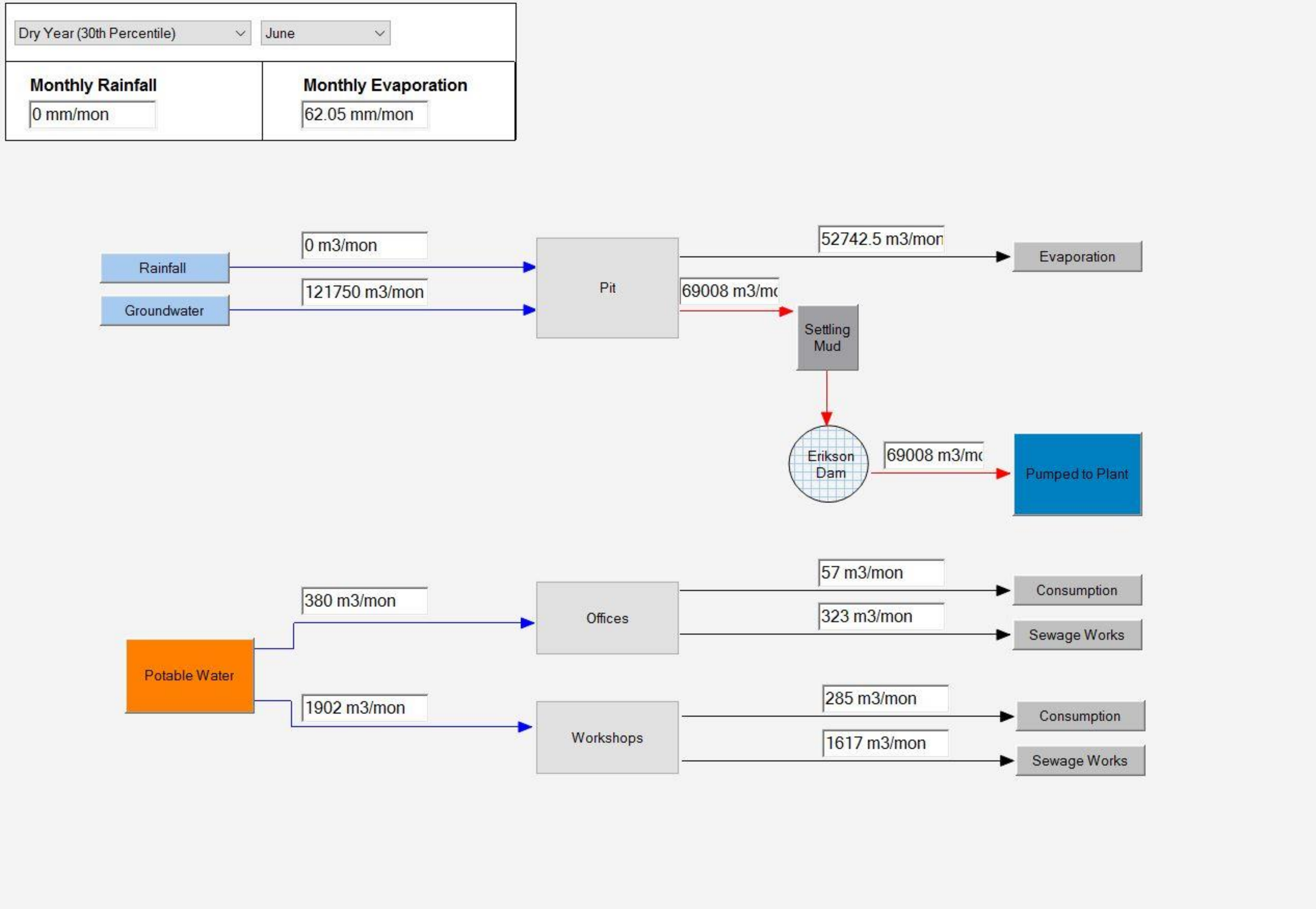

Figure A-2: Dry scenario water balance

Appendix B: Clean water area and associated channel sizes

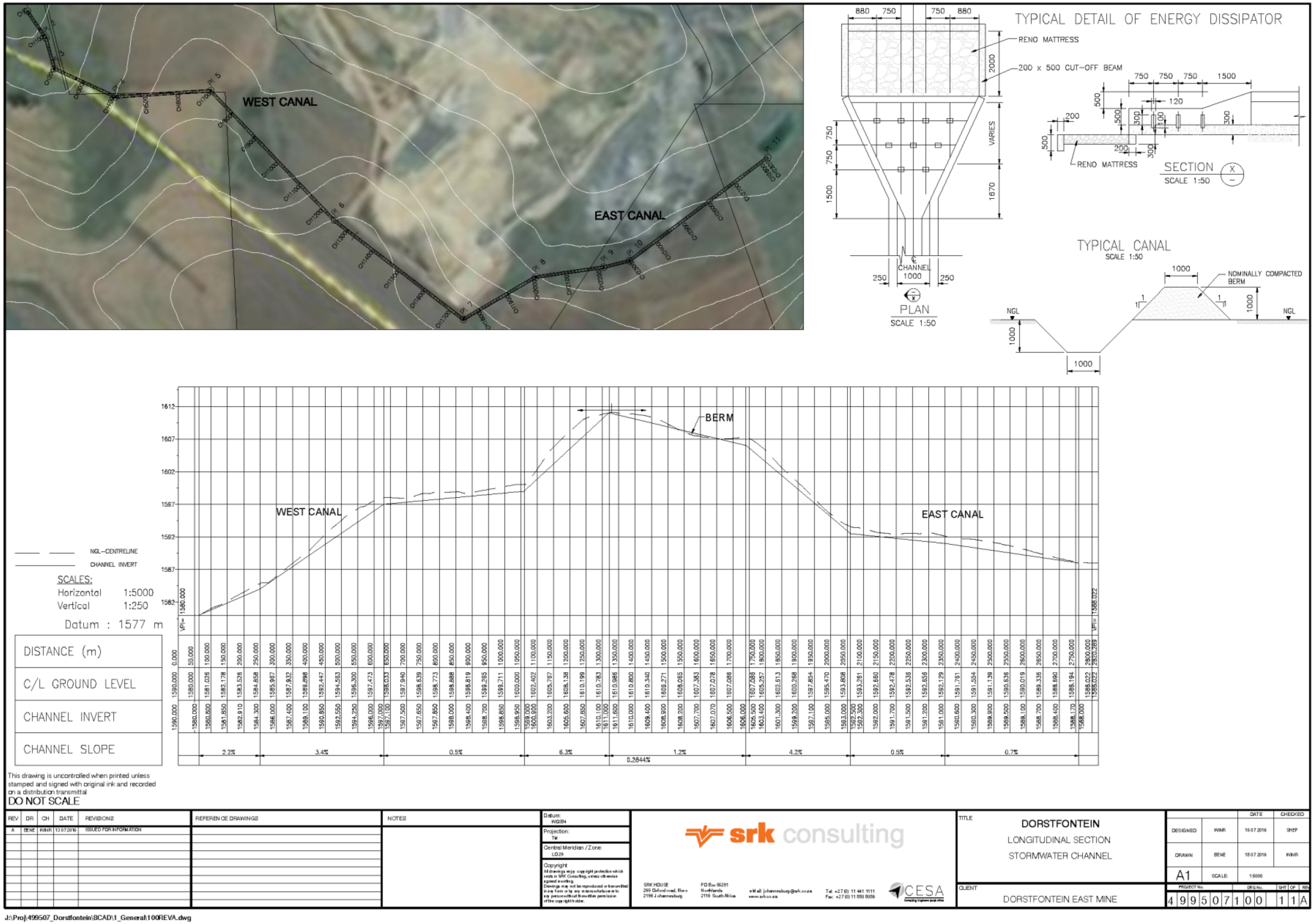

Figure B-1: clean water area and associated channel sizes

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