Surface Water Hydrological Study for the Proposed Pure Source Mine

Project Number:

PSM001

Prepared for:

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ACRONYMS AND ABBREVIATIONS

ABA	Acid Base Accounting
AMD	Acid Mine Drainage
BPG	Best Practice Guideline
DEM	Digital Elevation Model
DWAF	Department of Water and Sanitation
DWS	Department of Water and Sanitation
EC	Electrical Conductivity
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EMP	Environmental Management Programme
FAO	Food and Agricultural Organisation
GIS	Geographical Information Systems
GN704	Government Notice No. 704
LOM	Life of Mine
MAP	Mean Annual Precipitation
mbgl	Metres below ground level
MR	Mining Right
MRA	Mining Right Area
MAR	Mean Annual Runoff
mamsl	metres above mean sea level
MPRDA	Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002)
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998)
NWA	National Water Act, 1998 (Act No. 36 of 1998)
PCD	Pollution Control Dam
Pr.Sci.Nat.	Professional Natural Scientist
ROM	Run of Mine
SWMP	Stormwater Management Plan
SANS	South African National Standards
SACNASP	South African Council for Natural Scientific Professions
WMA	Water Management Areas
WR2012	Water Resources of South Africa, 2012 Study
WUL	Water Use Licence
WULA	Water Use Licence Application

DECLARATION OF INDEPENDENCE

I, Andy Pirie declare that:

- I act as an independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have the expertise in conducting the specialist study relevant to this application, including knowledge of the various Acts, regulations and any guidelines that have relevance to the proposed project;
- I will comply with the Acts, regulations and all other applicable legislation;
- I have no, and will not engage in no conflicting interests in the undertaking of this study;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the competent authority; and the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority; and
- All the particulars furnished by me in this report are true and correct.

....

Andy Pirie
Hydrologist
Pr.Sci.Nat (reg no. 114988)

1 INTRODUCTION AND BACKGROUND

Hydrospatial (Pty) Ltd (hereafter Hydrospatial) was appointed by Monte Cristo Commercial Park (Pty) Ltd (hereafter the client) to conduct a surface water hydrological study for an environmental authorisation and a Mining Right Application (MRA) process, for the Pure Source Mine (hereafter the Project).

This report provides the surface water hydrological assessment for the Environmental Impact Assessment (EIA) phase of the Project.

1.1 Project Location

The Project is located near Vaal Oewer on the southern bank of the Vaal River within Free State Province of South Africa. The Project is located on portions 3, the remaining extent of portion 1, and the remaining extent of the farm Woodlands 407. The location of the Project is indicated on Figure 1-1.

1.2 Project Description

1.2.1 Mine Infrastructure and Alternatives

Three alternative mine infrastructure layout plans are being considered, with the most appropriate from an environmental, economic and buffer zone perspective selected. The three alternative mine infrastructure layout plans are indicated on Figure 1-2, Figure 1-3 and Figure 1-4. The following mine infrastructure is proposed:

- Dams;
- Wash plant for the washing of mined sand;
- Rotary pan processing plant for alluvial diamond mining;
- Potential alluvial diamond X-ray and/or flow sorting facility;
- Clean and dirty water management infrastructure such as Pollution Control Dams (PCD), water recycling plan (part of the wash plant), settling ponds, stormwater runoff structures, water pipeline network and pump stations;
- Drying and screening plants; and
- Topsoil and Run of Mine (ROM) stockpiles.

Additional mining and processing infrastructure will include haul roads, workshop, weighbridge and offices, conveyor systems, powerlines, change houses, staff accommodation and recreation facilities and portable chemical ablution facilities for employees during the construction and operational phases.

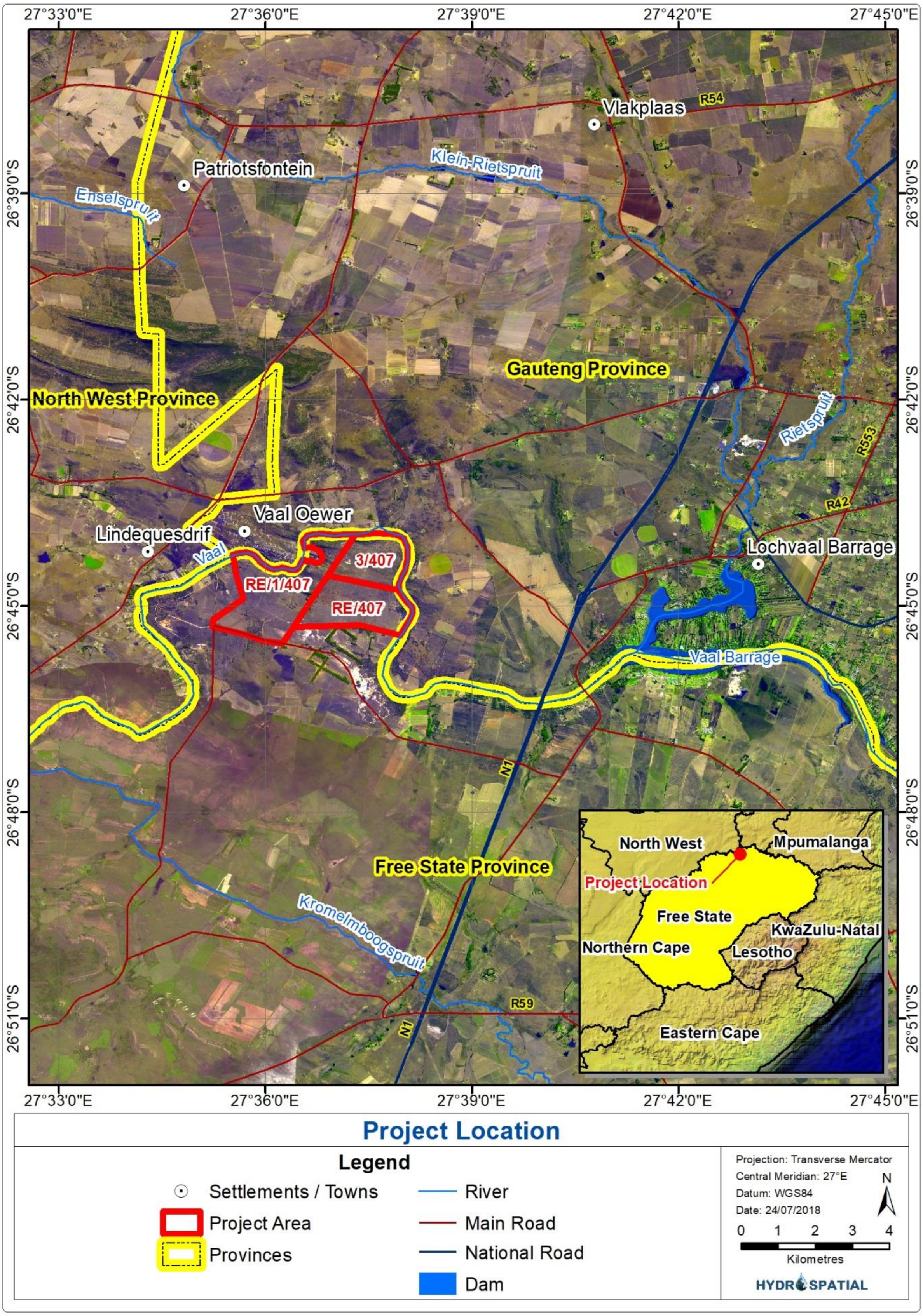

Figure 1-1: Project location

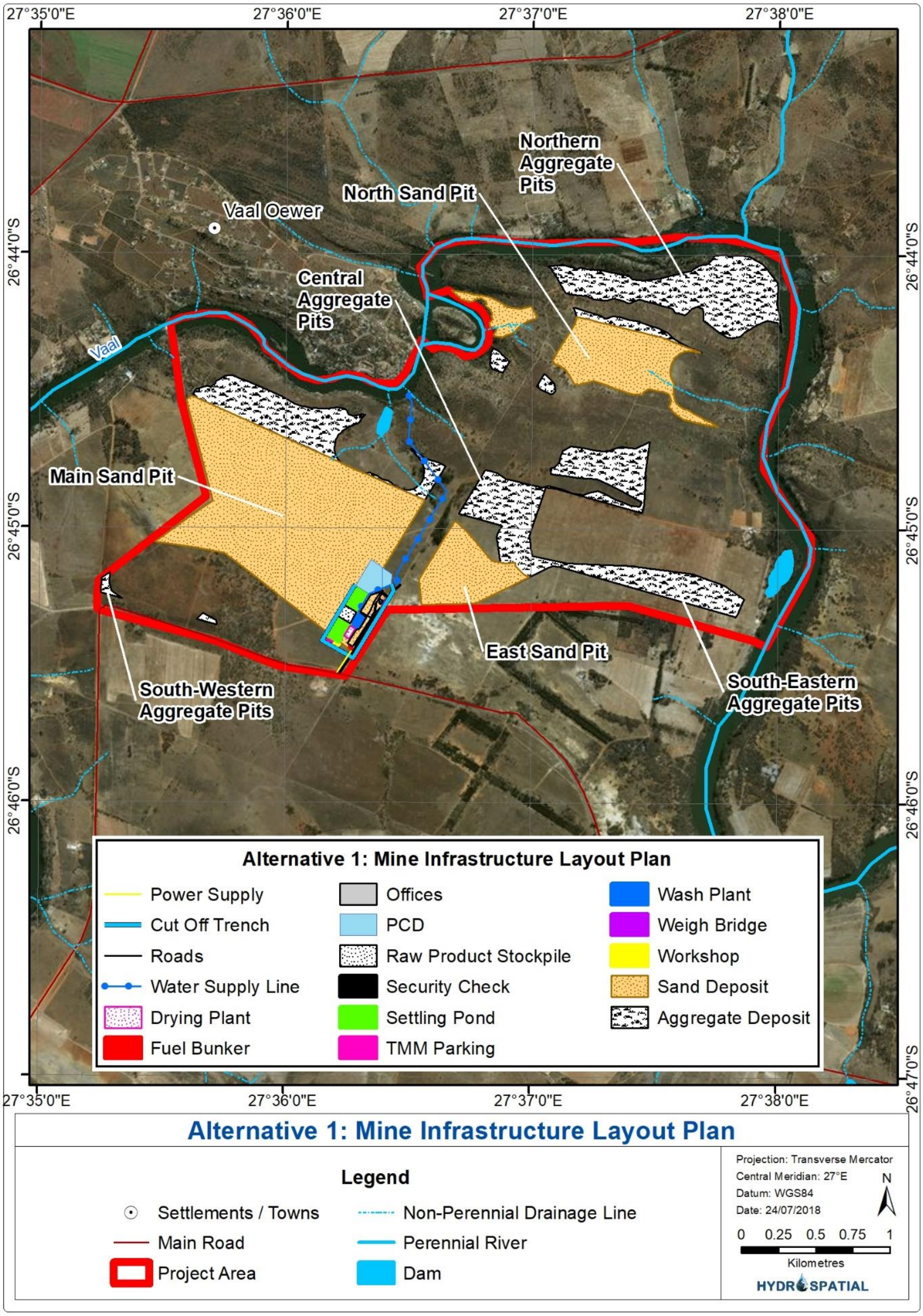

Figure 1-2: Alternative 1: mine infrastructure layout plan

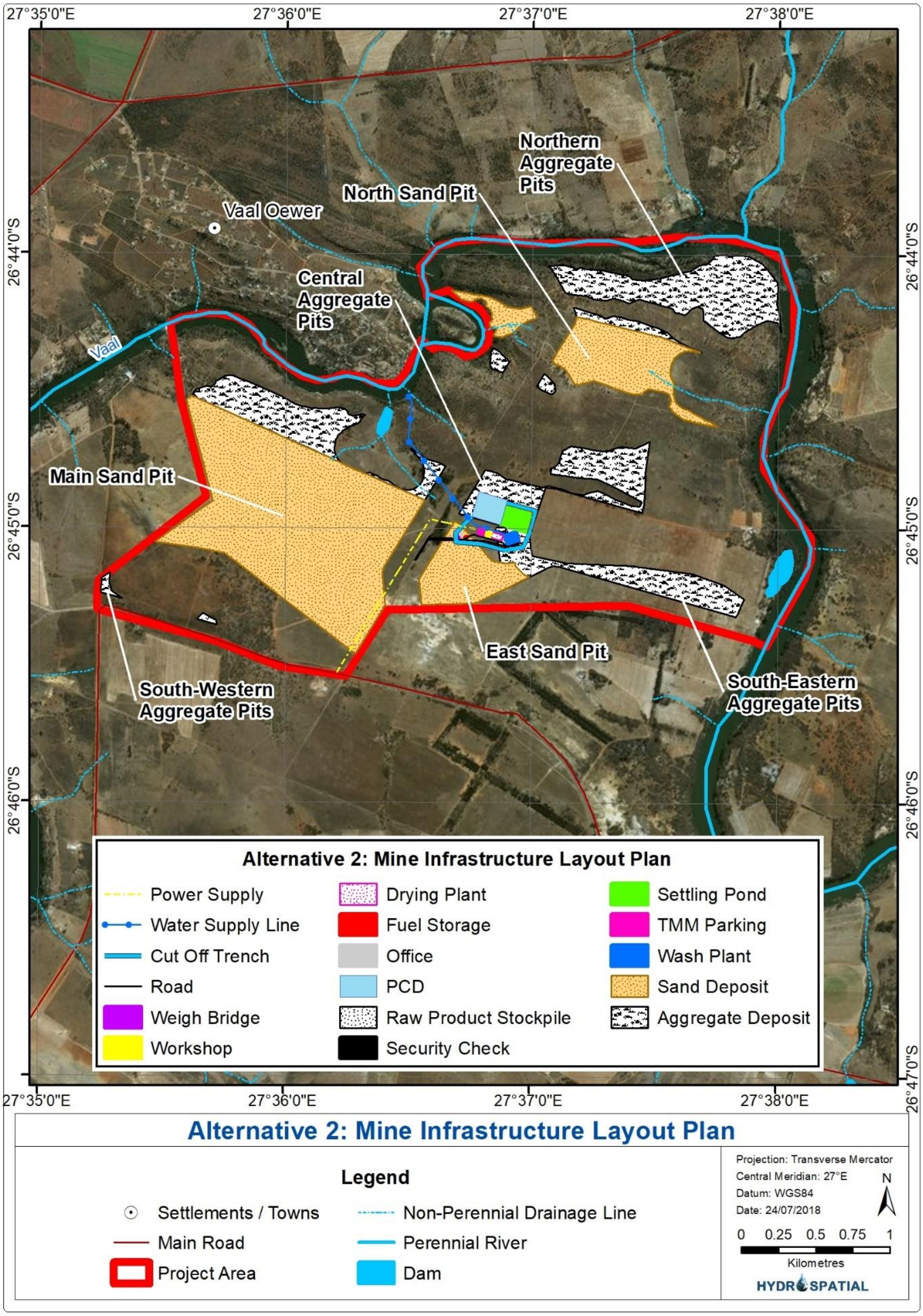

Figure 1-3: Alternative 2: mine infrastructure layout plan

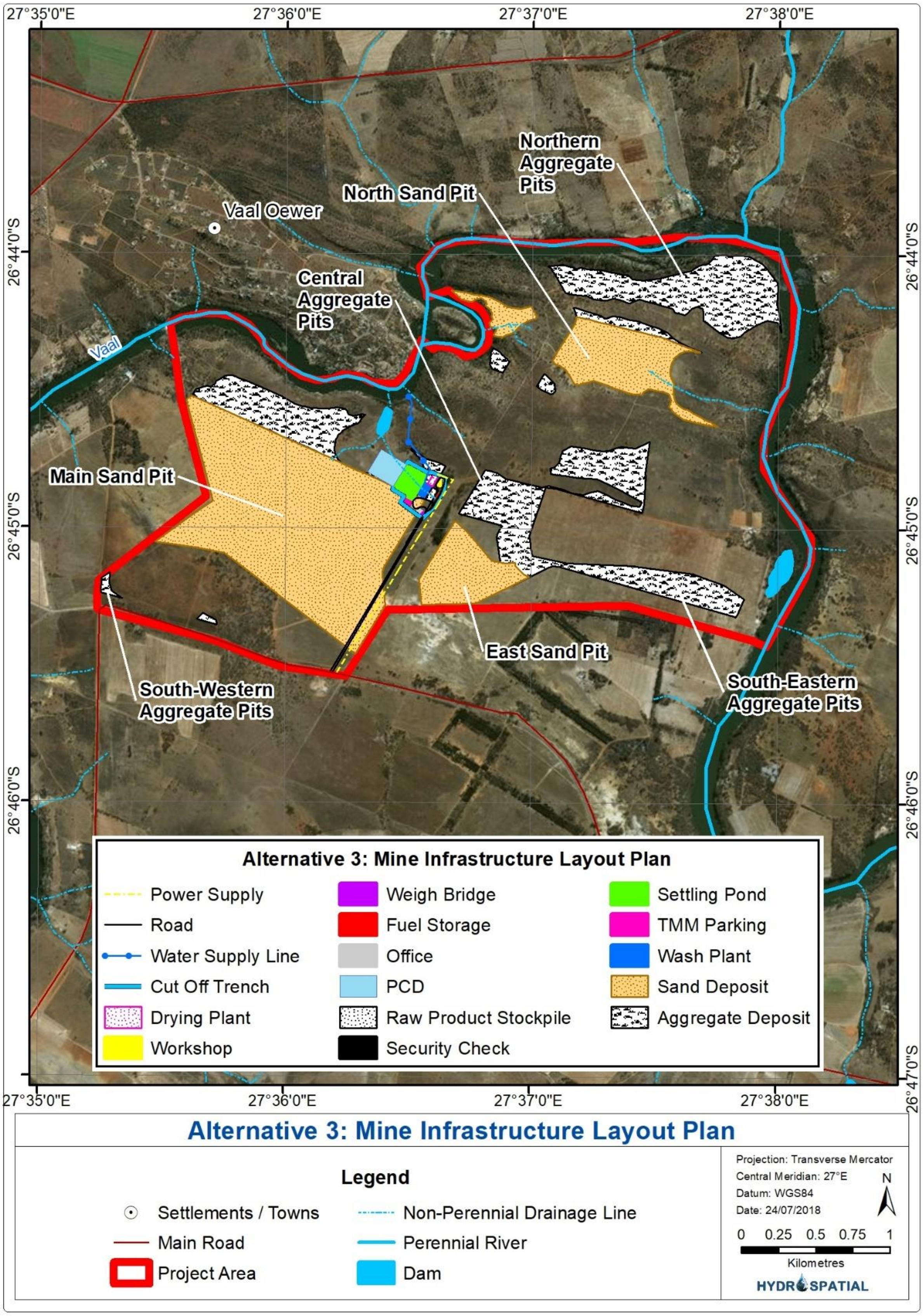

Figure 1-4: Alternative 3: mine infrastructure layout plan

1.2.2 Mining Method and Resource

The Project will involve the development of an open pit mine, processing plant and associated infrastructure. Sand, aggregate and alluvial diamonds are proposed to be mined in a phased open pit mining process, using a “truck and shovel” method. The planned open pit mine will comprise three distinct areas for the sand (main pit, north pit and east pit), and four areas for the aggregate (northern pit, central pit, south eastern pit and south western pit). Each area will be mined to an estimated maximum depth of 12 m, but may exceed this depth in certain areas. The entire application area could have the potential for diamond bearing gravels. The anticipated Life of Mine (LoM) is 30 years.

The mining method for each of the commodities is described in further detail below:

1.2.2.1 Sand Mining

Prior to commencement of sand mining, topsoil will be removed from the area demarcated for mining and stockpiled next to the pit for the purpose of rehabilitation. The area containing the sand deposit will be mined in portions of on average 6.8 ha per year (in most years, however, the area to be mined will not exceed 5 ha). The sand will be mined in benches and reject material will be backfilled into the previously mined out void as mining advances (roll-over rehabilitation). Open pit benches will be established with a maximum height of between 1.5 m to 3 m. The mined sand will either be screened in the pit or transported by truck or conveyer to the washing plant. A total sand resource of 21 910 291 million m^3 is estimated for the application area, at an average depth of 10.64 m.

1.2.2.2 Aggregate Mining

In the absence of sand, topsoil will be stripped to expose the aggregate and will be stockpiled adjacent to the pit. The area containing the aggregate resource will be mined in portions of on average 4.6 ha per year (in most years, however, the area to be mined will not exceed 4 ha). The aggregate will be extracted and crushed in the pit by a mobile crusher and reject material will be backfilled into the previously mined out void as mining advances. The total volume of fresh aggregate is calculated to be 9 565 043 million m^3, at an average depth of 6.98 m, whilst the oxidised aggregate is estimated at 10 498 882 million m^3, at an average depth of 7.67 m.

1.2.2.3 Alluvial Diamond Mining

Once sand mining has commenced, the underlying gravel (potentially diamondiferous) will be exposed and Reverse Circulation boreholes will be drilled to ascertain gravel quality and the diamond potential. Where appropriate, the gravel will be excavated and screened. The oversize will be used as infill, the -2 mm will report to the sand mining operation, and the +2-32 mm fraction will be processed near the pit, to extract diamonds. The diamond potential exists across the entire Project area, but will initially be evaluated in the Main, Northern and East sand deposit area. Should diamond potential be established via the proposed drilling programme referred to above, the appropriate gravel fraction will be transported to an on-site processing plant to extract diamonds. The alluvial diamond mining process will commence as soon as the Mining Right is granted.

1.2.3 Mining Schedule and Project Phases

The yearly open pit mining schedule for the sand and aggregate deposits are indicated on Figure 1-5, with the areas indicated in Table 1-1. These are discussed below.

During Years 1 and 2, mining will consist only of excavating sand and aggregate at the locations as set out in the 30-year mining plan. The processes will include screening and crushing. Prospecting of diamonds will also occur during this time. The only infrastructure that will be constructed in the beginning of Year 1 will be roads, weighbridge, offices and a security check point. During this time other preparations may include the installation of the water supply line, electrical supply and cut-off trenches. The wash plant, drying plant, workshop, settling ponds and PCDs will be finalised for use in Year 3. Between Years 3 to 27, full production of sand and aggregate/gravel is expected during which the wash plant and drying plant will be in use. Depending on the outcome of the diamond prospecting, diamondiferous gravel may also be processed. During Years 27 to 30, production will decrease to meet closure targets at the end of Year 30.

Based on the above, the Project phases can be classified as follows:

- **Construction Phase:** Years 1 and 2 can be classified as the construction phase for specialised sand, in conjunction with mining activities for screened products only;
- **Operational Phase:** Years 3 to 30 will be the operational phase; and
- **Closure Phase:** The last three years will involve the lowering of production to achieve closure objectives and is classified as the closure phase.

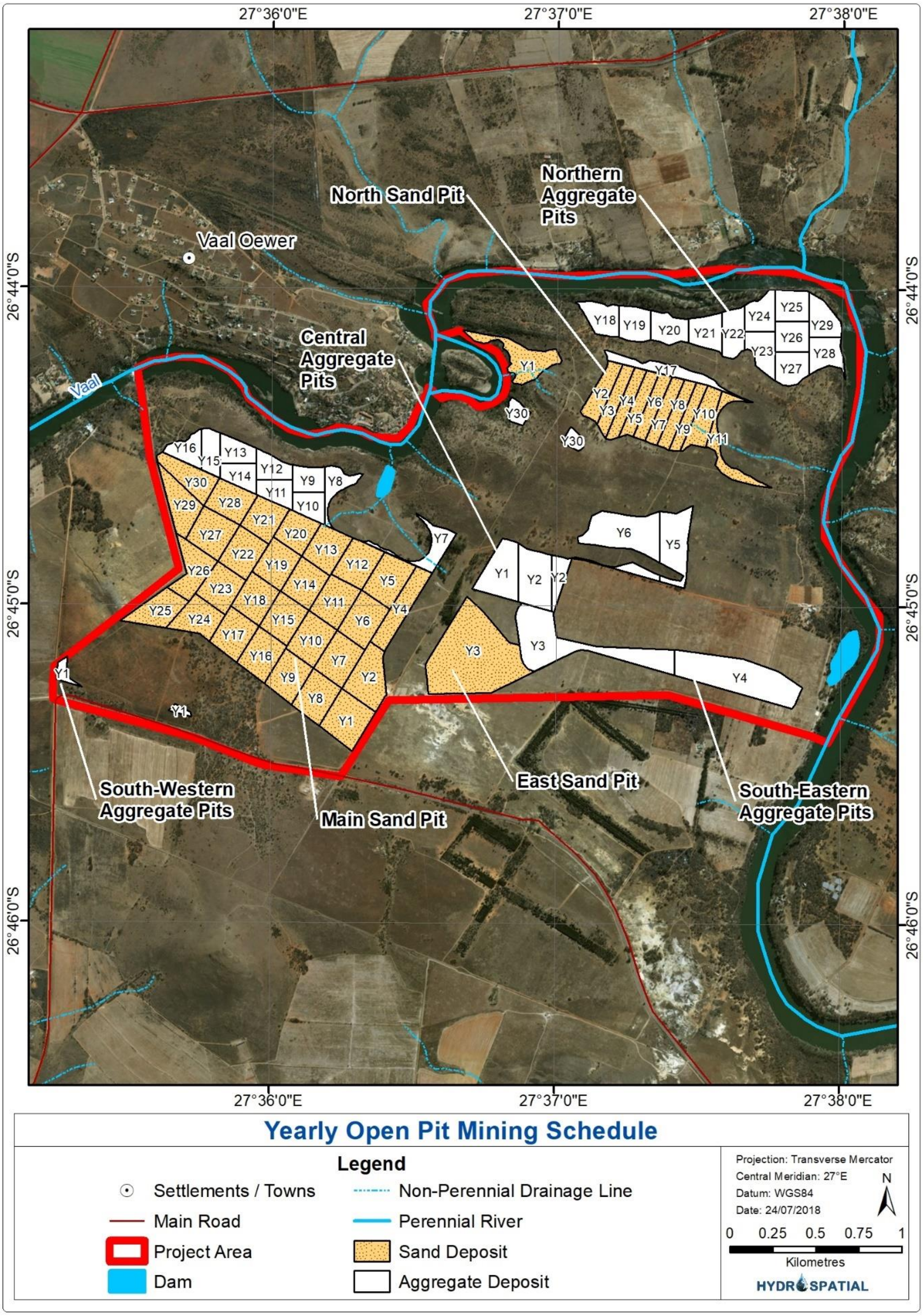

Figure 1-5: Yearly open pit mining schedule

Table 1-1: Open pit mining schedule areas

Mining Year	Sand Mining Area (m²)	Aggregate Mining Area (m²)
Y1	57 614	63 027
Y1	62 304	9 141
Y1	-	4 741
Y2	35 034	63 027
Y2	60 985	35 391
Y3	30 152	132 373
Y3	226 489	-
Y4	30 919	132 373
Y4	52 519	-
Y5	30 626	63 027
Y5	55 413	-
Y6	30 271	90 664
Y6	55 061	-
Y7	29 754	35 468
Y7	52 234	-
Y8	30 599	27 952
Y8	50 153	-
Y9	27 032	27 952
Y9	48 776	-
Y10	39 954	27 952
Y10	51 712	-
Y11	35 676	27 952
Y11	52 093	-
Y12	50 777	27 952
Y13	48 114	27 952
Y14	47 339	27 952
Y15	48 203	27 952
Y16	50 308	27 952
Y17	48 840	39 001
Y18	47 581	35 497
Y19	47 127	35 497
Y20	41 215	35 497
Y21	44 189	35 497
Y22	49 400	35 497
Y23	48 121	35 497
Y24	47 649	35 497
Y25	46 999	35 497
Y26	49 331	35 497
Y27	54 236	35 497
Y28	47 439	35 497
Y29	49 118	35 497
Y30	45 949	10 256
Y30	-	13 552

1.2.4 Water Demand and Sources

It is envisaged that water for mining purposes will be sourced from groundwater or abstracted from the Vaal River. The estimated annual water demand is as follows:

- 500 000 m^3 for sand mining;

- 300 000 m^3 for aggregate and diamond mining; and
- 10 000 m^3 for dust suppression.

It is estimated that the water demand for the wash plant would be approximately 800 - 1 000 m^3/hr. However, a planned water recycling plant (part of the wash plant) will reduce the demand to 80 – 100 m^3/hr (90 % reduction). It is expected that the water recycling plant will recycle more than 80 % of the water used in the washing process back to the plant for reuse.

A small volume of potable water will be required for the workshops, offices and change house.

An Integrated Water Use License Application (IWULA) and associated Water and Waste Water Management Plan (IWWMP) will be undertaken to obtain a Water Use Licence (WUL) from the Department of Water and Sanitation (DWS).

1.2.5 Employment and Operating Hours

Employment would constitute approximately 22 to 25 workers during the construction phase and approximately 48 to 50 full-time employees during the operational phase.

For mining activities, a 5.5 day work week with a 2 shift system is proposed. Operating hours would be from 06:00 to 18:00. For diamond sorting, a 6 day work week with a 2 shift system, operating 24 hours a day. The 24 hour shift for diamond sorting is being reconsidered as part of this Environmental Impact Assessment (EIA) phase.

1.2.6 Offices, Workshop and Change House

The offices, workshop, change house and dormitories will be established adjacent to the plant infrastructure. As per industry standard they will be portable in nature. The mine offices, workshops and change house will initially be in the form of portable containers or "Kwikspace" type facilities.

1.2.7 Sewage

Portable chemical toilets will be utilised and serviced regularly by external services providers during the construction and operational phases of the Project.

1.2.8 Waste and Storage of Dangerous Goods

General and hazardous industrial waste will be temporarily stored on-site in designated areas (waste/salvage yard), and disposed of at off-site permitted waste disposal facilities.

During the construction and operational phases, limited quantities of diesel fuel, oil and lubricants may be stored on-site. A maximum amount of 60 m^3 of diesel fuel may be stored in above ground diesel storage tanks with elevated bunded walls.

1.2.9 Roads

Existing farm roads will be utilised and may need to be widened to haul the resource from the pits to the plant. An access road will be established from the gate to the plant area and will be utilised throughout the life of the project. The Vaal Eden Road (S171), which forms the southern boundary of the project area, will be utilised during transporting of materials to and from site.

1.2.10 Post Mining Land Use

After mining, the closure objective is to develop the area as an eco-estate with residential and hospitality facilities on the banks of the Vaal River. The area is currently utilised as a game farm and for crop production.

1.3 Acid Base Accounting

1.4 Legislative Requirements and Guidelines

The following key legislative requirements and guidelines are relevant to this study:

- National Water Act, 1998 (Act No. 36 of 1998) (NWA);
- Government Notice No. 704 (GN704) of the NWA – Regulations on the Use of Water for Mining and Related Activities Aimed at the Protection of Water Resources;
- National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) and associated Environmental Impact Assessment (EIA) 2014 Regulations;
- Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA); and
- Department of Water and Sanitations (DWS) Best Practice Guideline (documents.

2 SCOPE OF WORK

The scope of work included the following:

- Description of the baseline (current) surface water hydrology in terms of water quality and quantity. The purpose of the baseline is to ensure that a thorough understanding of the pre-mining surface water conditions is provided;
- Development of a conceptual Stormwater Management Plan (SWMP) in accordance with the DWS Best Practice Guideline G1: Storm Water Management and GN R704 Regulations. The primary purpose of the SWMP is to ensure that clean (non-impacted water) and dirty water (mine impacted water) are clearly separated in accordance with the above-mentioned Guideline and Regulations;

- Determination of the 1:50 and 1:100 year floodlines. According to GN704 Regulations, no mine infrastructure should be developed within the floodlines;
- Development of a water balance according to the DWS Best Practice Guideline G2: Water and Salt Balances. The water balance will provide the sources and water volumes required for mining and human consumption;
- An assessment of the potential surface water impacts and possible mitigation measures; and
- Development of monitoring plans that can be used to monitor potential impacts resulting from the proposed mining area.

3 BASELINE HYDROLOGY

The primary purpose of this section is to provide the baseline (pre-mining) surface water description for the Project. It will also be used to inform the floodline determination, conceptual stormwater management plan and water balance.

3.1 Climate

The following sources of climatic data were investigated for use:

- South African Weather Service (SAWS) weather station data;
- Department of Water and Sanitation (DWS) weather station data;
- Lynch (2003) rainfall database;
- Design Rainfall and Flood Estimation in South Africa (Smithers and Schulze, 2002);
- Water Resources of South Africa, 2012 Study (WR2012); and
- The Food and Agriculture Organisation (FAO) New LocClim Local Climate Estimator software programme.

3.1.1 Rainfall

Daily rainfall depths were extracted from the Lynch (2003) database for the South African Weather Service (SAWS) station: Barrage (RWB) (0438315 W). The Daily Rainfall Extraction Utility software programme was used to extract the rainfall depths for the period 1920/1/1 to 2000/8/31 (79 years and 8 months of rainfall data). Although the Woodlands weather station (0438225 W) is the closest weather station to the site, the Barrage (RWB) weather station, which is located 7.2 kilometres (km) south-east of the site, had a longer rainfall record (82 years compared to 39 years), and a higher reliability in terms of observed rainfall. Rainfall from the Barrage (RWB) weather station was therefore adopted for this study.

The site has a Mean Annual Precipitation (MAP) of 680 mm. The total average monthly rainfall is indicated in Figure 3-1. The wettest months occur from October through to March, with the driest months occurring over the period of June to August. Rainfall is mostly in the form of convective thunderstorms, which are often brief, but regularly high in intensity. Tropical and frontal rainfall systems also occur in the region, but are not as common.

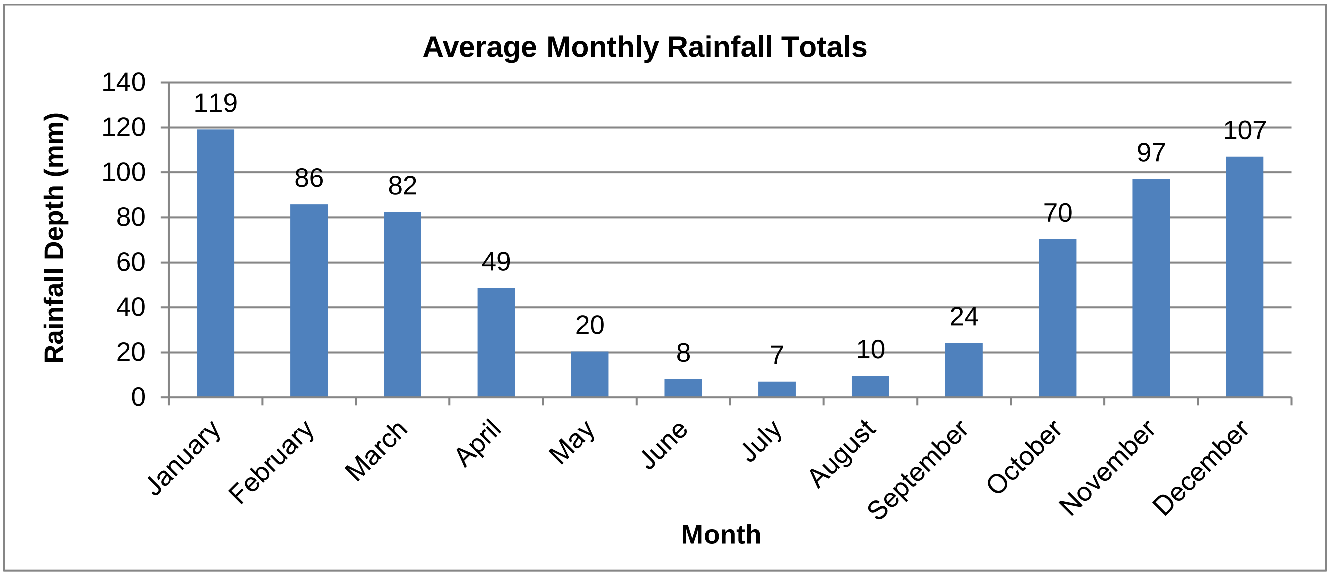

Figure 3-1: Average monthly rainfall totals for the Project

3.1.1.1 Storm Rainfall Depths

The storm rainfall depths for the centre position of the Project area were extracted from the Design Rainfall Estimation in South Africa software programme (Smithers and Schulze, 2002). The programme uses the six closest rainfall stations to a user specified coordinate, to calculate the storm rainfall depths for that area. The six closest rainfall stations to the Project area are indicated in Table 3-1.

Table 3-1: Six closest rainfall stations to the Project

Station Name	Station No.	Distance from Site (km)	Record (Years)	Latitude	Longitude	MAP (mm)	Altitude (mamsl)
WOODLANDS	0438225 W	1	39	26°45'S	27°37'E	633	1415
LINDEQUESDRIFT	0438134 W	5.7	32	26°44'S	27°34'E	619	1440
BARRAGE (RWB)	0438315 W	7.2	82	26°45'S	27°41'E	657	1420
WOOLDRIGDE	0438047 W	9.7	55	26°47'S	27°32'E	634	1470
ZANDFONTEIN	0438404 W	12.7	31	26°44'S	27°44'E	612	1418
GROENVLEI	0438323 W	14.5	46	26°52'S	27°41'E	561	1440

The extracted storm rainfall depths for the Project are indicated in Table 3-2.

Table 3-2: Storm rainfall depths for the Project

Storm Duration	Return Period / Storm Rainfall Depth (mm)						
min / hr / day	**1:2 yr**	**1:5 yr**	**1:10 yr**	**1:20 yr**	**1:50 yr**	**1:100 yr**	**1:200 yr**
5 min	8.6	11.5	13.4	15.3	17.8	19.6	21.5
10 min	12.6	16.7	19.6	22.3	25.9	28.6	31.3
15 min	15.6	20.9	24.3	27.7	32.2	35.6	38.9
30 min	19.9	26.5	31	35.3	41	45.3	49.6
45 min	22.9	30.6	35.7	40.7	47.2	52.1	57.1
1 hr	25.3	33.8	39.5	45	52.2	57.6	63.1
1.5 hr	29.2	38.9	45.4	51.8	60.1	66.3	72.7
2 hr	32.3	43	50.2	57.2	66.4	73.3	80.3
4 hr	38	50.7	59.2	67.5	78.3	86.4	94.7
6 hr	41.9	55.8	65.2	74.3	86.2	95.2	104.2
8 hr	44.8	59.7	69.8	79.5	92.2	101.9	111.6
10 hr	47.2	63	73.6	83.8	97.2	107.4	117.6
12 hr	49.3	65.8	76.8	87.5	101.5	112.2	122.8
16 hr	52.8	70.4	82.2	93.7	108.7	120.1	131.5
20 hr	55.7	74.2	86.7	98.8	114.6	126.6	138.6
24 hr	58.1	77.5	90.5	103.1	119.7	132.2	144.8
1 day	50.4	67.2	78.4	89.4	103.7	114.5	125.4
2 day	61.9	82.6	96.4	109.9	127.5	140.8	154.2
3 day	69.9	93.1	108.8	123.9	143.8	158.8	173.9
4 day	75.7	100.9	117.8	134.2	155.7	172	188.4
5 day	80.5	107.3	125.3	142.8	165.7	183	200.4
6 day	84.6	112.9	131.8	150.2	174.2	192.5	210.8
7 day	88.3	117.8	137.5	156.7	181.8	200.9	219.9

3.1.2 Evaporation

Monthly Symon's Pan evaporation was downloaded from the Department of Water and Sanitations (DWS) Hydrological Services website, for the Vaalplaats weather station (C2E001), located 7.3 km south-east of the Project. Symon's Pan evaporation measurements are not a true reflection of open water evaporation, as water temperatures in the Symonds Pan are higher than that of a natural open water body, resulting in higher evaporation rates. In order to convert Symon's Pan measurements to open water evaporation, a monthly open water evaporation conversion factor was used, which was obtained from the WR2012 study. The adopted monthly evaporation for the Project is indicated in Table 3-3.

Table 3-3: Symon's Pan and open water evaporation for the Project

Month	Symon's Pan Evaporation (mm)	Open Water Evaporation Factor	Open Water Evaporation (mm)
January	179	0.84	150
February	147	0.88	129
March	136	0.88	119
April	102	0.88	90
May	78	0.87	68
June	59	0.85	50
July	65	0.83	54
August	93	0.81	75
September	129	0.81	105
October	161	0.81	131
November	169	0.82	138
December	180	0.83	149
Total	**1498**	**N/A**	**1259**

3.1.3 Temperature

The average monthly temperatures for the Project were extracted using the nearest neighbour method from weather stations in the region, using the LocClim Local Climate Estimator software programme (FAO, 2005). Figure 3-2 indicates the minimum, average and maximum temperatures for the Project. The warmest months occur from October through to March. The coolest months occur over the period of May to August.

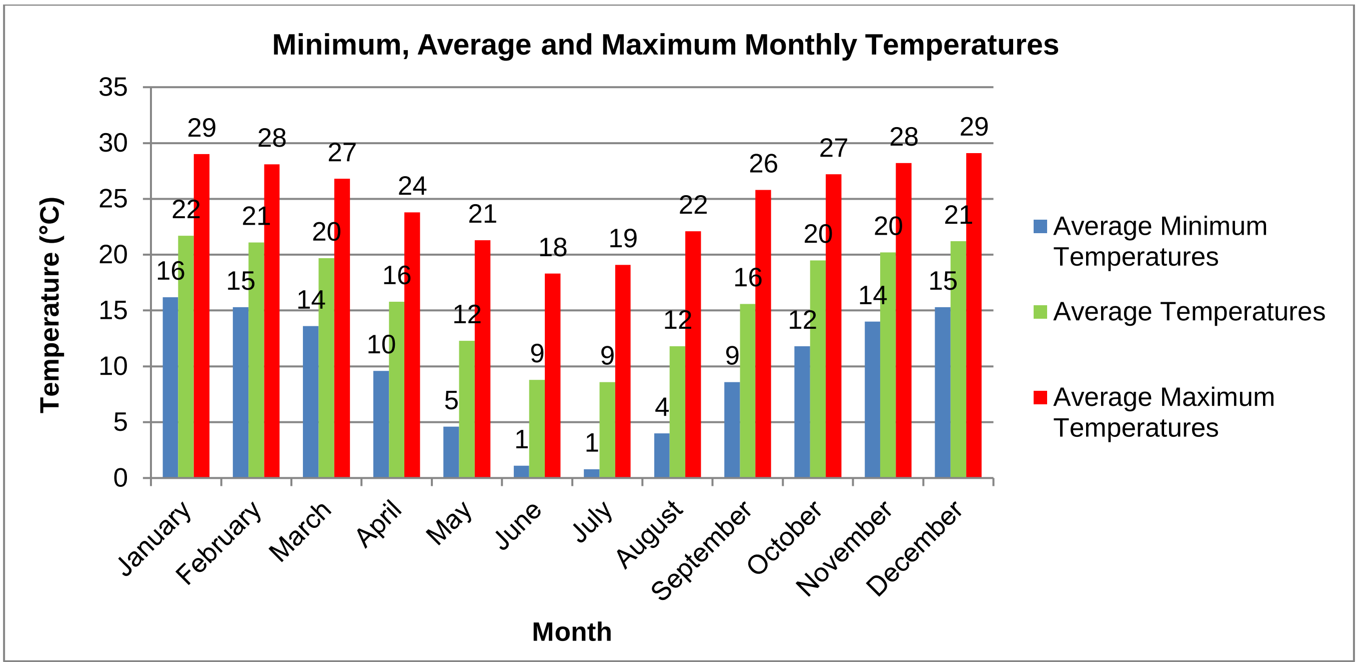

Figure 3-2: Minimum, average and maximum monthly temperatures for the Project

3.2 Hydrological Setting

The hydrological setting of the Project is described in this section.

3.2.1 Regional Catchments and Drainage

The DWS and the Surface Water Resources of South Africa studies (WR90, WR2005 and WR2012) have divided South Africa into primary, secondary, tertiary and quaternary catchments. Primary catchments are the largest defined catchments for South Africa, of which there are 22, and are assigned a letter ranging from A – X (excluding O). Secondary catchments are subdivisions of the primary catchments, and are the second largest catchments in South Africa, and are assigned the primary catchment letter within which they are located, and a number e.g. A5 (secondary catchment 5 located within primary catchment A). Similarly, tertiary catchments are subdivisions of secondary catchments, and are represented for example by A53 (tertiary catchment 3 located within secondary catchment A5). Lastly, quaternary catchments are the smallest defined catchments and are assigned the tertiary catchment number, along with a quaternary catchment letter e.g. A53D (quaternary catchment D located within tertiary catchment A53).

Further to the above, the DWS have divided South Africa into 9 Water Management Areas (WMAs), which are managed by separate Catchment Management Agencies (CMA). The 9 WMAs include the Limpopo, Olifants, Inkomati-Usuthu, Pongola-Mtamvuna, Vaal, Orange, Mzimvubu-Tsitsikamma, Breede-Gouritz and Berg-Olifants.

The Project is located in the Vaal WMA within quaternary catchment C23B (Figure 3-3). The Project area is drained by a number of non-perennial drainage lines into the Vaal River. The Vaal River is a tributary of the Orange River, which flows into the Atlantic Ocean at Alexander Bay.

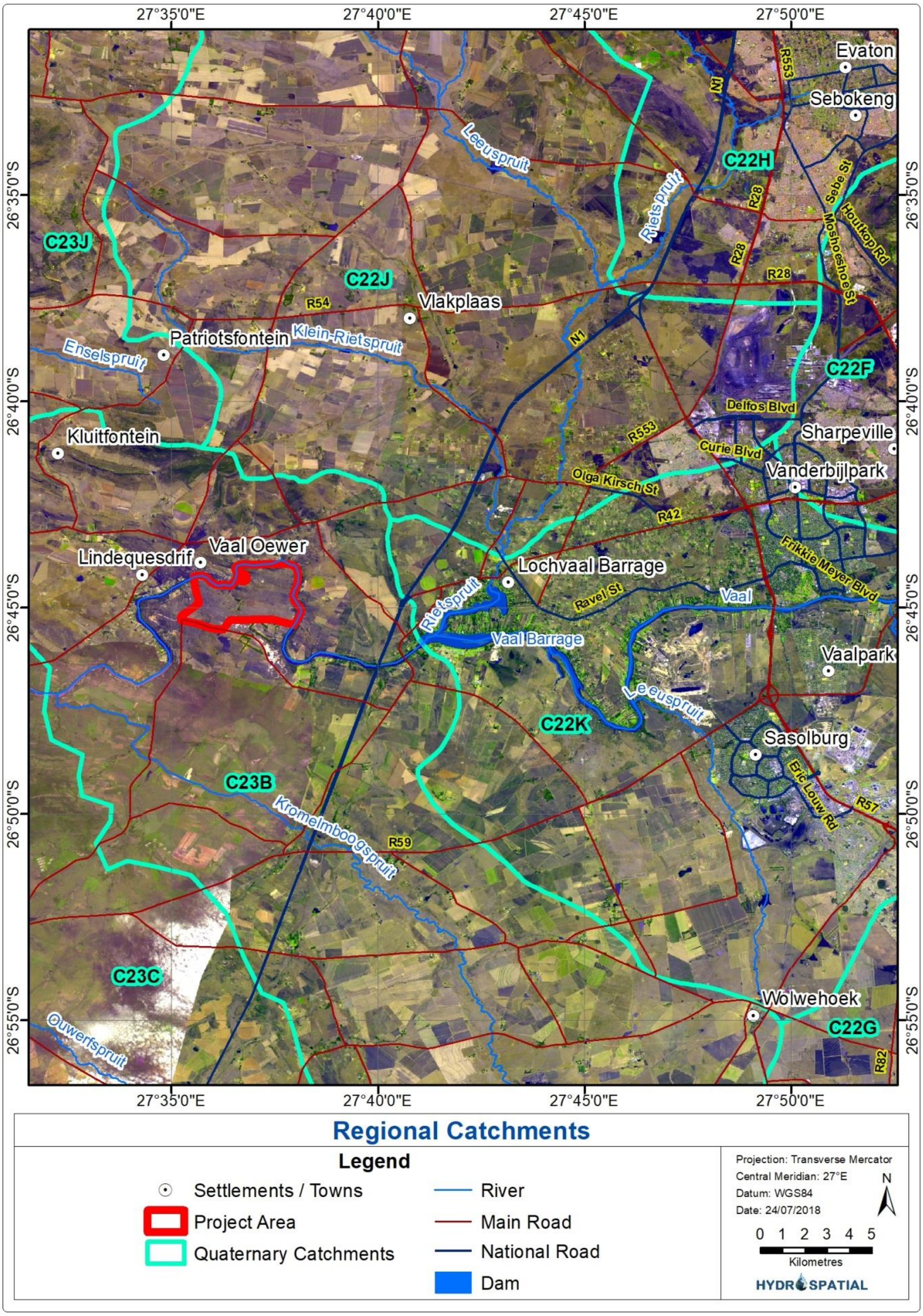

Figure 3-3: Regional catchments

3.2.2 Topography and Site-Specific Drainage

Elevation within the Project area varies from 1 470 metres above mean sea level (mamsl), along an elevated ridge which runs in an east to west direction through the site, to 1 406 mamsl along the Vaal River (Figure 3-4). A smaller ridge which reaches a height of 1 450 mamsl, is located directly north of the above-mentioned ridge and runs in the same direction.

A hill reaching a height of 1 520 mamsl is located immediately south of the project area and main road (Figure 3-4). Drainage from this hill is in a northerly direction towards a non-perennial drainage line located to the north of the proposed infrastructure. A small farm dam is located on this drainage line before it enters the Vaal River, and all surface drainage from the three proposed infrastructure alternative areas are captured in this dam. Three more non-perennial drainage lines are located within the Project area, and drain the elevated ridge located north-east of the proposed infrastructure. A further farm dam is located to the south-east of the Project area near the Vaal River.

3.2.3 Groundwater

The following was obtained from Pure Source Mine Groundwater report (Noa Agencies, 2018):

The groundwater levels vary from 2.5 m to 7 m across the proposed mining area, to a maximum depth of 20.5 metres below ground level (mbgl) to the south along the tar road. Further to the south of the tar road and proposed mining area, the average water table depth is 10 m below surface. The general groundwater flow direction is in a northerly direction towards the Vaal River. There is a strong possibility of good surface water-groundwater interaction, based on the shallow groundwater levels in the proposed mining area and the proximity of the Vaal River. The shallow groundwater table in the proposed mining area indicates the possibility of groundwater inflows into the sand and aggregate pits.

Elevated element concentrations recorded in the sampled groundwater are only elevated in one or two of the sampling points, mostly in the Vaal River and boreholes close to the river. Most of the salts and metals were present in concentrations below the SANS241 guideline limits. Based on the SANS241 drinking water guideline and on the sampled borehole water results, the groundwater sampled from the 9 boreholes are fit for human consumption (treatment still recommended). The sampled groundwater currently shows no negative impacts associated with the historical mining activities on the Pure Source Mine farm, or from the neighbouring sand mine operations.

3.2.4 Wetlands

According to the Wetland Scoping Report (TBC, 2018a), wetlands within the Project area will be associated with the non-perennial drainage lines.

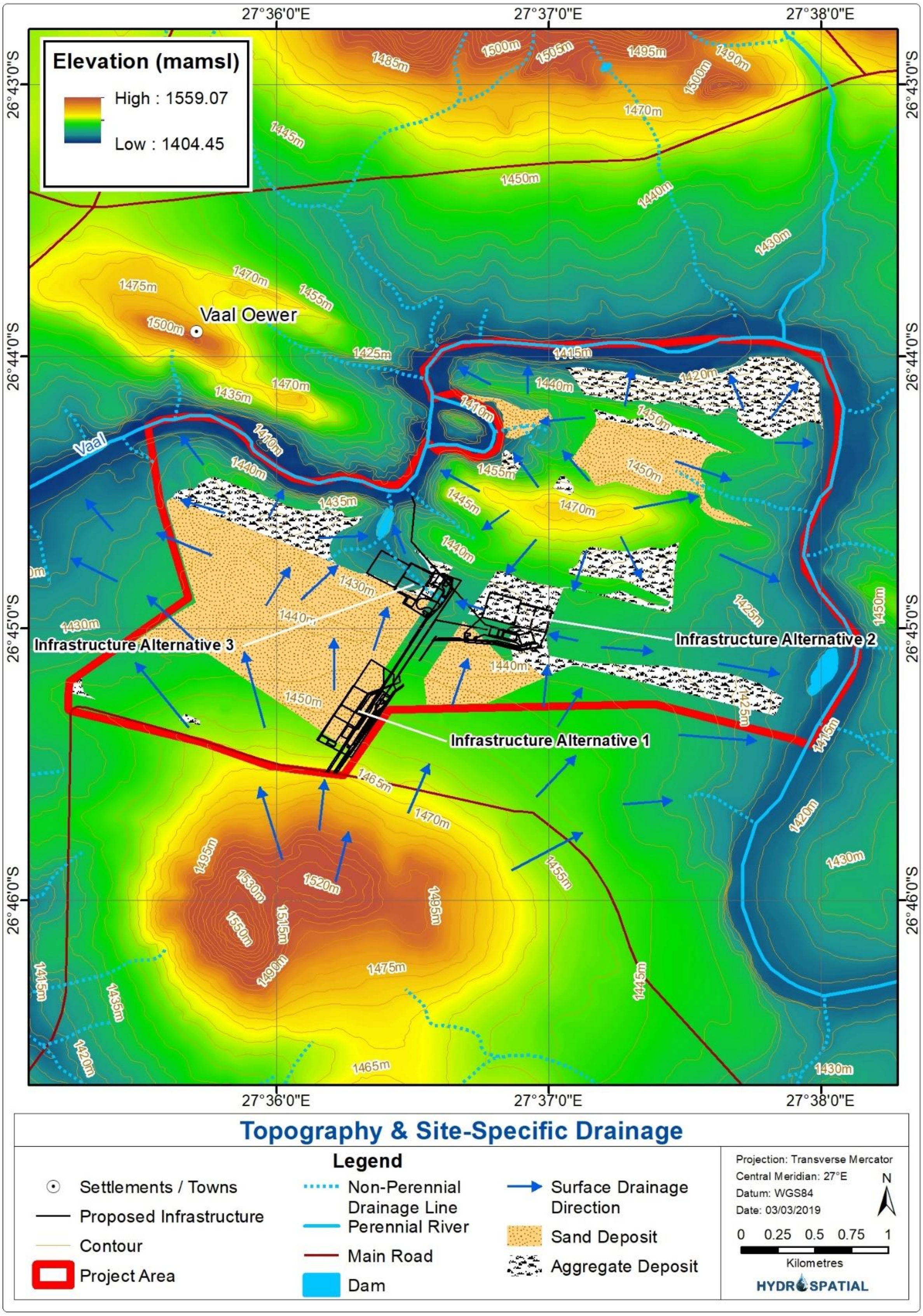

Figure 3-4: Topography and site-specific drainage

3.2.5 Soils

A soil delineation was undertaken by The Biodiversity Company (TBC). The northern section of the Project area consists mostly of Glenrosa and Clovelly soil forms, with the middle to southern section's consisting of Oakleaf, Hutton, Clovelly and Westleigh soil forms. Figure 3-5 indicates the delineated soils within the Project area, whilst Table 3-4 provides a description of their hydrological properties.

Table 3-4: Hydrological properties of the soils within the Project area

Soil Form	Soil Hydrological Group	Hydrological Properties
Mispah	C	Moderately high stormflow potential. Low infiltration rates (final infiltration +- 6 mm/h). Restricted permeability (1.3 to 3.8 mm/h). Poor drainage (frequently shallow soils).
Oakleaf	B	Moderately low stormflow potential. Moderate infiltration rates (final infiltration +- 13 mm/h). Moderate permeability (3.8 to 7.6 mm/h). Moderate drainage.
Westleigh	C	Moderately high stormflow potential. Low infiltration rates (final infiltration +- 6 mm/h). Restricted permeability (1.3 to 3.8 mm/h). Poor drainage (frequently shallow soils).
Avlon	B	Moderately low stormflow potential. Moderate infiltration rates (final infiltration +- 13 mm/h). Moderate permeability (3.8 to 7.6 mm/h). Moderate drainage.
Clovelly	A/B	Low to moderately low stormflow potential.
Fernwood	A	Low stormflow potential. High infiltration rates (final infiltration +- 25 mm/h). Rapid permeability (> 7.6 mm/h). Rapid drainage.
Glenrosa	B/C	Moderately low to moderately high stormflow potential.
Hutton	A	Low stormflow potential. High infiltration rates (final infiltration +- 25 mm/h). Rapid permeability (> 7.6 mm/h). Rapid drainage.
Longlands	C	Moderately high stormflow potential. Low infiltration rates (final infiltration +- 6 mm/h). Restricted permeability (1.3 to 3.8 mm/h). Poor drainage (frequently shallow soils).

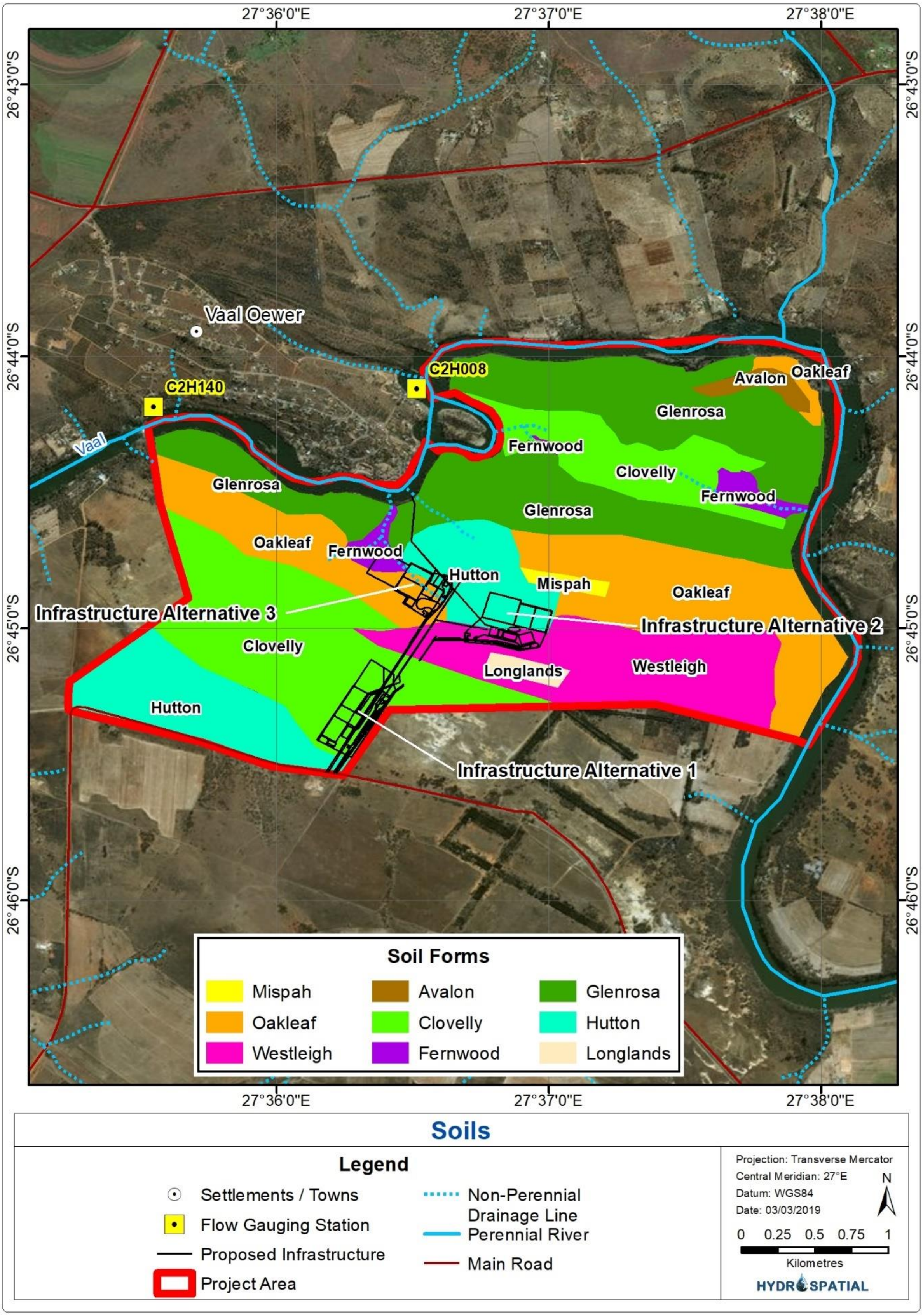

Figure 3-5: Soils within the Project area

3.2.6 Land Cover/Use

According to the 2013 – 2014 South African National Land Cover Dataset (Geoterraimage, 2015), the Project area consists mostly of grassland, with agricultural fields occurring towards the south. Thicker riparian vegetation occurs along the banks of the Vaal River. Beyond the Project area, the dominant land use is agriculture.

3.2.7 Surface Water Use

Surface water within the vicinity of the Project is mostly used for crop irrigation, livestock watering and recreational purposes such as water sports and fishing.

3.3 Surface Water Runoff

Two flow gauging stations are located within close proximity to the Project on the Vaal River. This includes flow gauging station C2H140, located at the north-western tip of the Project area, as well as flow gauging station C2H008, located directly north (Figure 3-5). Flow data for Station C2H140 was adopted to represent the runoff volumes for the Vaal River, as the gauge is located at the most downstream point of the Project, and has more recent data (October 1996 – February 2018), albeit having a shorter record than station C2H008 (September 1952 – October 1996).

Monthly runoff volumes for station C2H140 was downloaded from the DWS Hydrological Services website. The gauging station has a catchment area of 47 222 km^2. Missing data, particularly for months occurring within the years 2002 to 2004 was noted. The average monthly runoff volumes are indicated in Figure 3-6. Discharge is highest over the period of December to March, with the lowest discharge months occurring from July to September. It must be noted that flows within this section of the Vaal River is highly regulated by the upstream Vaal Barrage and Vaal Dam.

The non-perennial drainage lines that occur within the Project area are seasonal, and are only likely to flow in response to high rainfall during the summer months.

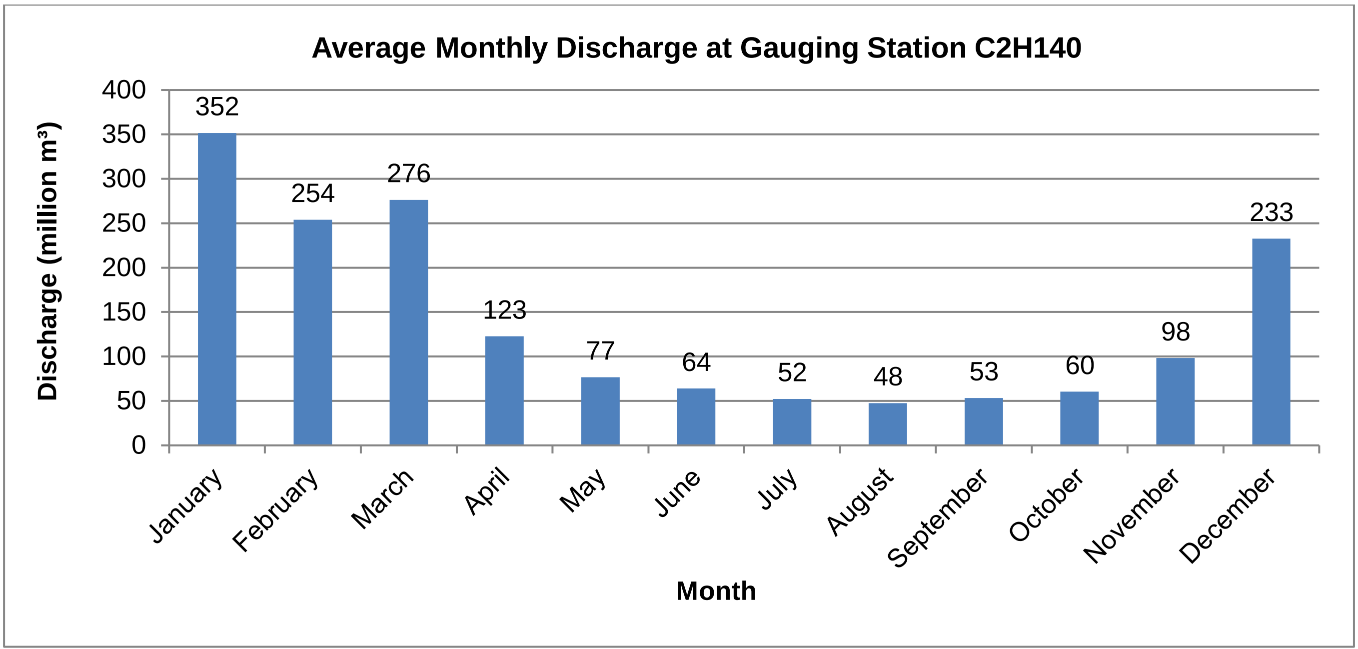

Figure 3-6: Average monthly runoff volumes for gauging station C2H140

3.4 Surface Water Quality

The surface water quality for the Project is discussed in this section in terms of the sampling date, sampling procedure, standards/guideline limits selected, sampling locations and results.

3.4.1 Sampling Date and Site Conditions

Surface water quality sampling was conducted on the site visit on 1 August 2018. Site conditions can be described as dry, windy and dusty at the time of sampling.

3.4.2 Sampling Procedure and Handling

Water quality sampling was conducted according to the following:

- DWS Best Practice Guideline G3: Water Monitoring Systems;
- ISO 5667-2: 1991 Part 2: Guidance on sampling techniques;
- ISO 5667-3: 2003 Part 3: Guidance on preservation and handling of samples; and
- ISO 5667-6: 2005 Part 6: Guidance on sampling of rivers and streams.

Sample bottles were collected from Aquatico Laboratory prior to the site visit. This included 500 ml bottles for chemical analysis and 100 ml sterile bottles for bacteriological analysis. All 500 ml bottles were rinsed thoroughly with the sample water before taking the sample. The sterile bottles do not require rinsing. Samples were taken using a grab sampling technique in areas where good mixing of water was noted. The sample bottles were immediately stored in a cooler box with frozen ice packs, out of direct sunlight. The samples were kept cool at all times and were transported to Aquatico Laboratory (SANAS accredited) within 24 hours of sampling for analysis.

3.4.3 Water Quality Standards/Guidelines and Parameters

The laboratory results were compared to the following standards and guideline limits:

- The South African National Standards (SANS) 241:2015 Drinking Water Quality. This standard is generally used for comparison purposes, albeit providing stringent limits that are required for drinking water purposes. The limits provided in the SANS 241:2015 Drinking Water Quality standards are separated into the following risks:
    - <u>Acute health:</u> Parameter that poses immediate unacceptable health risk if consumed with water at concentration values exceeding the specified limit;
    - <u>Aesthetic:</u> Parameter that taints water with respect to taste, odour and colour, and that does not pose an unacceptable health risk if present at concentration values exceeding the specified limit;
    - <u>Chronic health:</u> Parameter that poses an unacceptable health risk if ingested over an extended period if present at concentration values exceeding the specified limit; and
    - <u>Operational:</u> Parameter that is essential for assessing the efficient operation of treatment systems and risks to infrastructure.
- South African Water Quality Guidelines (SAWQG) Volume 4: Agricultural Use: Irrigation. This guideline was selected as surface water in the vicinity of the Project is used for agricultural irrigation;
- SAWQG Volume 5: Agricultural Use: Livestock Watering. This guideline was selected as surface water in the vicinity of the Project is used for livestock watering; and
- SAWQG Volume 2: Recreational Use. This guideline was selected as the Vaal River is used for recreational purposes.

The Classes and Resource Quality Objectives (RQOs) of Water Resources for Catchments of the Upper Vaal (Government Gazette No. 39943, 22 April 2016) was examined for water quality RQOs on the Vaal River downstream of the Project. The closest biophysical node was EWR5 located approximately 100 km downstream of the Project. The only parameter specified for this site was for *E.coli* (≤ 130 counts/100 ml). Due to the limited parameters specified for EWR5, and the fact that *E.coli* did not form part of the sampling parameters analysed, the RQOs were not used for comparison purposes in this study.

The parameters that were selected for laboratory analysis are indicated in Table 3-6.

3.4.4 Sampling Locations

The surface water quality sampling locations are provided in Table 3-5 and indicated on Figure 3-7. Samples were taken at upstream and downstream points of the Project, as well as from an old mined out sand pit within the Project area. Long-term (01/05/1996 to 09/04/2018) water quality for the DWS monitoring point 90688 (C2H140Q01) was extracted from the National Water Management System database.

Table 3-5: Details of the surface water sampling points

Sampling Point & Coordinates*	Description	Photograph of Sampling Point
SW1 26°45'22.561"S 27°37'55.848"E	Located upstream of the Project on the Vaal River.	
SW2 26°44'17.088"S 27°35'35.347"E	Located downstream of the Project on the Vaal River near gauging weir C2H140.	
SW3 26°45'6.793"S 27°36'17.334"E	Located in an old mined out sand pit.	
DWS Monitoring Point 90688 (C2H140Q01) 26°44'16.800"S 27°35'30.984"E	DWS monitoring point located at the gauging weir C2H140.	

*Coordinates are displayed as degrees, minutes and seconds in a geographical (latitude and longitude) coordinate system using the WGS 1984 datum

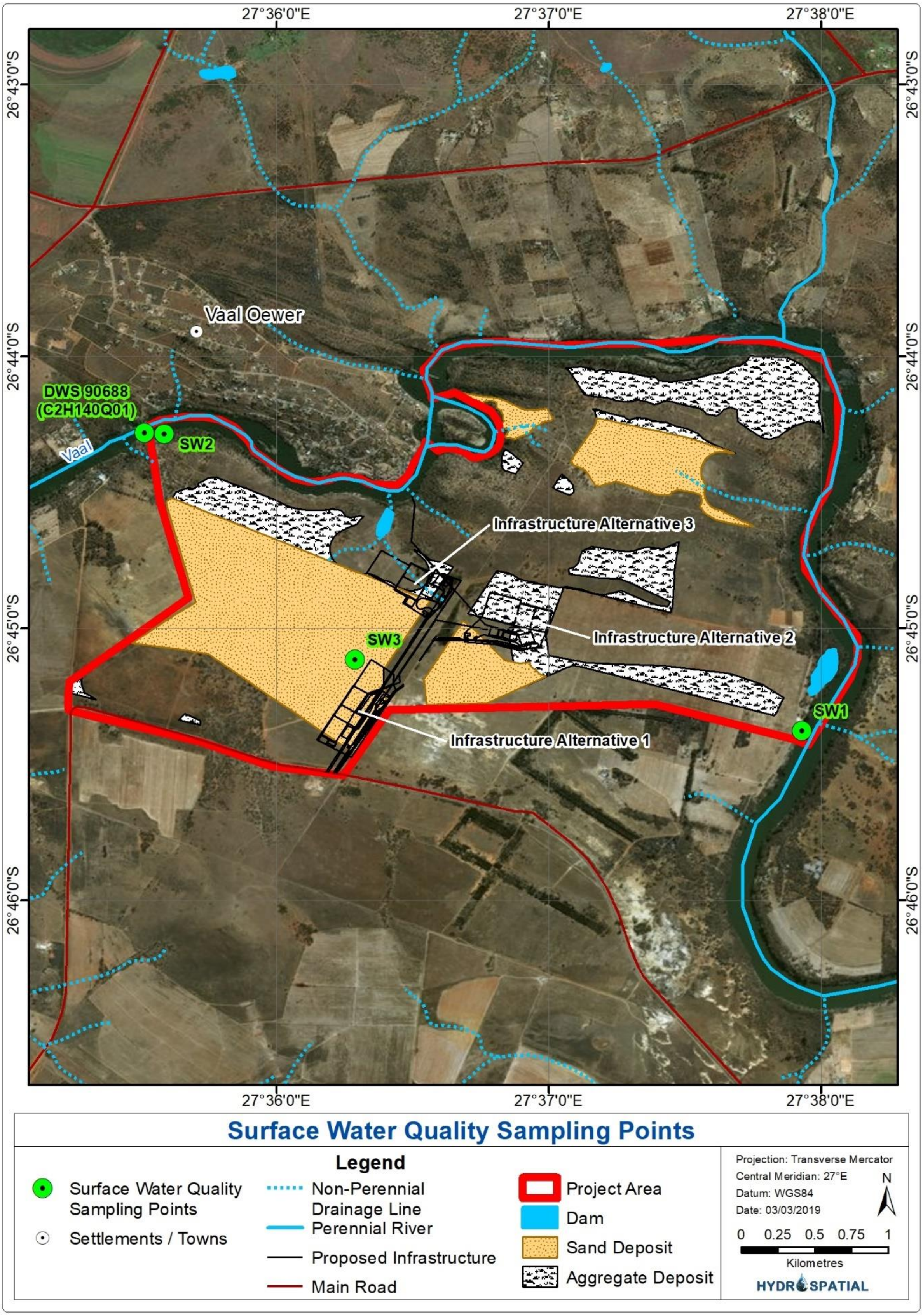

Figure 3-7: Surface water quality sampling points

3.4.5 Results

The surface water quality results are presented below. The water quality laboratory certificate is provided in Appendix A.

3.4.5.1 Site Visit Sampling Results

The surface water quality results for sampling undertaken on the site visit on 1 August 2018 are indicated in Table 3-6 (laboratory certificate provided in Appendix A). The median water quality concentrations for long term monitoring (01/05/1996 to 09/04/2018) at the DWS site 90688 (C2H140Q01) is also indicated in Table 3-6.

The water quality is summarised as follows:

- pH was within limits at all sampling points. The water quality in the Vaal River can be described as being alkaline;
- Electrical Conductivity (EC) and Total Suspended Solids (TDS) exceeded the SAWQG limits for irrigation at the sampling points along the Vaal River, but were within the SANS 241:2015 and SAWQG limits for livestock watering. The irrigation guideline limits for EC and TDS can be considered stringent in comparison to the other guideline limits;
- Turbidity exceeded the SANS 241:2015 limits at all monitoring points. This is expected as the Vaal is naturally turbid with fairly high Total Suspended Solids (TSS);
- Metal concentrations (aluminium, iron, zinc, lead, copper, cadmium, chromium, etc.) were all within limits;
- The median value for long-term monitoring of combined nitrate and nitrite exceeded the SANS 241:2015 limits at the DWS monitoring point 90688 (C2H140Q01). This indicates that elevated nutrients can be expected in the Vaal River; and
- Faecal coliforms exceeded the SAWQG limits for irrigation at all sampling points and was particularly elevated at SW2. The exceedance of faecal coliforms in the Vaal River is expected, as upstream sewage treatment plants are known to discharge raw sewage on a regular basis.

Table 3-6: Surface water sampling quality

Parameter	Units	Standard/Guideline Water Quality Limits					Sampling/Monitoring Points & Water Quality			
		SANS 241:2015 Drinking Water Quality Limits – Risk	SANS 241:2015 Drinking Water Quality Limits – Limit/s	SA Water Quality Guideline Limits Recreational Use	SA Water Quality Guideline Limits Agricultural Use: Irrigation	SA Water Quality Guideline Limits Agricultural Use: Livestock Watering	SW1	SW2	SW3	DWS 90688 (C2H140Q01) (Median Value)
pH – Value at 25°C	pH Units	Operational	≥ 5 to ≤ 9.7	≥ 6.5 to ≤ 8.5	≥ 6.5 to ≤ 8.4	-	8.04	8.11	7.78	8.15
Electrical Conductivity (EC) at 25°C	mS/m	Aesthetic	≤ 170	-	≤ 40	≤ 153	79.9	79.3	12.8	72.70
Total Dissolved Solids (TDS) at 180°C	mg/l	Aesthetic	≤ 1 200	-	≤ 260	≤ 1000	493	488	81	510
Total Suspended Solids (TSS)	mg/l	-	-	-	≤ 50	-	21	15	12	-
Turbidity	NTU	Operational Aesthetic	≤ 1 ≤ 5	-	-	-	14.7	11.9	12.8	-
Total Alkalinity as CaCO3	mg/l	-	-	-	-	-	149	146	13.3	118
Total Hardness as CaCO3	mg/l	-	-	-	-	-	260	255	42	-
Chloride as Cl	mg/l	Aesthetic	≤ 300	-	≤ 100	≤ 1500	45.5	45.6	2.93	57.32
Sulphate as SO_4	mg/l	Acute health	≤ 500	-	-	≤ 1000	175	174	9.38	146.55

Parameter	Units	Standard/Guideline Water Quality Limits					Sampling/Monitoring Points & Water Quality			
		SANS 241:2015 Drinking Water Quality Limits		SA Water Quality Guideline Limits Recreational Use	SA Water Quality Guideline Limits Agricultural Use: Irrigation	SA Water Quality Guideline Limits Agricultural Use: Livestock Watering	SW1	SW2	SW3	DWS 90688 (C2H140Q01) (Median Value)
		Risk	Limit/s							
		Aesthetic	≤ 250							
Fluoride as F	mg/l	Chronic health	≤ 1.5	-	≤ 2	≤ 2	0.27	0.286	<0.263	0.32
Nitrate as N	mg/l	Acute health	≤ 11	-	-	≤ 100	3.87	4.41	8.9	-
Combined Nitrate and Nitrite	mg/l	Acute health	≤ 1	-	-	-	-	-	-	1.81
Faecal Coliforms	Count/100ml	-	-	≤ 130	≤ 1	≤ 200	9	47	10	-
Ammonium as N	mg/l	-	-	-	-	-	1.48	0.875	0.159	0.048
Orthophosphate as P	mg/l	-	-	-	-	-	0.262	0.274	<0.005	0.25
Sodium as Na	mg/l	Aesthetic	≤ 200	-	≤ 70	≤ 2000	62.7	61	4.09	56.81
Potassium as K	mg/l	-	-	-	-	-	10	9.78	3.42	10.50
Calcium as Ca	mg/l	-	-	-	-	≤ 1000	65.4	64.3	9.13	55.50
Magnesium as Mg	mg/l	-	-	-	-	≤ 500	23.4	23	4.56	20.58
Aluminium as Al	mg/l	Operational	≤ 0.3	-	≤ 5	≤ 5	<0.002	<0.002	<0.002	-
Cadmium as Cd	mg/l	Chronic health	≤ 0.003	-	≤ 0.01	≤ 0.01	<0.002	<0.002	<0.002	-

Parameter	Units	Standard/Guideline Water Quality Limits					Sampling/Monitoring Points & Water Quality			
		SANS 241:2015 Drinking Water Quality Limits		SA Water Quality Guideline Limits Recreational Use	SA Water Quality Guideline Limits Agricultural Use: Irrigation	SA Water Quality Guideline Limits Agricultural Use: Livestock Watering	SW1	SW2	SW3	DWS 90688 (C2H140Q01) (Median Value)
		Risk	Limit/s							
Total Chromium as Cr	mg/l	Chronic health	≤ 0.05	-	-	-	<0.003	<0.003	<0.003	-
Copper as Cu	mg/l	Chronic health	≤ 2	-	≤ 0.2	≤ 0.5	<0.002	<0.002	<0.002	-
Iron as Fe	mg/l	Chronic health	≤ 2	-	≤ 5	≤ 10	<0.004	<0.004	<0.004	-
		Aesthetic	≤ 0.3							-
Lead as Pb	mg/l	Chronic health	≤ 0.01	-	≤ 0.2	≤ 0.1	<0.004	<0.004	<0.004	-
Manganese as Mn	mg/l	Chronic health	≤ 0.4	-	≤ 0.02	≤ 10	0.027	<0.001	0.008	-
		Aesthetic	≤ 0.1							-
Nickel as Ni	mg/l	Chronic health	≤ 0.07	-	≤ 0.02	≤ 1	0.002	<0.002	<0.002	-
Cobalt as Co	mg/l	-	-	-	≤ 0.05	≤ 1	<0.003	<0.003	<0.003	-
Zinc as Zn	mg/l	Aesthetic	≤ 5	-	≤ 1	≤ 20	0.008	0.01	<0.002	-

*<: Below laboratory detection limit

3.4.5.2 DWS Long-Term Water Quality Trends

The long-term (01/05/1996 to 09/04/2018) surface water quality for DWS monitoring point 90688 (C2H140Q01) was extracted from the National Water Management System database. Water quality trends for TDS, EC, pH and combined nitrate and nitrite are indicated in Figure 3-8, Figure 3-9, Figure 3-10 and Figure 3-11 respectively.

Trends in TDS and EC indicated elevated levels over the low flow months of the year, when dilution is at its lowest. The maximum recorded TDS concentration is 747.6 mg/l, with the maximum recorded EC being 105.5 mS/m.

Long-term trends in pH indicated that pH fluctuates from a minimum recording of 6.96, to a maximum recording of 9.2 (all readings within the SANS 241:2015 limits).

Combined nitrate and nitrite indicated trends similar to TDS and EC, with elevated levels occurring over the low flow months of the year. An increasing trend in levels is noted from 2011, with spikes higher than any previous years occurring in 2015, 2016 and 2017. The maximum recorded level is 6.52 mg/l.

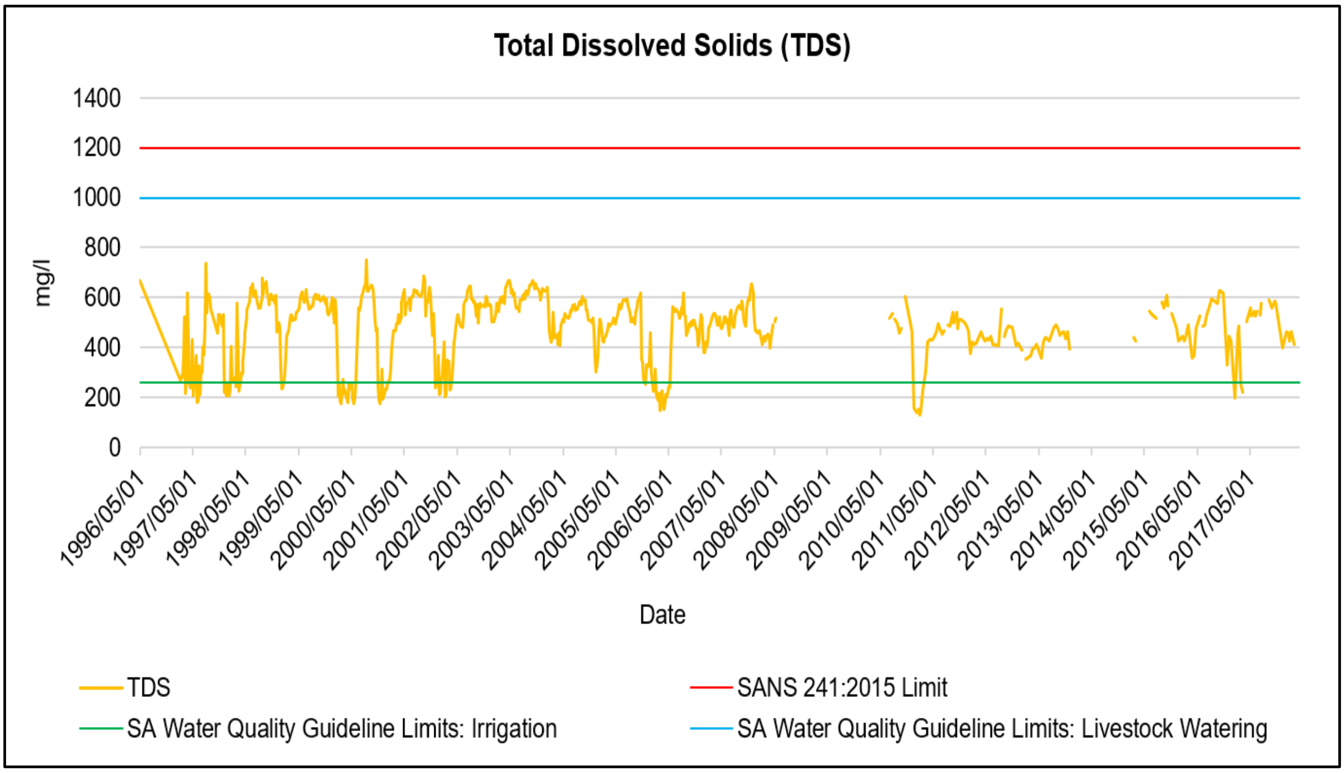

Figure 3-8: Long-term water quality trends in TDS

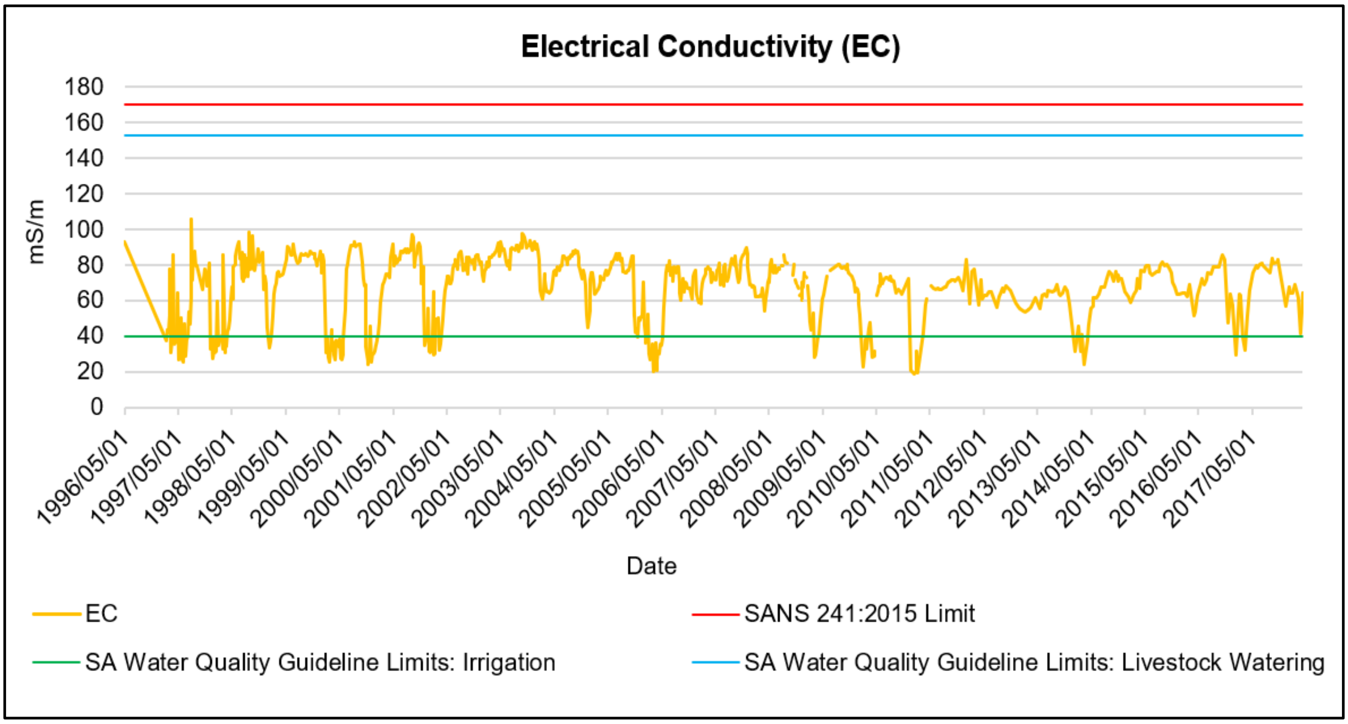

Figure 3-9: Long-term water quality trends in EC

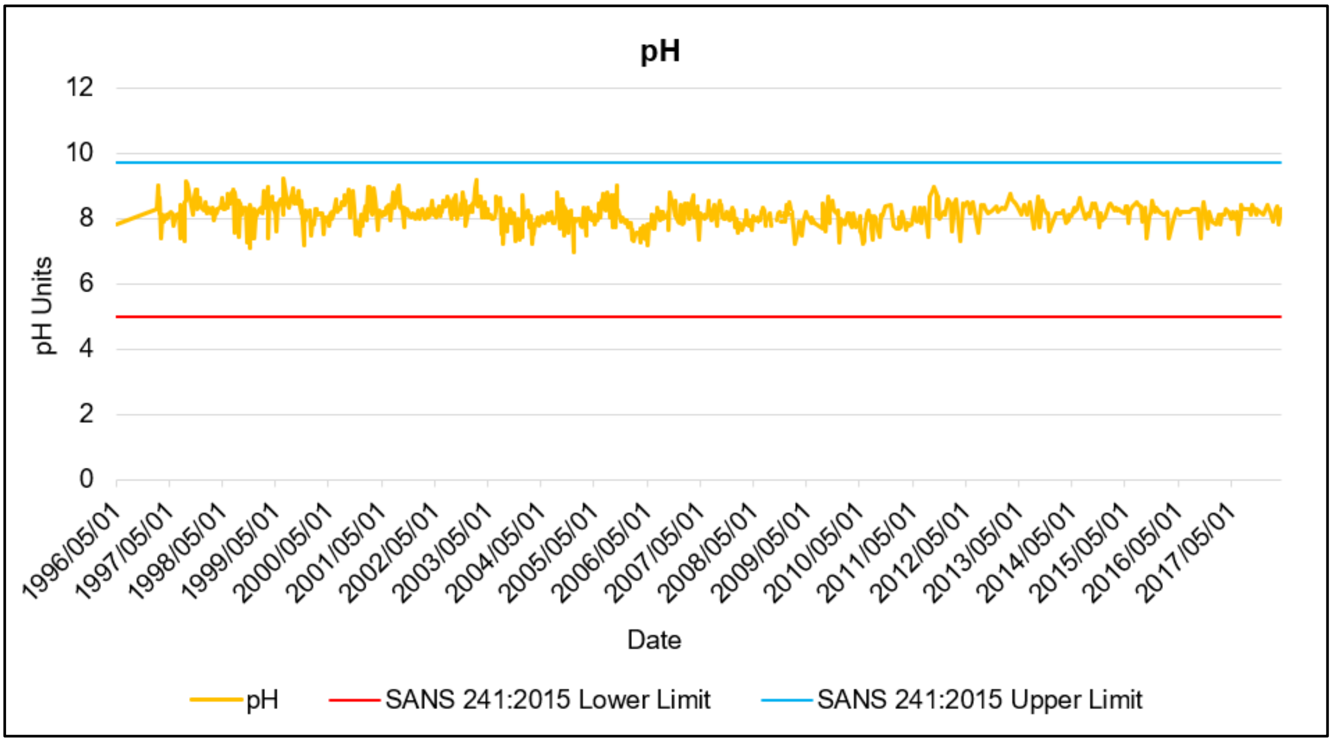

Figure 3-10: Long-term water quality trends in pH

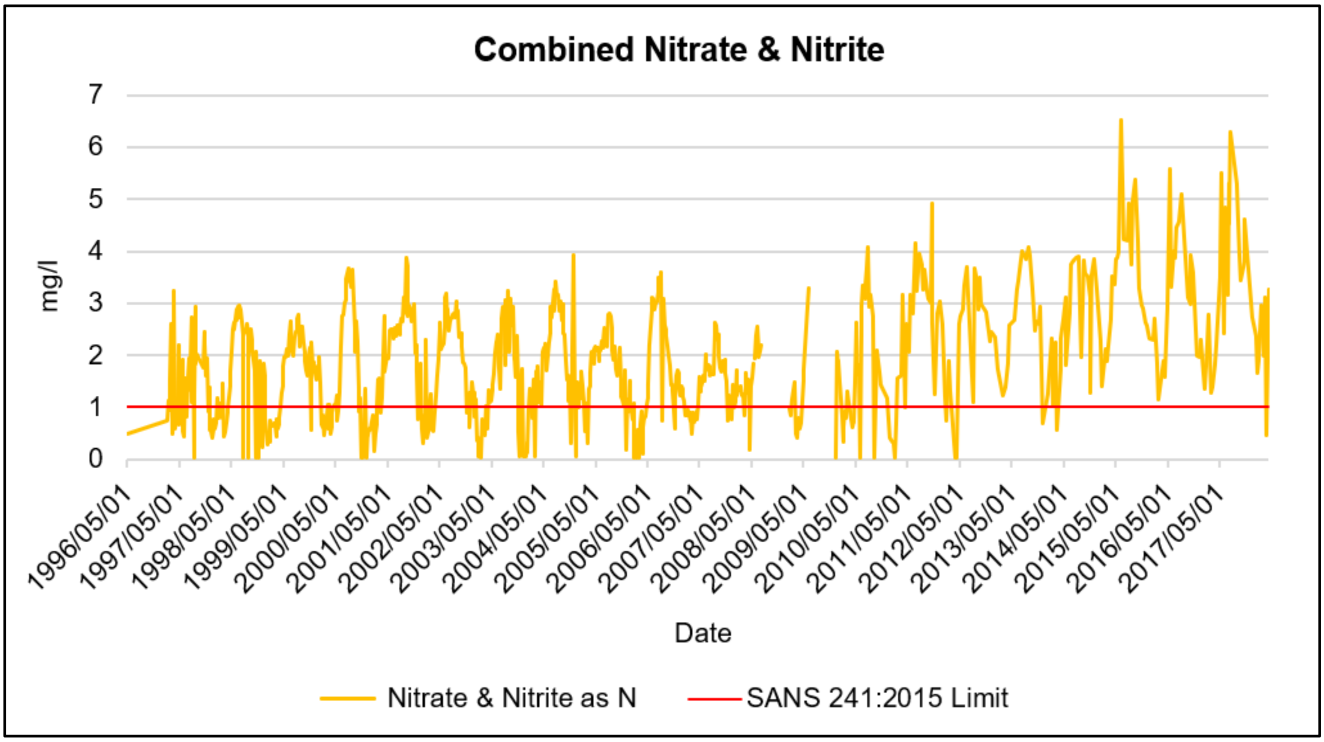

Figure 3-11: Long-term water quality trends in combined nitrate and nitrite

4 FLOODLINE DETERMINATION

According to Regulation 4 of GN704, no person in control of a mine or activity may –

(a) Locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year floodline or within a horizontal distance of 100 metres from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on water-logged ground, or on ground likely to become water-logged, undermined, unstable or cracked; and
(b) Carry on any underground or opencast mining or prospecting or any other operation or activity under or within the 1:50 year floodline or within a horizontal distance of 100 m from any watercourse or estuary, whichever is the greatest.

The purpose of this section is to determine 1:50 and 1:100 year floodlines, as well as the 100 m buffer of watercourses, to identify mining activities that may be at risk of flooding, and to ensure compliance with GN704.

4.1 Methodology and Data Sources

The methodology and data sources used to determine the floodlines is discussed in this section.

4.1.1 Elevation Data

Elevation data in the form of 1 m contour intervals covering the Project area was sourced from the client. The contours were used to generate a 1 m spatial resolution Digital Terrain Model (DTM). The DTM was used to extract the longitudinal and cross-sectional stream and floodplain elevations. The DTM was further used in the post processing to undertake floodplain delineations.

4.1.2 Catchments

The contributing catchments of the watercourses were delineated from the abovementioned 1 m contours. For catchment areas extending beyond the Project area (where 1 m contours were not available), 5 m contours obtained from the Chief Directorate: National Geo-spatial Information were used.

4.1.3 Land Cover and Soils

Land cover and soil data form an important component in the hydrological assessment undertaken to calculate the peak flows. The land cover and soils are discussed under section 3.2 of this report.

4.1.4 Manning's Roughness Coefficients

The Manning's roughness coefficients are values that represent the channel and adjacent floodplains resistance to flow. The Manning's roughness was assessed during the site investigation. A Manning's roughness coefficient of 0.06 was used to represent the channels and floodplain areas of the non-perennial drainage lines, as these areas were dominated by dense grassland and shrubs. For the Vaal River, a Manning's roughness coefficient of 0.035 was used for the main channel, whilst for the banks and floodplain areas 0.06 was used. This was in agreement with the SRK (2005) study.

4.1.5 Peak Flows

The peak flows for the Vaal River were obtained from the Woodlands 407 50- and 100-Year Floodline report (SRK, 2005). The peak flows for the non-perennial drainage lines within the Project area were calculated using the Rational Method which is described below. The contributing catchment areas and peak flow points are indicated on Figure 4-1.

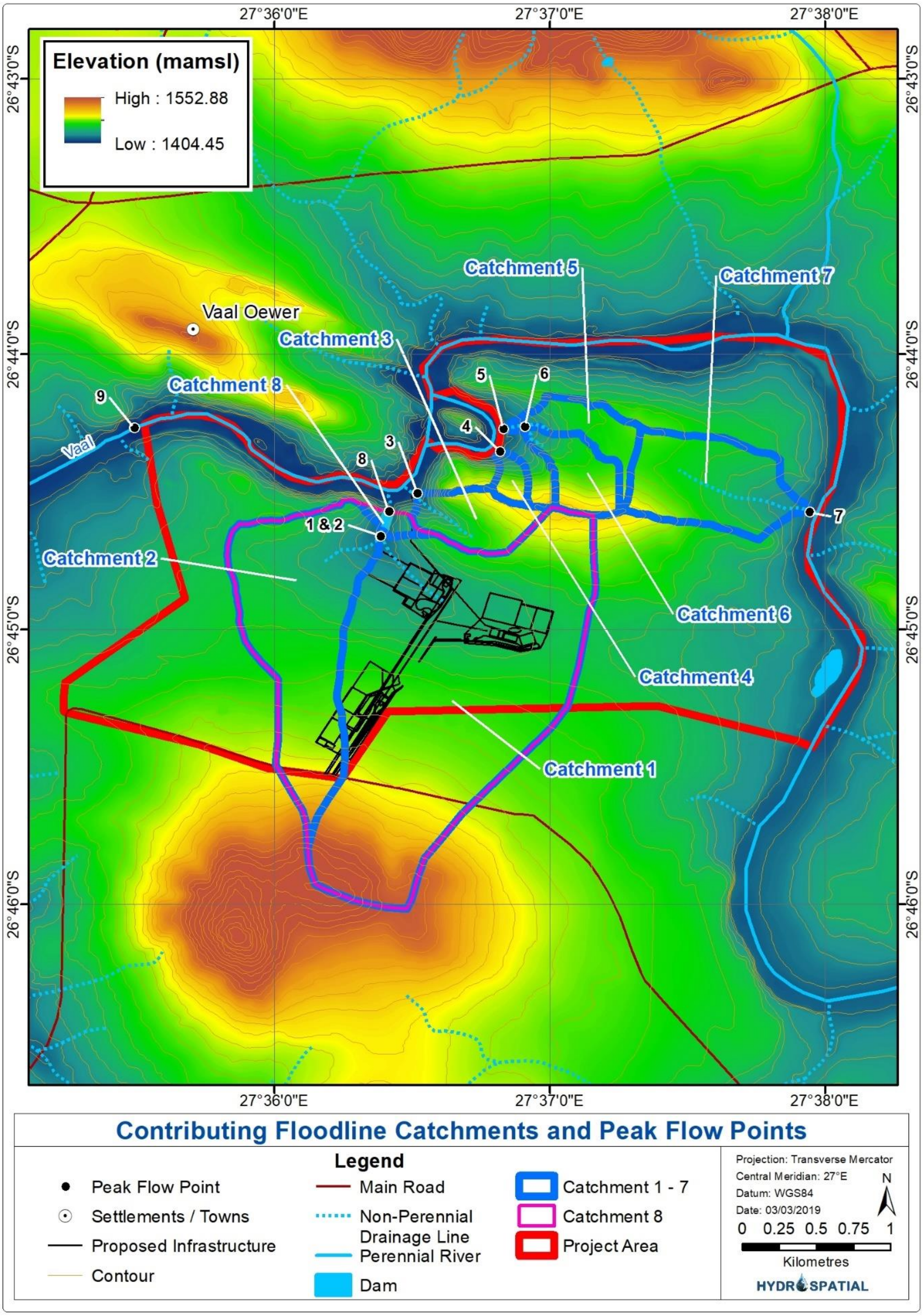

Figure 4-1: Floodline catchments and peak flow points

The Rational Method is a hydrological method that was used to estimate the 1:50 and 1:100 year peak flows. It is based on the following equation:

$$Q_T = \frac{C\ I\ A}{3.6}$$

where:

Q_T = Peak flow for a recurrence interval e.g. a 1:100 year flood (m^3/s)

C = Runoff coefficient (dimensionless)

I = Average rainfall intensity over the catchment (mm/hour)

A = Catchment area contributing to the peak flow (km^2)

3.6 = Conversion factor

The runoff coefficient "C" is calculated by specifying the percentage area covered by different physical characteristics of the contributing catchment. This includes the vegetation, slope, soil permeability and land use characteristics.

The average rainfall intensity "I" was calculated by dividing the gridded storm rainfall depths obtained from Smithers and Schulze (2002) by the time of concentration (Tc). The Tc is the amount of time it takes for water to travel from the hydraulically most remote point in the contributing catchment to the catchment outlet. It is essentially the amount of time for runoff in the catchment to contribute to the peak flow.

The contributing catchment area "A" was calculated by delineating a catchment for the peak flow point from the DTM in ArcMap 10.2. The delineated catchments are indicated on Figure 4-1.

A Microsoft Excel spreadsheet (Gericke and du Plessis, 2013) was used to perform the calculations based on the South African National Roads Agency Limited (SANRAL) procedure (SANRAL, 2013).

The Rational Method is based on the following key assumptions:

- Rainfall has a uniform area distribution across the total contributing catchment;
- Rainfall has a uniform time distribution for at least a duration equal to the Tc;
- The peak discharge occurs when the total catchment contributes to the flow occurring at the end of the critical storm duration, or Tc;
- The runoff coefficient "C" remains constant for the storm duration, or Tc; and
- The return period of the peak flow is the same as that of the rainfall intensity.

The Rational Method is recommended for catchments smaller than 15 km^2, however, it has been successfully applied to larger catchments in South Africa as shown in Gericke and du Plessis (2013).

4.1.6 Software Choice

The following software's were used:

- ArcMap 10.2 is a GIS software programme used to view, edit, create and analyse geospatial data. ArcMap was used to view spatial data and to create maps. Its extension 3D Analyst was used for terrain modelling purposes, for converting the contour data into a DEM grid format;
- HEC-GeoRAS utilises the ArcMap environment and is used for the preparation of geometric data (cross-sections, river profile, banks and flow paths) for input into the HEC-RAS hydraulic model. It is further used in post processing to import HEC-RAS results back into ArcMap, to perform flood inundation mapping; and
- HEC-RAS 4.1 (Brunner, 2010) was used to perform hydraulic modelling. HEC-RAS is a hydraulic programme used to perform one-dimensional hydraulic calculations for a range of applications, from a single watercourse to a full network of natural or constructed channels.

4.1.7 Hydraulic Model Setup

Development of the hydraulic model included the following steps:

- Preparation of geometric data (cross-sections, stream centre line, bank lines and flow paths) in HEC-GeoRAS;
- Importing of geometric data into HEC-RAS;
- Entering HEC-RAS model parameters such as the Manning's roughness coefficients, boundary conditions, peak flows and hydraulic structures (dam walls and weir);
- Performing steady, mixed flow (combination of subcritical, supercritical, hydraulic jumps and drawdowns) modelling within HEC-RAS to calculate the flood water elevations at cross-sections; and
- Importing flood level elevations at cross-sections into HEC-GeoRAS to perform floodplain delineations.

4.2 Results

4.2.1 Peak Flows

The catchment characteristics, parameters and calculated peak flows are indicated in Table 4-1.

Table 4-1: Catchment characteristics, parameters and calculated peak flows

Catchment	Peak Flow Point	MAP (mm)	Catchment Area (km²)	Longest Water-course (km)	Average Slope of Longest Water-course (m/m)	1:50 Year Runoff Coefficient	1:100 Year Runoff Coefficient	Tc (hrs)	1:50 Year Rainfall Intensity (mm/h)	1:100 Year Rainfall Intensity (mm/h)	Peak Flow Method	1:50 Year Peak Flow (m³/s)	1:100 Year Peak Flow (m³/s)
Catchment 1	1	680	2.814	0.70	0.021	0.313	0.378	0.88	56.6	62.5	Rational	13.9	18.5
Catchment 2	2	680	1.100	0.41	0.035	0.283	0.341	0.69	66.0	72.9	Rational	5.7	7.6
Catchment 3	3	680	0.238	0.49	0.072	0.336	0.405	0.76	62.2	68.7	Rational	1.4	1.8
Catchment 4	4	680	0.056	0.20	0.116	0.371	0.447	0.36	100.0	110.5	Rational	0.6	0.8
Catchment 5	5	680	0.194	0.31	0.055	0.301	0.363	0.52	79.3	87.6	Rational	1.3	1.7
Catchment 6	6	680	0.206	0.24	0.050	0.337	0.406	0.53	78.9	87.2	Rational	1.5	2.0
Catchment 7	7	680	0.534	0.56	0.039	0.282	0.340	0.69	66.4	73.3	Rational	2.8	3.7
Catchment 8	8	680	3.954	0.70	0.021	0.313	0.378	0.88	56.6	62.5	Rational	19.5	25.9
Vaal River	9	-	-	-	-	-	-	-	-	-	-	3 800*	5 600*

* Peak flows obtained from the Woodlands 407 50- and 100-Year Floodline report (SRK, 2005)

4.2.2 Floodlines and 100 m Watercourse Buffer

The 1:50 and 1:100 year floodlines as well as the 100 m watercourse buffer are indicated on Figure 4-2. The following proposed infrastructure and pits are potentially at risk of flooding, and fall within the floodlines and/or 100 m watercourse buffer:

- Majority of infrastructure alternative 3 (water supply line, PCD, settling ponds, fuel storage area, raw product stockpile, etc.);
- Central aggregate pit and aggregate pits to the west;
- Main sand pit;
- North sand pit and sand pit directly to the west;
- Aggregate pits to the west of the main sand pit; and
- Northern aggregate pits.

4.3 Recommendations

The following is recommended:

- An alternative water supply pipeline route which avoids as much of the 1:100 year floodline should be investigated. Should it not be possible to avoid the floodline, then the pipeline should be constructed above the 1:100 year floodline; and
- Proposed infrastructure and pits listed above, should as far as possible be located outside of the floodlines and 100 m watercourse buffer, whichever is the greatest (as required by GN704 Regulations). Should this not be possible, then a GN704 exemption from the DWS must be obtained for infrastructure and pits located within the floodlines and 100 m watercourse buffer, prior to any construction works or mining.

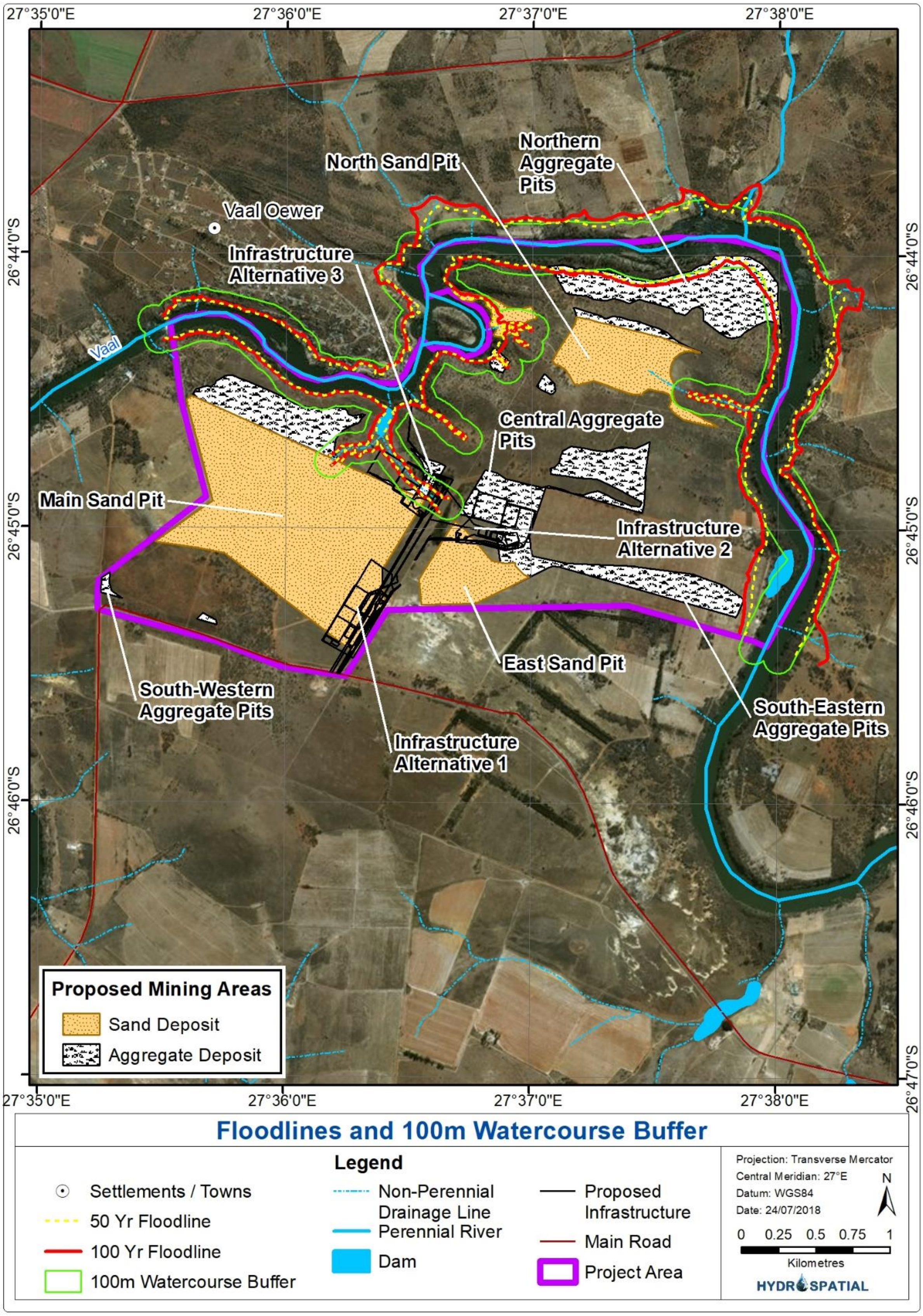

Figure 4-2: Floodlines and 100m watercourse buffer

5 CONCEPTUAL STORMWATER MANAGEMENT PLAN

The purpose of the conceptual SWMP is to ensure that clean and dirty water are adequately separated, by diverting clean water away from dirty areas, and ensuring that dirty water from the operation is captured, contained and managed appropriately in accordance with GN704 Regulations.

5.1 Terminology

The following definitions are relevant to the SWMP. These are provided here for clarity, as they are commonly referred to in this section of the report:

- **Activity:** Any mining related process on the mine including the operation of washing plants, mineral processing facilities, mineral refineries and extraction plants; the operation and the use of mineral loading and off-loading zones, transport facilities and mineral storage yards, whether situated at the mine or not; in which any substance is stockpiled, stored, accumulated, dumped, disposed of or transported;
- **Clean area:** This refers to any area at or near a mine or activity, which is unlikely to cause pollution of a water resource, but has the potential to become contaminated by mining activities if not managed appropriately;
- **Clean water system:** This includes any dam, other form of impoundment, canal, works, pipeline and any other structure or facility constructed for the retention or conveyance of clean unpolluted water;
- **Dam:** This includes any return water dam, settling dam, tailings dam, evaporation dam, catchment or barrier dam and any other form of impoundment used for the storage of unpolluted water or water containing waste;
- **Dirty area:** This refers to any area at a mine or activity which causes, has caused or is likely to cause pollution of a water resource (i.e. generate contaminated water as a result of mining activities);
- **Dirty water system:** This includes any dam, other form of impoundment, canal, works, pipeline, residue deposit and any other structure or facility constructed for the retention or conveyance of water containing waste; and
- **Watercourse:** This is defined in the NWA as -
  - A river or spring;
  - A natural channel in which water flows regularly or intermittently;
  - A wetland, lake or dam into which, or from which, water flows; and
  - Any collection of water which the Minister may, by notice in the *Gazette,* declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

5.2 Design Philosophy

The following design philosophy was adopted to guide the development of the SWMP, and is based on GN704 Regulations and the DWS Best Practice Guideline (BPG) G1: Storm Water Management:

- Confine or divert any unpolluted water to a clean water system, away from a dirty area;
- Runoff from dirty areas must be captured, contained and managed appropriately;
- Clean and dirty water systems must be designed and constructed to prevent cross contamination;
- Dirty water must, as far as possible, be recycled and reused, or treated and discharged;
- Clean and dirty water systems must convey/contain runoff from the 50 year storm event, and should not lie within the 100 year floodline or within a horizontal distance of 100 m from any watercourse, whichever is the greater of the two; and
- Appropriate maintenance and management of stormwater related infrastructure should always be ensured.

5.3 Assumptions and Limitations

The following are key assumptions and limitations for the conceptual SWMP:

- Infrastructure alternative 1 was the only alternative considered in the design of the SWMP, as it is the most favourable alternative;
- The SWMP and associated calculations are based on the current infrastructure layout. Should the infrastructure layout change, then the SWMP will need to be amended; and
- The channels were sized to take the maximum flow calculated at the downstream end of the contributing catchment, and it is assumed that the channel sizing will be uniform along the entire length.

5.4 Clean and Dirty Areas

Dirty areas include the following:

- Mine infrastructure area (PCD, settling ponds, wash plant, fuel storage area, raw product stockpile, drying plant, etc.); and
- Open pit mining areas.

Clean areas include all areas surrounding the abovementioned dirty areas.

5.5 Proposed Stormwater Measures and Conceptual Designs

The proposed SWMPs for the mine infrastructure area and open pits are discussed below.

5.5.1 Mine Infrastructure Area

The proposed SWMP and clean and dirty areas for the mine infrastructure area is indicated on Figure 5-2. The SWMP has been designed as a closed system (i.e. no discharge of dirty water to the environment) and is discussed below.

It is proposed that a clean cut off trench is constructed to capture upslope clean water runoff and to convey it around the mine infrastructure area (dirty area). The cut-off trench should be trapezoidal in shape, with side slopes of 1V:2H (Figure 5-1). The cut off trench does not need to be lined, but should be vegetated with indigenous grass species to prevent erosion. It is further proposed that lined trapezoidal dirty water channels are constructed on the eastern and western sides of the infrastructure area, to capture dirty water runoff from the operation, and to convey it to the PCD. It is expected that the PCD will be lined. The soil excavated from the channels must be placed between the clean cut off trench and dirty water channel, to create a separation berm between clean and dirty areas. The berm must be vegetated to prevent erosion. It is further proposed that the cut off trench exit points are lined with riprap consisting of large and small rocks, in order to dissipate flow velocity, preventing downslope erosion.

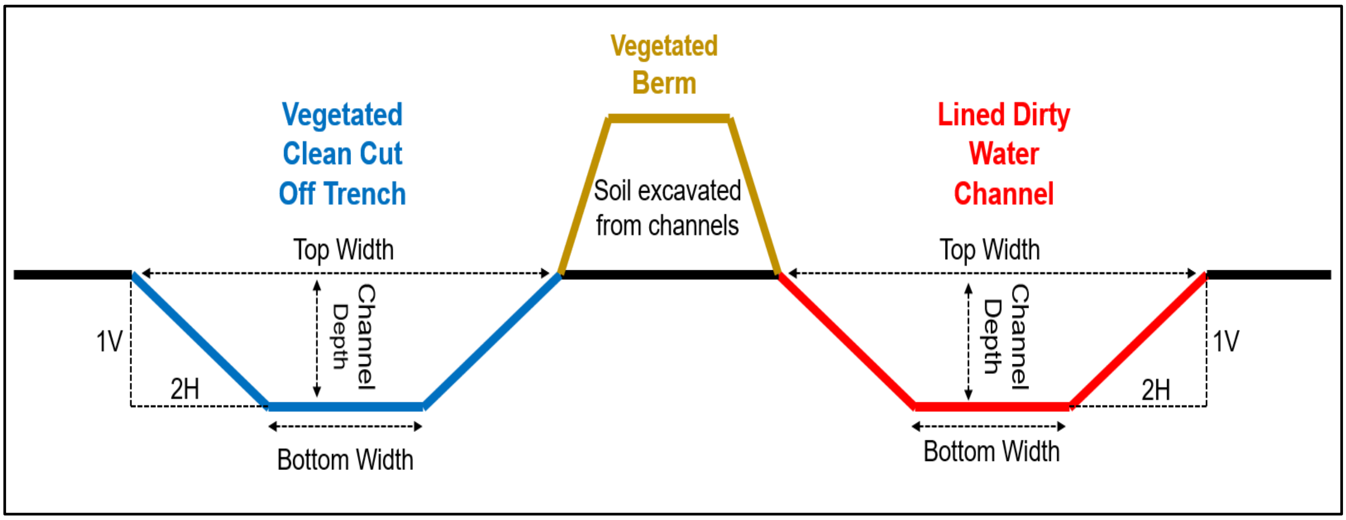

Figure 5-1: Proposed trench/channel and berm design

Due to the high sediment loads expected in the runoff from the infrastructure area, silt traps are proposed at the dirty water channel entrances to the PCD. At the points were the mine roads will cross the channels, culverts are proposed.

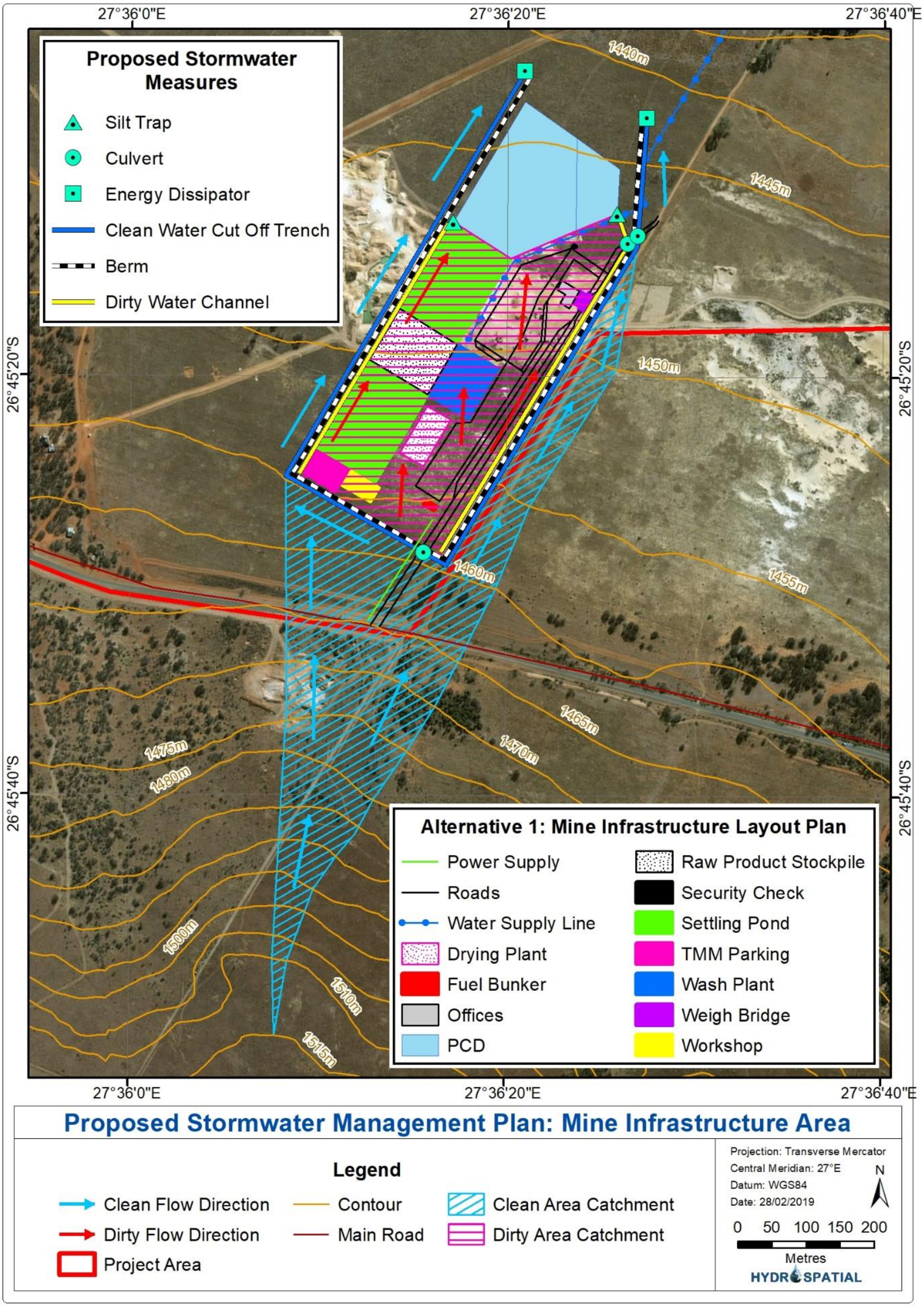

Figure 5-2: Proposed stormwater management plan and clean and dirty areas

GN704 requires that the clean and dirty water systems are designed, constructed, maintained and operated so that they do not spill more than once in 50 years. The Rational Method (described under 4.1.5) was used to calculate the 1:50 year peak flows, whilst the Manning's Equation was used to size the clean and dirty channels. The Manning's equation is described below:

$$Q = A\frac{1}{n}R^{2/3}S^{1/2}$$

Where:

Q = Peak flow (m^3/s)

A = Cross sectional area of the channel (m^2)

R = Hydraulic radius (m)

S = Longitudinal slope of channel (m/m)

n = Manning's roughness coefficient 'n'

A Mannings 'n' roughness coefficient of 0.030 was used for the grassed clean water cut off trench, whilst a roughness coefficient of 0.017 was used for the dirty water channels, as they are expected to be concrete lined.

A summary of the proposed channel sizes is provided in Table 5-1.

Table 5-1: Proposed sizing of the clean water cut-off trench and dirty water channels

Trench/Channel	Catchment Area (km^2)	1:50 Year Peak Flow (m^3/s)	Channel Length Slope (m/m)	Bottom Width* (m)	Top Width* (m)	Channel Depth* (m)	Velocity (m/s)
Clean water cut off trench	0.143	1.06	0.023	0.5	2.1	0.8	3.1
Dirty water channel	0.115	1.60	0.021	0.5	2.5	1.0	2

*See Figure 5-1

5.5.2 Open Pit Mining Areas

For the open pit mining areas, it is proposed that for each mining year block, the stripped top soils are placed around the pit to create a perimeter berm. This should be done to ensure that clean water runoff from the adjacent areas does not potentially become contaminated by entering the pit, but rather that it is diverted around the pit. Figure 5-3 provides an example of the proposed stormwater measures for open pit mining year 3.

Further to the above, any proposed washing of sand and aggregate at the pits, should take place within the pits, to avoid unnecessary contamination of surrounding water resources.

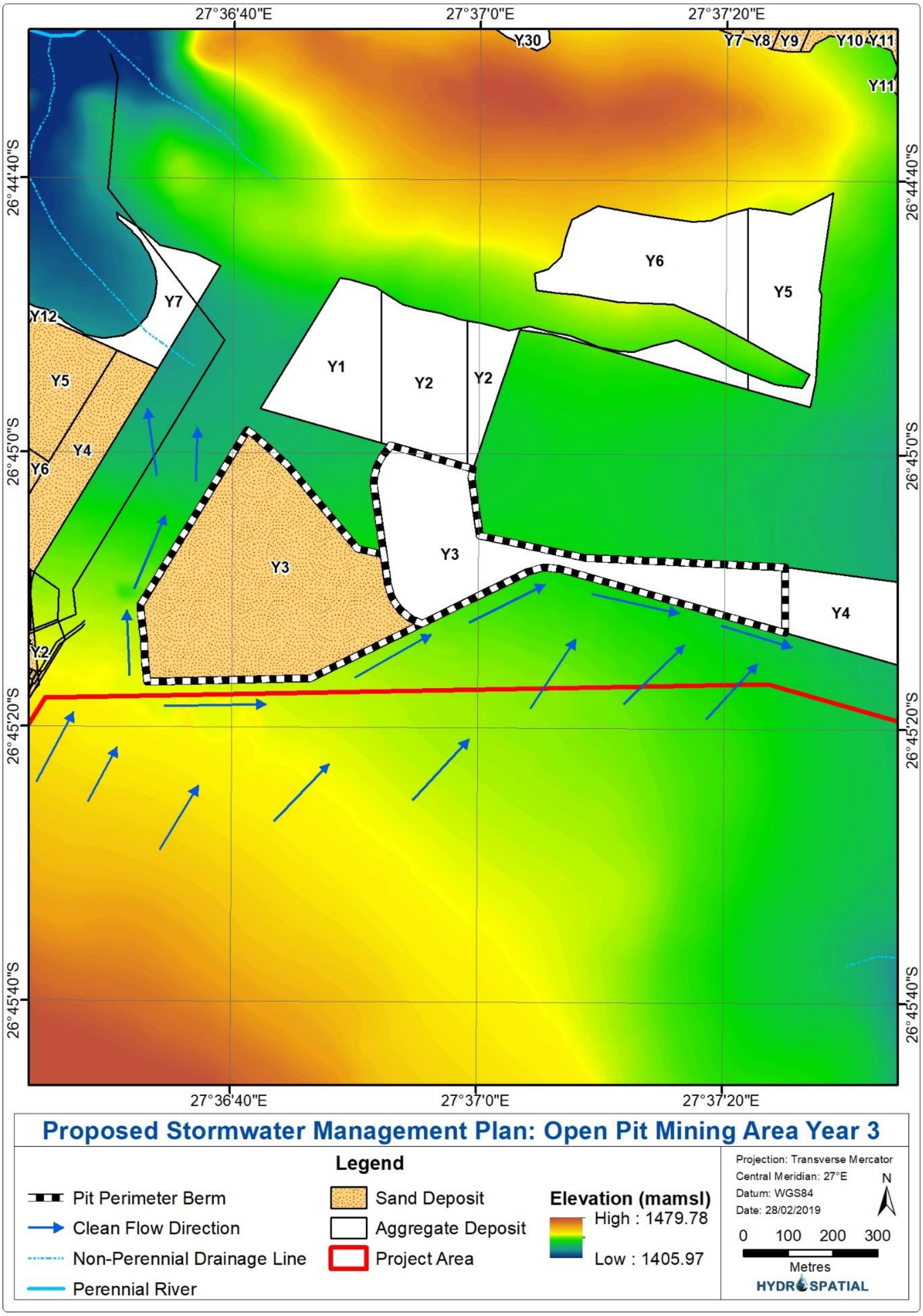

Figure 5-3: Proposed stormwater management plan for the open pit mining areas (mining year 3)

6 WATER BALANCE

A monthly water balance was setup in Microsoft Excel spreadsheet format, to estimate the volumes of water under average climatic conditions (average monthly rainfall and evaporation). This section details the water balance which has been prepared in accordance with the Best Practice Guideline G2: Water and Salt Balances.

6.1 Assumptions and Limitations

The water balance is based on the following assumptions:

- It is assumed that the water recycling plant will recycle 80 % of the water used in the washing process back to the plant for reuse;
- The potable water demand was assumed to be 150 L/day per employee;
- Groundwater inflows into the pits were estimated to be 432 m^3/day;
- It was assumed that the lowest section of the pits would be used as a pit sump area, to capture runoff and groundwater inflows. The sump area was estimated to be 20 % of the open pit area;
- A runoff coefficient of 50 % of the average monthly rainfall was used for the plant area and PCD;
- A runoff coefficient of 20 % of the average monthly rainfall was used for the pits;
- The estimated runoff coefficients were fixed and not influenced by antecedent climatic conditions; and
- Seepage losses from the pits was estimated at 10 % of the monthly inflow volumes (rainfall, runoff and groundwater inflows) into the pits.

6.2 Model Input Parameters

The parameters and assumptions/sources used in the water balance calculations are provided in Table 6-1.

Table 6-1: Parameters and assumptions/sources used in the water balance calculations

Parameter	Value	Units	Assumption/Source
Pit sump area	0.2	-	Assumed to be 20 % of the pit area
Plant dirty area	115 493	m^2	Dirty area from SWMP
PCD area	32 311	m^2	Mine infrastructure layout plan
Number of employees in the construction phase	25	-	Final scoping report

Parameter	Value	Units	Assumption/Source
Number of employees in the operational phase	50	-	Final scoping report
Operating hours per day (6am to 6pm)	12	hours/day	Final scoping report
Operating days per week	5.5	days/week	Final scoping report
Potable water demand	150	L/day/employee	Assumed that 150 L/day is required for each employee
Hourly plant demand	1 000	m³/hour	Final scoping report
Monthly plant demand	264 000	m³/month	Calculated based on the operating hours and days per week with an average of 4 weeks per month
Dust suppression demand	10 000	m³/annum	Final scoping report
Sand washing demand at pits	500 000	m³/annum	Final scoping report
Aggregate and diamond washing demand at pits	300 000	m³/annum	Final scoping report
Pit rainfall-runoff coefficient	0.2	-	Assumed 20 % of the monthly rainfall runs off to the pit sump
Plant area rainfall-runoff coefficient	0.5	-	Assumed 50 % of the monthly rainfall runs off to the PCD
Plant water recycled	0.8	-	Assumed that 80 % of the water used at the plant will be recycled back to the plant for reuse in the washing process
Plant spillages	0.02	-	Assumed that 2 % of the monthly water used at the plant runs off to PCD
Plant losses	0.18	-	18 % lost to evaporation, infiltration and moisture retained in material
Groundwater inflows	432	m³/day	Groundwater inflows initially estimated to vary from 432 m³/day to 864 m³/day. Initial estimate from groundwater specialist (Stephan Meyer).
Pit seepage losses	0.1	-	Assumed 10% losses to seepage in the pits

6.3 Results

The monthly water balance under average climatic conditions is indicated on Figure 6-1.

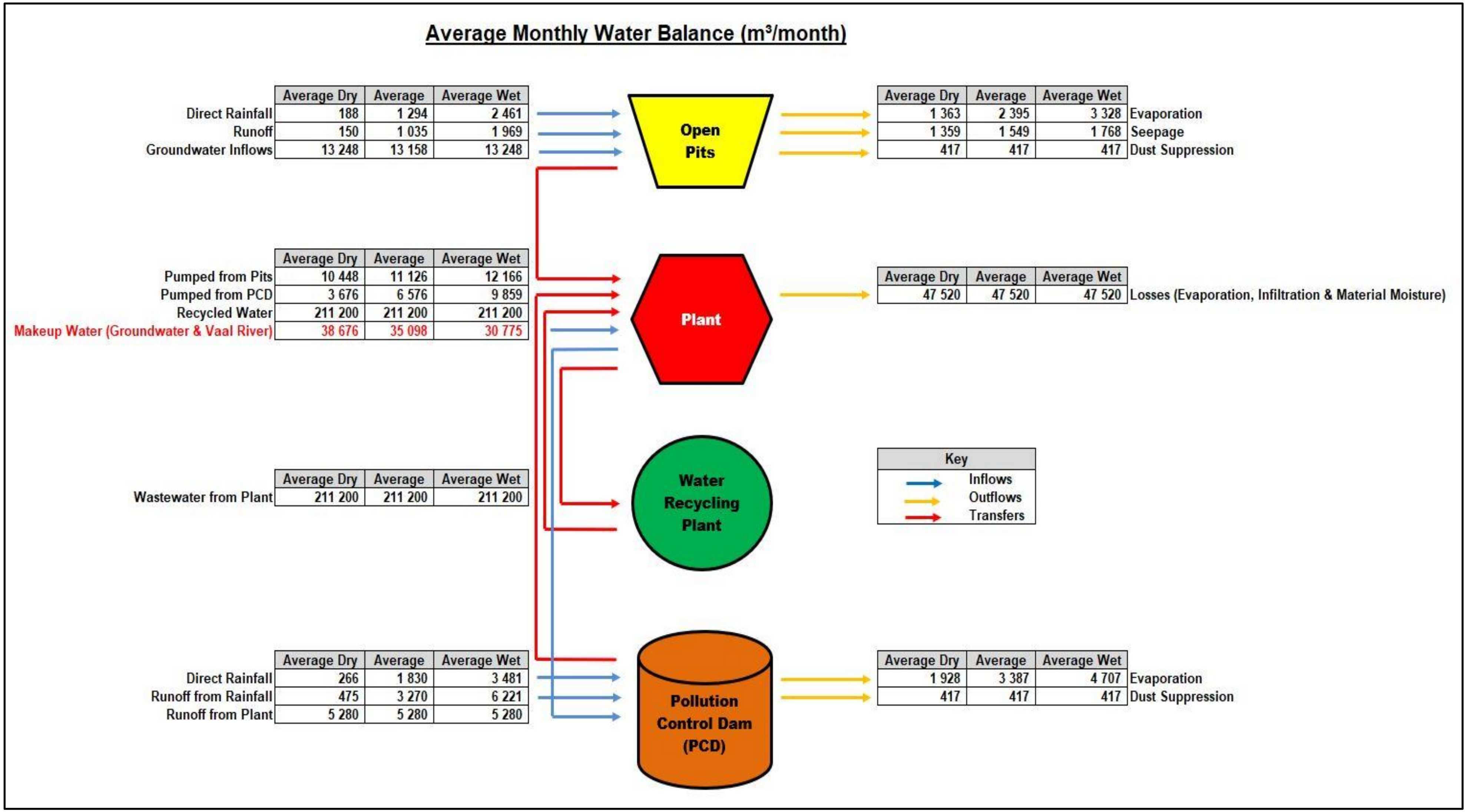

Figure 6-1: Water balance

7 SURFACE WATER IMPACT ASSESSMENT

This section details the impact assessment methodology, project phases, ratings of the impacts pre- and post-mitigation and cumulative impacts.

7.1 Methodology

The impact significance rating process serves to highlight the critical impacts requiring consideration in the management and approval process.

The impact significance rating system is presented in Table 7-1, Table 7-2 and Table 7-3, and involves three parts:

- **Part A**: Define impact consequence using the three primary impact characteristics of magnitude, spatial scale/population and duration;
- **Part B**: Use the matrix to determine a rating for impact consequence based on the definitions identified in Part A; and
- **Part C**: Use the matrix to determine the impact significance rating, which is a function of the impact consequence rating (from **Part B**) and the probability of occurrence.

These are discussed in further detail below.

7.1.1 Part A: Defining Consequence in Terms of Magnitude, Duration and Spatial Scale

Table 7-1 is used to determine the impact consequence characteristics for magnitude, spatial scale/population and duration.

Table 7-1: Consequence rating definitions

IMPACT CHARACTERISTICS	DEFINITION	CRITERIA
Magnitude	Major -	Substantial deterioration or harm to receptors; receiving environment has an inherent value to stakeholders; receptors of impact are of conservation importance; or identified threshold often exceeded
	Moderate -	Moderate/measurable deterioration or harm to receptors; receiving environment moderately sensitive; or identified threshold occasionally exceeded
	Minor -	Minor deterioration (nuisance or minor deterioration) or harm to receptors; change to receiving environment not measurable; or identified threshold never exceeded

IMPACT CHARACTERISTICS	DEFINITION	CRITERIA
	Minor +	Minor improvement; change not measurable; or threshold never exceeded
	Moderate +	Moderate improvement; within or better than the threshold; or no observed reaction
	Major +	Substantial improvement; within or better than the threshold; or favourable publicity
Spatial scale or population	Site or local	Site specific or confined to the immediate project area (within the proposed MRA)
	Regional	Beyond the project area
	National/ International	Nationally or beyond
Duration	Short term	Up to 18 months
	Medium term	18 months to 5 years
	Long term	Longer than 5 years

7.1.2 Part B: Determining the Consequence Rating

Once the impact consequence characteristics have been determined from Table 7-1, they are applied to Table 7-2 to obtain the consequence rating.

Table 7-2: Consequence rating methodology

			SPATIAL SCALE/ POPULATION		
			Site or Local	**Regional**	**National/ international**
MAGNITUDE					
Minor	**DURATION**	**Long term**	Medium	Medium	High
		Medium term	Low	Low	Medium
		Short term	Low	Low	Medium
Moderate	**DURATION**	**Long term**	Medium	High	High
		Medium term	Medium	Medium	High
		Short term	Low	Medium	Medium
Major	**DURATION**	**Long term**	High	High	High
		Medium term	Medium	Medium	High
		Short term	Medium	Medium	High

7.1.3 Part C: Determining Significance Rating

The probability of the impact occurring is assessed as either being definite, possible or unlikely, and is selected in Table 7-3. The consequence rating determined from Table 7-2, is then used to obtain the significance of the impact in Table 7-3.

Table 7-3: Significance rating methodology

		CONSEQUENCE		
		Low	**Medium**	**High**
PROBABILITY (of exposure to impacts)	**Definite**	Medium	Medium	High
	Possible	Low	Medium	High
	Unlikely	Low	Low	Medium

The significance rating of the impact is determined prior to mitigation (without mitigation), as well as after mitigation measures have been implemented.

7.2 Project Phases

The different phases of the project are discussed below.

7.2.1 Construction Phase

Vegetation will need to be cleared by machinery at the plant and open pit areas prior to mining. It is recommended that the clean water cut-off trenches are constructed prior to vegetation clearance, to minimise erosion by ensuring that upslope runoff is diverted around the cleared areas. Soil excavated from the clean cut-off trenches should be placed on the downslope side, between the trench and the pit. The stripping of topsoil will also take place during this phase, and should be stockpiled around the open cut, to form a perimeter berm that will ensure adequate separation of clean and dirty areas. The use of heavy machinery for construction purposes, has the potential to result in hydrocarbon spillages, that may be washed into downslope watercourses. Existing farm roads will be used as far as possible, and may need to be widened between the pits and plant.

7.2.2 Operational and Rehabilitation Phase

During the operational phase, open pit mining and rehabilitation will take place concurrently. As each open pit is created, the reject material will be placed in the previous mined out pit, followed by the subsoils and topsoils. The mined sand will either be screened in the pit or transported by truck or conveyer to the washing plant. In the absence of sand, topsoil will be stripped to expose the aggregate and will be stockpiled adjacent to the pit. The aggregate will be extracted and crushed in the pit by a mobile crusher and reject material will be backfilled into the previously mined out void as mining advances. Groundwater inflows (seepage) into the pits is expected.

7.2.3 Post Mine Closure

After mining, the closure objective is to develop the area as an eco-estate with residential and hospitality facilities on the banks of the Vaal River. This phase of the project has not been assessed, as it is understood that an environmental authorisation has been granted for the eco-estate.

7.3 Cumulative Impacts

Cumulative impacts result from the incremental impact of proposed activities on a common resource when added to the impacts of other past, present or reasonably foreseeable future activities Cumulative impacts can occur from the collective impacts of individual minor actions over a period of time and can include both direct and indirect impacts.

Although a small volume of water will be abstracted, when compared to the flow volumes in the Vaal River, the abstraction of water will cumulatively add to the loss of water quantity in the Vaal River. It is therefore imperative that dirty water from the PCD and pits are used for sand and aggregate washing, and that a water recycling plant is implemented. This will reduce the water demand on the Vaal River.

7.4 Impact Assessment and Mitigation Measures

The pre- and post-mitigation impact assessment for the construction, operational/ rehabilitation and post mine closure phases, as well as for the cumulative impacts, are provided in Table 7-4.

Table 7-4: Impact assessment

Activities	Impact Description	PRE-MITIGATION						Mitigation Measures / Recommendations	POST-MITIGATION					
		Magnitude	Duration	Spatial Scale	Consequence	Probability	SIGNIFICANCE		Magnitude	Duration	Spatial Scale	Consequence	Probability	SIGNIFICANCE
CONSTRUCTION PHASE														
Removal of vegetation and the exposure of soils. Excavation of the clean water cut-off trenches and the construction of berms. Stripping and stockpiling of topsoils. Widening of existing farm roads.	Erosion of exposed soils leading to increased siltation and sedimentation of downslope watercourses impacting water quality.	*Moderate -*	*Medium Term > 18 months < 5 years*	*Site or Local*	Medium	*Possible*	Medium	Vegetation should only be cleared before mining each open cut and not for the entire open pit area. Trenches and berms should only be cleared as mining progresses. Erosion measures such as sediment nets should be used for the berms and topsoil stockpiles. The clean cut-off trenches and berms should be vegetated as soon as possible. Energy dissipation such as rock riprap at the cut-off trench outlets should be implemented to prevent erosion.	*Minor -*	*Medium Term > 18 months < 5 years*	*Site or Local*	Low	*Unlikely*	Low
Use of heavy machinery, trucks and vehicles for construction purposes.	Potential hydrocarbon spillages washed into downslope watercourses impacting water quality.	*Moderate -*	*Medium Term > 18 months < 5 years*	*Site or Local*	Medium	*Possible*	Medium	Machinery, trucks and vehicles must be well maintained and serviced regularly as per the recommended service guide. Refuelling must be undertaken over hard park bunded areas that adequately capture and contain spillages. Drip trays must be used under leaking machinery. Spillages should be reported immediately and spill kits should be readily available at all times.	*Minor -*	*Medium Term > 18 months < 5 years*	*Site or Local*	Low	*Unlikely*	Low

Activities	Impact Description	PRE-MITIGATION						Mitigation Measures / Recommendations	POST-MITIGATION					
		Magnitude	Duration	Spatial Scale	Consequence	Probability	SIGNIFICANCE		Magnitude	Duration	Spatial Scale	Consequence	Probability	SIGNIFICANCE
OPERATIONAL AND REHABILITATION PHASE														
Abstraction of water from the Vaal River for sand and aggregate washing.	The average monthly washing plant demand was estimated to be 264 000 m^3, which would need to be sourced from the Vaal River or from groundwater, if dirty water is not recycled and reused. This will result in a loss of water quantity in the Vaal River.	*Major -*	*Long Term > 5 years*	*Regional*	High	*Possible*	High	The water recycling plant should be implemented and should be able to recycle 80 % of water used at the wash plant. Dirty water from the PCD and groundwater inflows at the pits should be used at the wash plant. This will significantly reduce the monthly demand on the Vaal River and groundwater from 264 000 m^3 to an average of 35 098 m^3 per month.	*Moderate -*	*Long Term > 5 years*	*Site or Local*	Medium	*Possible*	Medium

Activities	Impact Description	PRE-MITIGATION						Mitigation Measures / Recommendations	POST-MITIGATION					
		Magnitude	Duration	Spatial Scale	Consequence	Probability	SIGNIFICANCE		Magnitude	Duration	Spatial Scale	Consequence	Probability	SIGNIFICANCE
Open pit mining upslope of wetlands and drainage lines.	Loss of contributing catchment area impacting on water quantity. This will be a temporary impact as the pits will be rehabilitated to a pre-mining topography.	*Moderate -*	*Medium Term > 18 months < 5 years*	*Regional*	Medium	*Definite*	Medium	The area of each of the progressive open cuts should be as small as possible. Concurrent backfilling and rehabilitation must be ensured as open pit mining progresses. This will limit the pit areas opened at any time.	*Moderate -*	*Medium Term > 18 months < 5 years*	*Site or Local*	Medium	*Possible*	Medium
Open pit mining to levels below surrounding wetlands and drainage lines.	Dewatering of surrounding wetlands and drainage lines.	*Major -*	*Medium Term > 18 months < 5 years*	*Site or Local*	Medium	*Definite*	Medium	The area of each of the progressive open cuts should be as small as possible. Concurrent backfilling and rehabilitation must be ensured as open pit mining progresses.	*Moderate -*	*Medium Term > 18 months < 5 years*	*Site or Local*	Medium	*Possible*	Medium
Open pit mining through non-perennial drainage lines, as well as within the floodlines and 100 m watercourse buffer.	Loss of hydrological connection and function. Loss of water quantity. Alteration of surface water drainage patterns.	*Major -*	*Medium Term > 18 months < 5 years*	*Regional*	Medium	*Definite*	Medium	Diversion of upslope runoff around the pits. Rehabilitation of the pits to a free flowing pre-mining topography. Restoration of the drainage lines. GN704 exemptions should be obtained for any mining or mine infrastructure placed within the 100 year floodline or 100 m watercourse buffer.	*Moderate -*	*Medium Term > 18 months < 5 years*	*Site or Local*	Medium	*Possible*	Medium
Runoff from upslope areas into the pits during mining.	Flooding of the pits and potential overflow of dirty water into the environment.	*Major -*	*Medium Term > 18 months < 5 years*	*Regional*	Medium	*Possible*	Medium	Diversion of upslope runoff around the pits as proposed by the SWMP.	*Minor -*	*Medium Term > 18 months < 5 years*	*Site or Local*	Low	*Possible*	Low

Activities	Impact Description	PRE-MITIGATION						Mitigation Measures / Recommendations	POST-MITIGATION					
		Magnitude	Duration	Spatial Scale	Consequence	Probability	SIGNIFICANCE		Magnitude	Duration	Spatial Scale	Consequence	Probability	SIGNIFICANCE
Use of heavy machinery, trucks and vehicles during mining and rehabilitation	Potential hydrocarbon spillages washed into downslope watercourses impacting water quality.	*Moderate -*	*Medium Term > 18 months < 5 years*	*Site or Local*	Medium	*Possible*	Medium	Machinery, trucks and vehicles must be well maintained and serviced regularly as per the recommended service guide. Refuelling must be undertaken over hard park bunded areas that adequately capture and contain spillages. Drip trays must be used under leaking machinery. Spillages should be reported immediately and spill kits should be readily available at all times.	*Minor -*	*Medium Term > 18 months < 5 years*	*Site or Local*	Low	*Unlikely*	Low
CUMULATIVE IMPACTS														
Long term abstraction of water from the Vaal River for sand and aggregate washing.	Although not a significant abstraction volume of water when compared to the flow volumes in the Vaal River, long term abstraction from the Vaal River will cumulatively add to a loss of water quantity.	*Major -*	*Long Term > 5 years*	*Regional*	High	*Possible*	High	The water recycling plant should be implemented and should be able to recycle 80 % of water used at the wash plant. Dirty water from the PCD and groundwater inflows at the pits should be used at the wash plant. This will significantly reduce the monthly demand on the Vaal River and groundwater from 264 000 m^3 to an average of 35 098 m^3 per month.	*Moderate -*	*Long Term > 5 years*	*Site or Local*	Medium	*Possible*	Medium

8 MONITORING PLANS

8.1 Surface Water Quality

A surface water quality monitoring programme is essential as a management tool to detect negative water quality impacts as they arise and to ensure that the necessary mitigation measures are implemented. Parameters suggested to be monitored are indicated in Table 3-6. Monthly monitoring should be implemented at least a year prior the commencement of construction activities to establish a baseline that captures all seasons, and then throughout the construction, operation and post closure phases.

Water quality samples must be kept cool (+-4°C) and transported immediately to an accredited laboratory for water quality analysis within 24 hours of sampling, as per the DWS Best Practice Guideline G3: Water Monitoring Systems. The impacts on water quality will be determined by comparing the monitoring results against the WUL limits or guidelines and standards provided in section 3.4, as well as to previous results to determine any deviations in trends over time. If the trend analysis indicates any deviations to the baseline monitoring, in terms of deteriorating water quality, then an immediate investigation must be undertaken to determine whether the mine may be responsible. If responsible, urgent action must be undertaken to implement mitigation against the source of pollution.

Reporting should be done on a quarterly basis (or as recommended by the DWS) and reports should be submitted to the DWS. Monitoring reports must include a trend analyses, as well as separate table/s where results received from the lab are compared to standard/guideline and WUL limits, indicating any parameters that may have exceeded limits. Water quality monitoring is recommended at the locations provided in Table 3-5 and indicated on Figure 3-7. It is recommended that a further sampling point is added to the dam directly north-west of infrastructure alternative 3.

8.2 Stormwater Infrastructure

Stormwater infrastructure (trenches, berms and PCD) must be monitored on a monthly basis during the dry season, and on a weekly basis during the wet season. They should further be monitored immediately after any large storm events. Should blockages, silted up structures or breaches occur, immediate action should be undertaken to remove debris and repair breaches. Monitoring should be undertaken by the onsite Environmental Control Officer (ECO) or maintenance manager. Inspections must be recorded and should include the following:

- Date of inspection;
- Rainfall amount received in a 24-hour period prior to inspection;
- Photographs of blockages, silted up structures or breaches witnessed;
- What action was undertaken to fix issues, and the amount of time taken to address them; and

- Photographs post action taken.

Inspection reports should be kept ready and supplied to the DWS when requested, and as part of the WUL audits (internal and external).

9 CONCLUSION AND RECOMMENDATIONS

In conclusion, no significant impacts are expected for surface water if the mitigation measures provided in Table 7-4 are implemented, and the recommendations below are adhered to.

The following is recommended:

- Mining and the placement of infrastructure does not take place within the floodlines or within a 100 m horizontal distance of a watercourse;
- The SWMP proposed in this report is implemented;
- The monitoring plans proposed in this report are implemented; and
- A water recycling plant is implemented and dirty water from the PCD and pits are used for washing at the plant. This will reduce the water demand on the Vaal River.

10 REFERENCES

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APPENDIX A: WATER QUALITY LABORATORY CERTIFICATE

Client:	Hydrospatial Pty Ltd	**Date of certificate:**	08 August 2018
Address:	17 Sonop Place, Randpark, Johannesburg, 2194	**Date accepted:**	02 August 2018
Report no:	55565	**Date completed:**	08 August 2018
Project:	Hydrospatial Pty Ltd	**Revision:**	0

Lab no:				44581	44582	44583
Date sampled:				02-Aug-2018	02-Aug-2018	02-Aug-2018
Sample type:				Water	Water	Water
Locality description:				PSM SW1	PSM SW2	PSM SW3
	Analyses	**Unit**	**Method**			
A	pH @ 25°C	pH	ALM 20	8.04	8.11	7.78
A	Electrical conductivity (EC) @ 25°C	mS/m	ALM 20	79.9	79.3	12.8
A	Total dissolved solids (TDS)	mg/l	ALM 26	493	488	81
A	Total alkalinity	mg CaCO3/l	ALM 01	149	146	13.3
A	Chloride (Cl)	mg/l	ALM 02	45.5	45.6	2.93
A	Sulphate (SO_4)	mg/l	ALM 03	175	174	9.38
A	Nitrate (NO_3) as N	mg/l	ALM 06	3.87	4.41	8.90
A	Ammonium (NH_4) as N	mg/l	ALM 05	1.48	0.875	0.159
A	Orthophosphate (PO_4) as P	mg/l	ALM 04	0.262	0.274	<0.005
A	Fluoride (F)	mg/l	ALM 08	0.270	0.286	<0.263
A	Calcium (Ca)	mg/l	ALM 30	65.4	64.3	9.13
A	Magnesium (Mg)	mg/l	ALM 30	23.4	23.0	4.56
A	Sodium (Na)	mg/l	ALM 30	62.7	61.0	4.09
A	Potassium (K)	mg/l	ALM 30	10.0	9.78	3.42
A	Aluminium (Al)	mg/l	ALM 31	<0.002	<0.002	<0.002
A	Iron (Fe)	mg/l	ALM 31	<0.004	<0.004	<0.004
A	Manganese (Mn)	mg/l	ALM 31	0.027	<0.001	0.008
A	Chromium (Cr)	mg/l	ALM 31	<0.003	<0.003	<0.003
A	Copper (Cu)	mg/l	ALM 31	<0.002	<0.002	<0.002
A	Nickel (Ni)	mg/l	ALM 31	0.002	<0.002	<0.002
A	Zinc (Zn)	mg/l	ALM 31	0.008	0.010	<0.002
A	Cobalt (Co)	mg/l	ALM 31	<0.003	<0.003	<0.003
A	Cadmium (Cd)	mg/l	ALM 31	<0.002	<0.002	<0.002
A	Lead (Pb)	mg/l	ALM 31	<0.004	<0.004	<0.004
N	Faecal coliform	CFU/100ml	ALM 42	9	47	10
A	Turbidity	NTU	ALM 21	14.7	11.9	12.8
A	Total hardness	mg CaCO3/l	ALM 26	260	255	42
A	Total suspended solids (TSS)	mg/l	ALM 25	21	15	12

A = Accredited N = Non accredited O = Outsourced S = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine ATR = Alternative test report ; The results relates only to the test item tested.
Results reported against the limit of detection.
Results marked 'Not SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory.
Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation.

M. Swanepoel
Technical Signatory