Consolidated Surface Water Hydrology Report for the Exxaro Matla Coal Mine

Report Prepared for

GCS (Pty) Ltd

Report Number GCS002

Report Prepared by

SD Hydrological Services (Pty) Ltd

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Table of Contents

List of Tables

List of Figures

Acronyms and Abbreviations

Below a list of acronyms and abbreviations used in this report.

Acronyms / Abbreviations	Definition
DEM	Digital Elevation Model
DWAF	Department of Water Affairs and Forestry
MAE	Mean Annual Evaporation
MAMSL	Meters Above Mean Sea Level
MAP	Mean Annual Precipitation
PCD	Pollution Control Dam
WMA	Water Management Area
WTP	Water Treatment Plant

1 Introduction

SD Hydrological Services (Pty) Ltd has been appointed by GCS (Pty) Ltd, to undertake a surface water specialist study which entails the consolidation of all surface water hydrology information together with the proposed stooping for the identified areas at the Exxaro Matla Coal Mine located in the Mpumalanga province of South Africa.

The section to follow briefly summarises the required scope of work.

2 Scope of Work

The scope of works entails the consolidation of all works undertaken relating specifically to the surface water hydrology of the project area, and will include:

- **Baseline hydrology** - Undertake a detailed desktop assessment which includes, review of all existing information for the project area including, mean annual runoff (MAR), mean annual precipitation (MAP), mean annual evaporation (MAE), catchment areas of interest, topography, identification of surface water resources (rivers, drainage paths etc.) and storm rainfall depths for various recurrence intervals.
- **Stormwater management plan** – Undertake a stormwwater management plan based on the Department of Water Affairs and Forestry (DWAF) (Best Practice Guidelines – G1: Storm Water Management, August 2006).
- **Surface water monitoring** – Consolidation of existing surface water quality.
- **Flood risk identification** – Identify various rivers/watercourses which may pose a risk to flooding of either existing or proposed infrastructures.
- **Stooping**– Collate existing data on the stooping project.
- **Surface water impact assessment** – Undertake a surface water impact assessment for the proposed stooping project activities.

A locality map indicating the project location is shown in Figure 2-1 below.

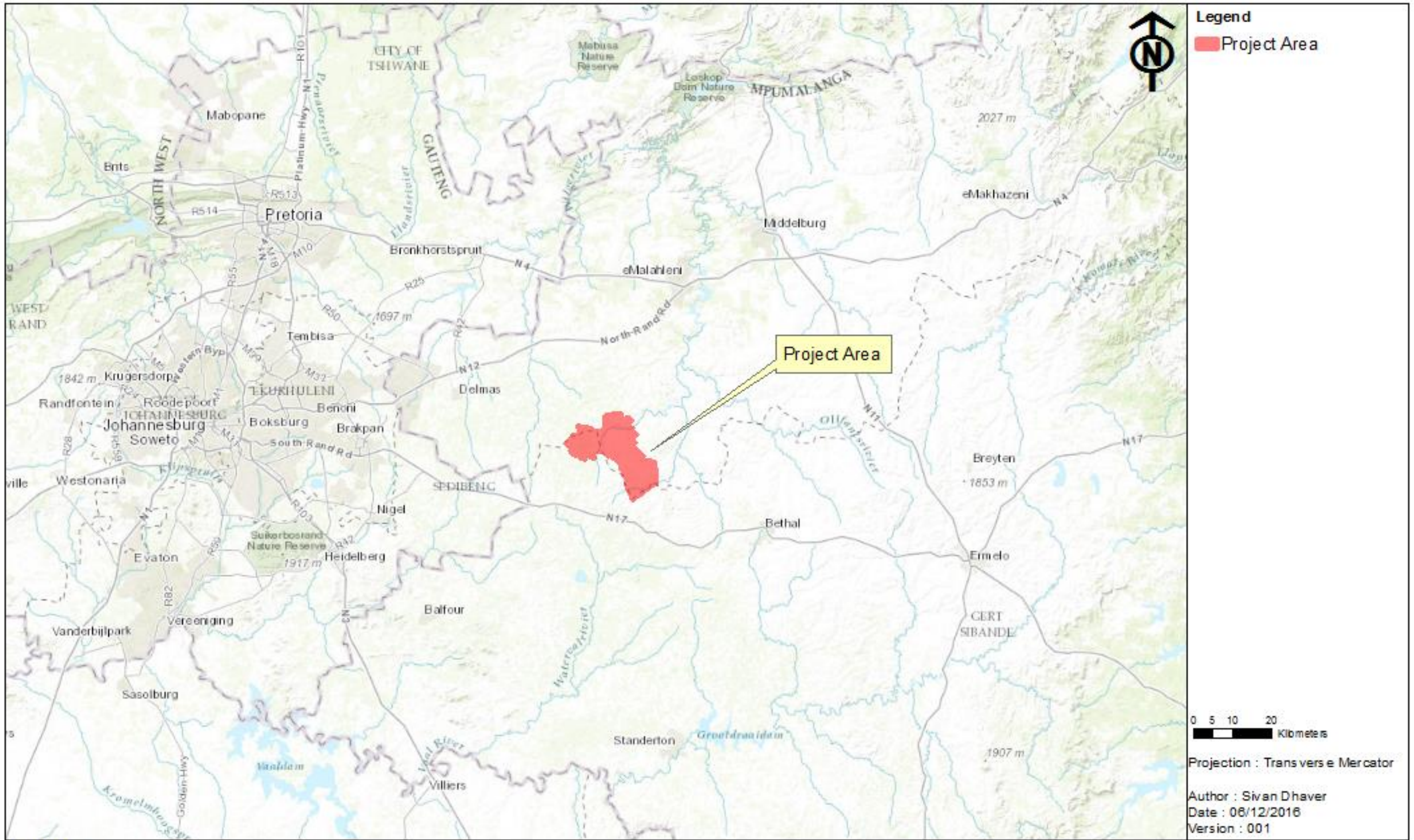

Figure 2.1

TITLE : Locality Map

SD Hydrological Services (Pty) Ltd

3 Baseline Hydrology

To inform the stormwater management plan an understanding of the baseline hydrology is required. This section presents a review of various information sources to define the baseline climatic and hydrological conditions of the project area and surroundings.

3.1 Hydrological Settings

3.1.1 Introduction

South Africa is divided into 9 water management areas (DWS, 2016), managed by its separate water board. Each of the water management areas (WMA) is made up of quaternary catchments which relate to the drainage regions of South Africa, ranging from A – X (excluding O). These drainage regions are subdivided into four known divisions based on size. For example, the letter A represents the primary drainage catchment, A2 for example will represent the secondary catchment, A21 represents the tertiary catchment and A21D would represent the quaternary catchment which is the lowest subdivision in the Water Resources 2005 Study (WR2005) manual. Each of the quaternary catchments have associated hydrological parameters including area, mean annual precipitation (MAP) and mean annual runoff (MAR) to name a few.

The project area falls within the Olifants WMA with the major river falling within the mentioned WMA being the Olifants River. Majority of the runoff from the project area is eventually drained south east into the Olifants River.

3.1.2 Regional Hydrology and Topography

The project area falls within the quaternary catchments B11D, B11E and B20E, with majority of the Matla Mine boundary falling within quaternary catchment B11E. The quaternary catchments B11D, B11E and B20E have a net mean annual runoff (MAR) of 24.56 million cubic meters (mcm), 20.68 mcm and 19.28 mcm respectively (WR2005). Major rivers include the Rietspruit which drains quaternary catchment B11E, with most of the runoff emanating from the mid to northern sections of the Matla Mine boundary being drained by the mentioned river. Minor tributaries of the Steenkoolspruit drain the southern section of Matla Mine boundary which falls within quaternary catchment B11D. Due to the Rietspruit being a tributary of the Steenkoolspruit, most of the runoff eventually ends up in the Steenkoolspruit. Only a small portion of runoff emanating from the furthest north western boundary of the Matla Mine is drained north westerly into the Wilgerivier.

Average elevations at the quaternary catchments range from 1600 meters above mean sea level (mamsl) to 1630 mamsl, with average catchment slopes within the project area falling below 3% and is therefore characterised as relatively flat.

The hydrological setting of the project site is indicated in Figure 3-1. The digital elevation model (DEM) was sourced from the USGS website (http://hydrosheds.cr.usgs.gov/dataavail.php).

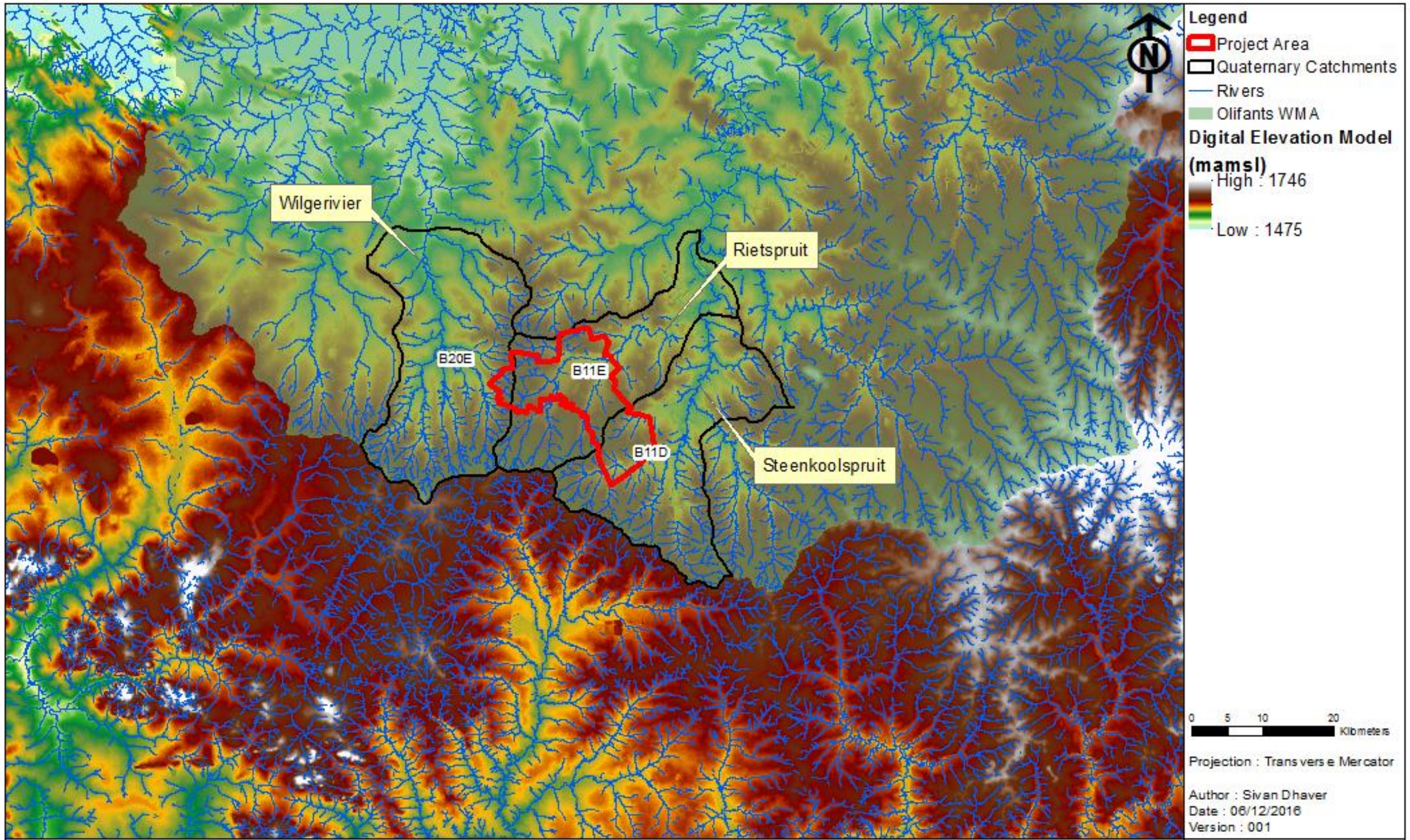

Figure 3.1

TITLE : Summary of Hydrological Setting

4 Climate

4.1 Rainfall and Evaporation

Summary of the mean annual precipitation (MAP) and the mean annual evaporation (MAE) where extracted from the report (Hydrology Specialist Study, Matla Colliery; Open Cast Extension, 2012)

The most significant evaporation figures for the site is the amount of water that is likely to evaporate off the surface of lakes and dams this lake evaporation is estimated at 1350 mm per annum and is shown below in Table 4-1. The table also summarises the MAP of the project area which is estimated at 582 mm.

Table 4-1 Summary of lake evaporation and rainfall (GCS, 2012)

Months	Rainfall (mm)	Lake Evaporation (mm)
January	105.5	147.0
February	85.4	133.3
March	71.5	125.0
April	31.7	101.7
May	12.4	83.8
June	1.2	66.2
July	0.0	71.3
August	1.1	93.0
September	12.4	116.9
October	61.2	130.7
November	101.5	137.6
December	98.4	143.3
Total	**582**	**1350**

4.2 Storm Rainfall Depths

The design storm rainfall depths were obtained from the design rainfall software (Smithers and Schulze, 2002). The programme is able to extract the storm rainfall depths for various recurrence intervals for the six closest rainfall stations as shown below in Table 4-2 below.

Table 4-2 Summary of SAWS stations as per the design rainfall software (GCS,2011)

Station Name	SAWS Number	Distance (Km)	Record length (Years)	Mean Annual Precipitation (mm)	Altitude (mamsl)
BOMBARDIE ESTATE	0478039 W	6.5	40	665	1594
COLOGNE	0478008 W	12.1	74	683	1610
STREHLA	0477762 W	14.5	79	666	1560
OGIES (POL)	0478093 W	18.1	92	745	1584
KRIEL (POL)	0478406 W	18.8	88	626	1543
LANGSLOOT	0478292 W	19.5	80	698	1572

The adopted storm rainfall depth to be used in the calculation of peak flows for the floodline delineation study is based on the gridded rainfall output obtained from the design rainfall software. The summary of the rainfall depths for the 5 minute duration up to the 1 day storm duration for various recurrence intervals are shown below in Table 4-3.

Table 4-3 Summary of storm rainfall depths (GCS, 2011)

Duration	Rainfall Depth (mm)					
(m/h/d)	1:2 year	1:5 year	1:10 year	1:20 year	1:50 year	1:100 year
5 m	8.7	11.7	13.9	16.1	19.1	21.5
10 m	12.7	17.0	20.1	23.2	27.6	31.1
15 m	15.7	21.1	24.9	28.8	34.3	38.6
30 m	20.1	26.9	31.8	36.8	43.8	49.3
45 m	23.2	31.1	36.7	42.5	50.5	56.9
1 h	25.6	34.4	40.6	47.1	55.9	63.0
1.5 h	29.6	39.7	46.9	54.3	64.5	72.7
2 h	32.8	44.0	51.9	60.1	71.4	80.5
4 h	38.9	52.3	61.7	71.5	84.9	95.7
6 h	43.1	57.8	68.3	79.1	94.0	105.9
8 h	46.3	62.1	73.4	85.0	101.0	113.8
10 h	49.0	65.7	77.6	89.9	106.8	120.3
12 h	51.2	68.8	81.2	94.1	111.7	125.9
16 h	55.1	73.9	87.3	101.1	120.1	135.3
20 h	58.2	78.1	92.3	106.9	127.0	143.1
24 h	60.9	81.8	96.6	111.8	132.9	149.8
1 day	52.8	70.8	83.7	96.9	115.1	129.7

5 Stooping and associated activities at Matla

5.1 Introduction

The stooping activities will result in a maximum subsidence of 1.53 m on the surface above the underground working areas. The project will be phased with Matla Stooping Project (Phase 1) to be undertaken on the following Eskom- and Exxaro-owned properties indicated below and shown in Figure 5-1 below. The key for Figure 5-1 is described within the brackets (Blue = Eskom Holding, Green = Exxaro owned, Orange outlined = Stooping areas).

- Kortlaagte 67 IS (10/67 and 1/67);
- Grootpan 86 IS (30/86, 29/86, 23/86, 10/86);
- Vierfontein 61 IS (22/61 and 27/61);
- Rietvlei 62 IS (14/62).

Due to the subsidence anticipated at the various identified area, a conceptual stormwater management plan was carried out. The primary objective of the stormwater management plan was to ensure that all runoff collected within these areas are safely conveyed to the downstream clean water environment, away from any of the existing mine infrastructure areas. The summary of the stormwater management plan for the proposed stooping area is described in further in section 6.3.

Figure 5-1 Locality map indicating the proposed stooping areas (GCS, 2015)

6 Stormwater Management Plan

Initially WSP had undertaken a study (Stormwater Assessment and Management Plan for the Matla Operations, WSP, 2012)), however all findings been updated in the 2017 study (Malta Mines Stormwater Design, Technical Design Report, WSP, 2017).

It should be noted at the time of the study Mine 1 was operational, however currently it isn't, and a separate stormwater management plan for the New Mine 1 area was undertaken.

The approach adopted for the above mentioned study included:

- Desktop review of existing information and site walkover
- GN 704 audit.
- Development of a conceptual stormwater management plan
- Design of infrastructure (to allow for the construction tender stage to commence).

The section to follow provides a brief introduction of stormwater management principles relating to GN 704, together with work already undertaken for Mine 1, Mine 2 and Mine 3. All results for the conceptual sizing of the proposed infrastructures are shown in Appendix A.

6.1 Government Notice 704

GN 704 (Government Gazette 20118 of June 1999) was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources. The five main principle conditions of GN 704 applicable to this project are:

- Condition 4 which defines the area in which, mine workings or associated structures may be located, with reference to a watercourse and associated flooding. Any residue deposit, dam, reservoir together with any associated structure or any other facility should be situated outside the 1:100 year flood-line. Any underground or opencast mining, prospecting or any other operation or activity should be situated or undertaken outside of the 1:50 year flood-line. Where the flood-line is less than 100 metres away from the watercourse, then a minimum watercourse buffer distance of 100 metres is required for infrastructure and activities.
- Condition 5 which indicates that no residue or substance which causes or is likely to cause pollution of a water resource may be used in the construction of any dams, impoundments or embankments or any other infrastructure which may cause pollution of a water resource.
- Condition 6 which describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated to ensure conveyance of flows of a 1:50 year recurrence event. Clean and dirty water systems should not spill into each other more frequently than once in 50 years. Any dirty water dams should have a minimum freeboard of 0.8m above full supply level.
- Condition 7 which describes the measures which must be taken to protect water resources. All dirty water or substances which may cause pollution should be prevented from entering a water resource (by spillage, seepage, erosion etc) and ensure that water used in any process is recycled as far as practicable.
- Condition 10 which describes the requirements for operations involving extraction of material from the channel of a watercourse. Measures should be taken to prevent impacts on the

stability of the watercourse, prevent scour and erosion resulting from operations, prevent damage to in-stream habitat through erosion, sedimentation, alteration of vegetation and flow characteristics, construct treatment facilities to treat water before returning it to the watercourse, and implement control measures to prevent pollution by oil, grease, fuel and chemicals.

The stormwater management plan for Mine 1, Mine 2 and Mine 3 are describe in the sections below.

6.2 Stormwater Management for Mine Summary

The stormwater management plan for Mine 1, Mine 2, Mine 3 and the Plant area is summarised in Figure 6-1 - Figure 6-4). All peak flow calculations used to size the stormwater controls are based on the Rational method (SANRAL, 2013).

All channels are either trapezoidal or triangular, with the exception of the rectangular grid channel, L1 on Mine 2, since it requires vehicles to be able to pass over it. Channels were designed to have a freeboard of 10% of the channel depth to act as a safety factor. Conventionally, collector channels are designed for 10-year storm events (where any excess is captured further downstream in the catchment) but due to the clean and dirty nature of the sites, it cannot be allowed for water to overflow into other catchments. Therefore, the channels were designed for a 50-year storm event (WSP, 2017).

Similarly, to pipes, Uniform Flow Analysis method with Manning's equation was used to analyse stormwater channels. Manning's n for concrete channels was estimated to be 0.015 (Chadwick, Morfett, & Borthwick, 2013) and 0.025 for grass-blocks (Technicrete, 2017). The design of channels targeted a self-cleansing velocity of 1.0 m/s to prevent siltation, while being designed to avoid backwater conditions (WSP, 2017).

Berms are specified in Mine 1 and Mine 2 to divert clean water away from dirty areas. The berms will require erosion protection in the form of dump rock. The dump rock will protect the toe of the berm by slowing down the flow, while allowing the water to infiltrate into the ground (WSP, 2017).

The new sediment traps are based on a 'settling channel' concept which attenuates stormwater flow through the channel. The channel is designed to be large enough to give particles enough time to fall out of suspension (WSP, 2017).

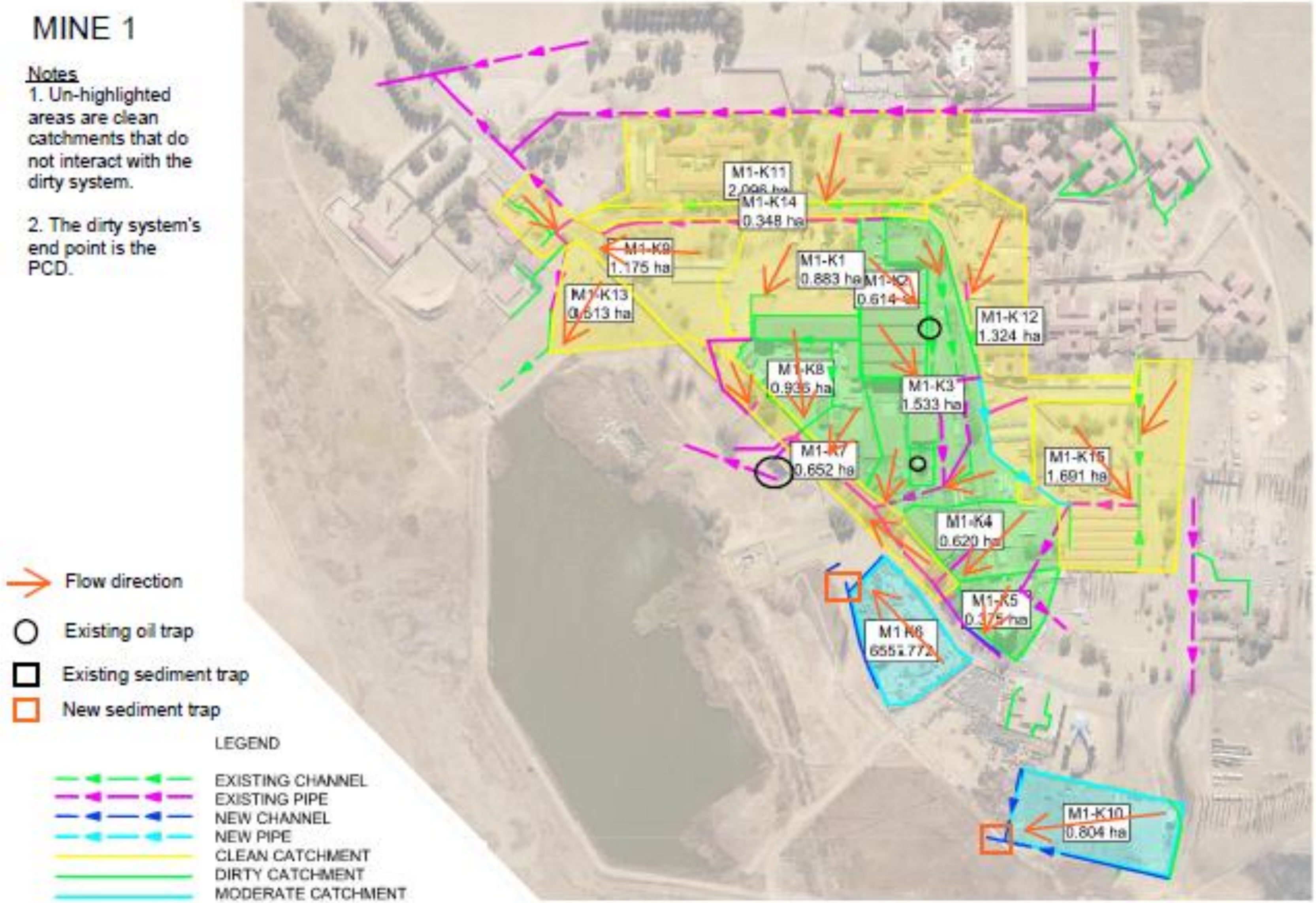

Figure 6-1 Proposed Stormwater Management (Mine 1) (WSP, 2017)

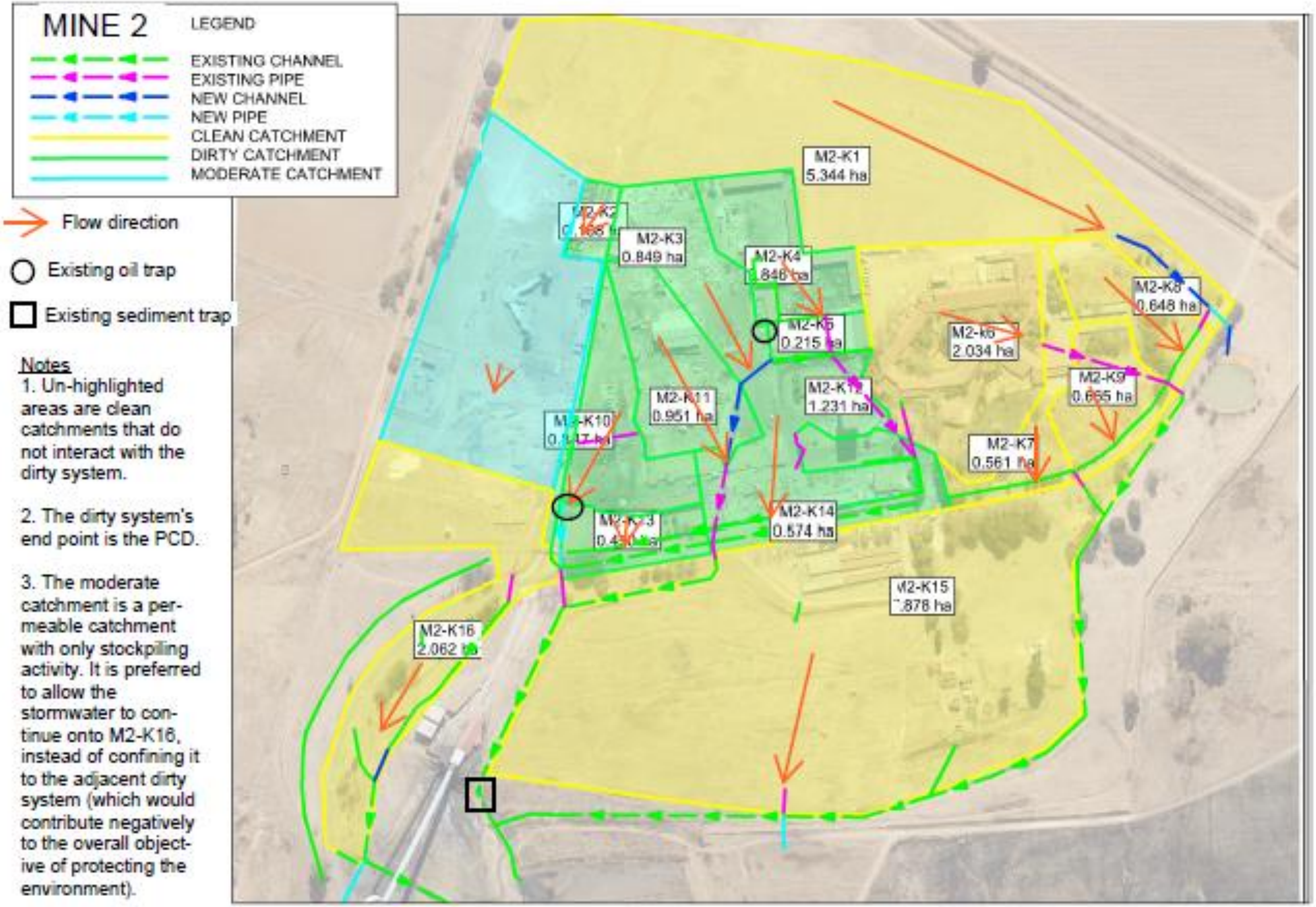

Figure 6-2 Proposed Stormwater Management (Mine 2) (WSP, 2017)

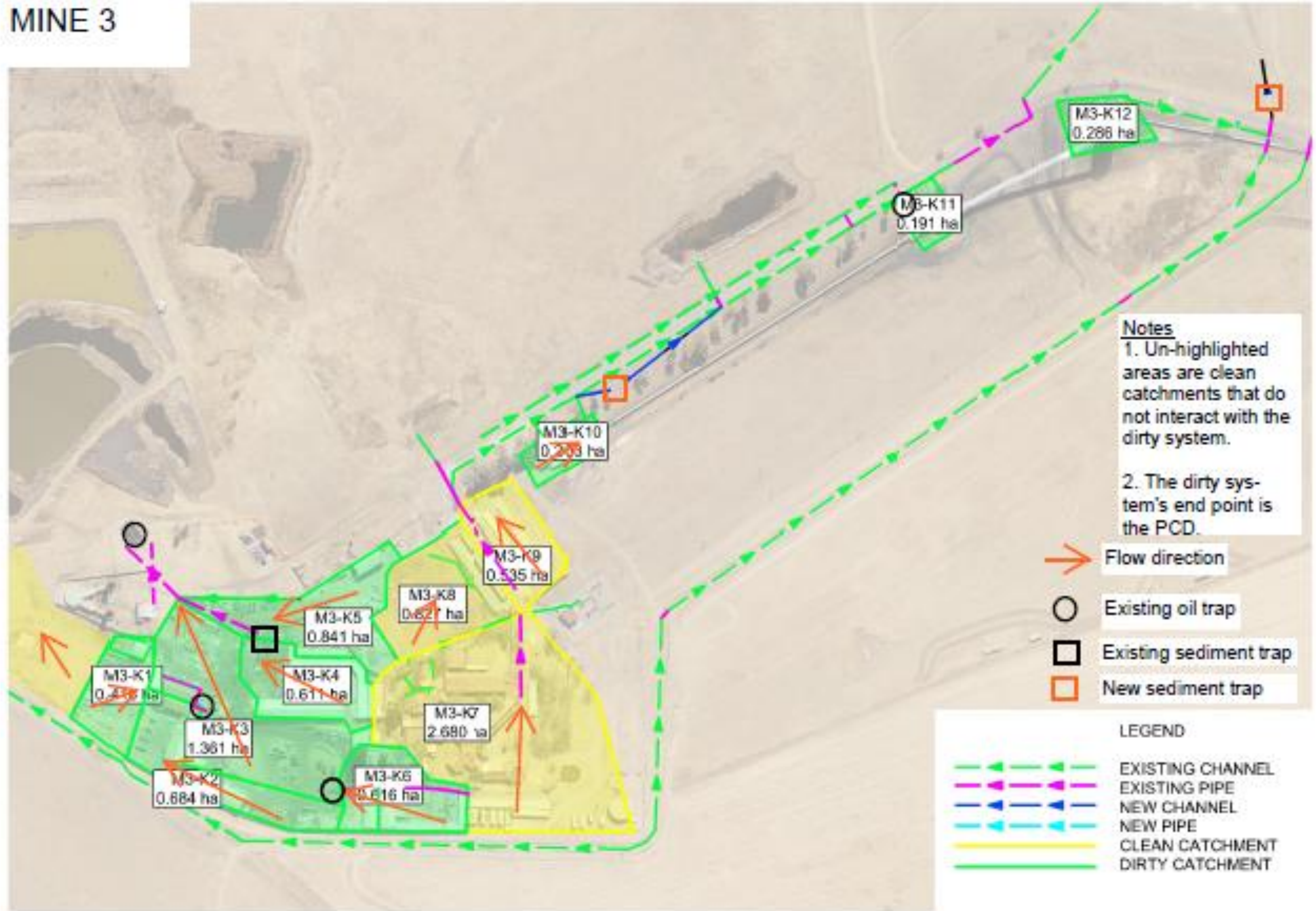

Figure 6-3 Proposed Stormwater Management (Mine 3) (WSP, 2017)

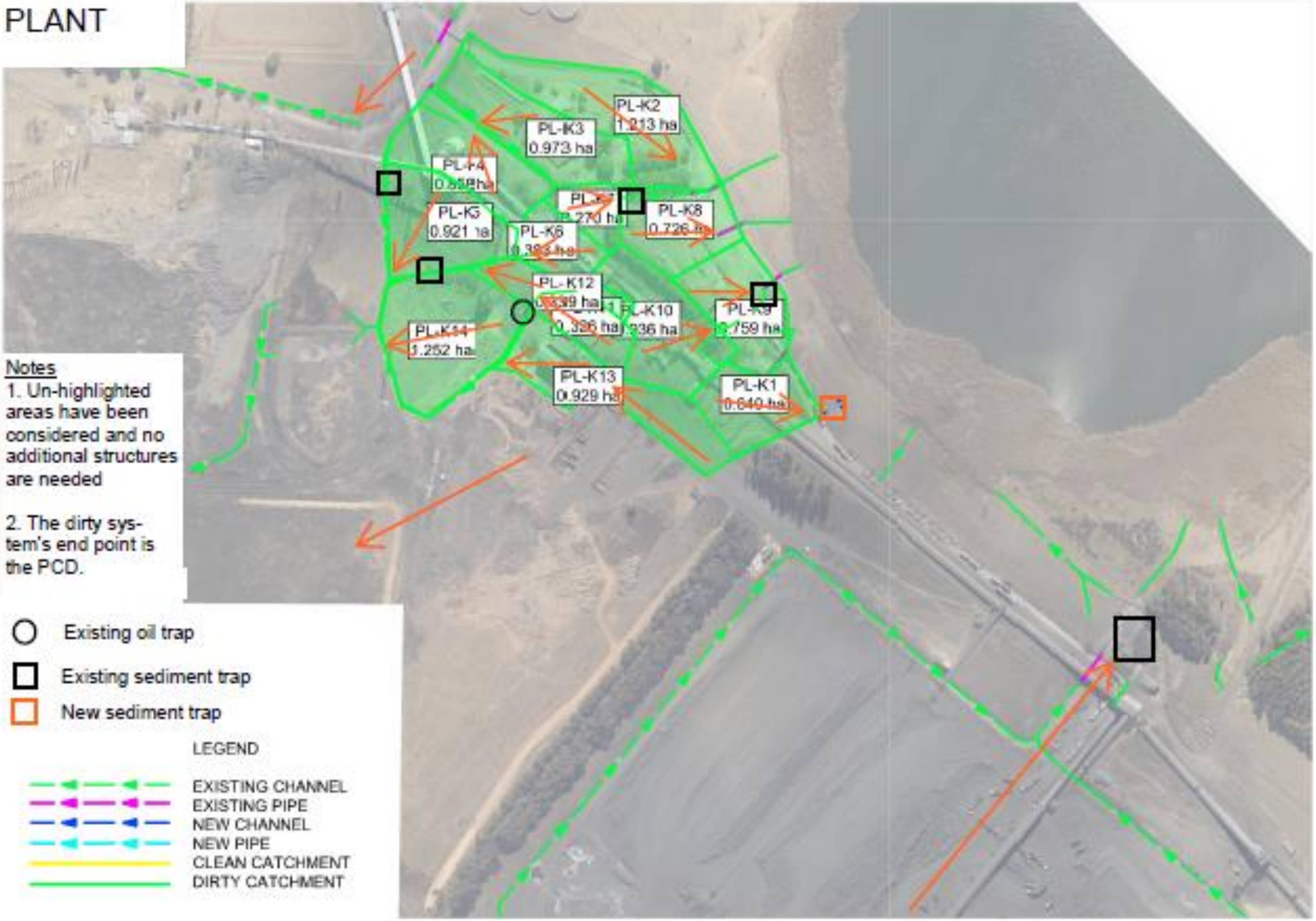

Figure 6-4 Proposed Stormwater Management (Plant Area) (WSP, 2017)

6.3 Stormwater management plan at the proposed stooping areas

All information regarding the stormwater management plan for the proposed stooping areas was obtained from the surface water study conducted by GCS, (Hydrological Assessment for the Proposed Stooping of Pillars of the Underground Works at Matla Colliery, GCS, 2015).

The Matla Stooping Project (Phase 1) will have no surface-related activities as the mining will be underground. There will be no dirty water generating areas as a result of this. The impacts to the surface will be in the form of subsidence of approximately 1.53 m, therefore the site-wide framework is to allow the subsided areas to be free-draining while at the same time limiting the amount of surface water runoff infiltrating into the underground workings. The clean water runoff being generated from the upslope clean water catchments will be diverted away from the subsided areas

The water runoff generated from the subsided areas will be diverted to flow out of these areas via channels. This conceptual stormwater management plan methodology was developed in accordance with GN704 of the South African National Water Act (NWA) (Act 36 of 1998) (South Africa, 1998). This guideline was adopted when sizing all storm water infrastructure as these guidelines are relevant to mining activities. Further to this, dirty water channels and storm water infrastructure were sized such that they will only spill once, on average, in a 50-year period (GCS, 2015).

6.3.1 Summary of catchment hydrology

Discretisation into sub-catchments is based on the topography of the study area, as shown in Figure 6-5 to Figure 6-8. This was undertaken in order to determine the clean water and dirty water catchment areas. No designation of the clean and dirty water catchments was carried out as there are no dirty water generating activities taking place on the surface. The parameters used to model the overland flow are listed in Table 6-1. Manning's 'n' coefficient used in the model for the impervious areas and pervious areas were 0.013 (float finish, concrete) and 0.15 (veld type vegetation), respectively (McCuen, 1996). The soils were identified as being in the sandy loam group (WR2012). The model uses these criteria to incorporate infiltration into the analysis using the Green-Ampt infiltration method. The sandy loam group resulted in a Suction Head of 110.1 mm, a Hydraulic Conductivity of 21.8 mm/hr and an Initial Deficit of 0.36 being used in the modelling. Simulated runoff volumes are summarised in for the 50-year recurrence interval storm event (GCS, 2015).

Table 6-1 Summary of catchment hydrology (GCS, 2015)

Name	Area (ha)	Flow Length (m)	Slope (%)	Runoff Volume (m^3)	Peak Runoff (m^3/s)
S1.	21.7	1093	1.7	3350	0.92
S2.	1.6	55	1.7	660	0.52
S3.	0.3	30	1.7	120	0.12
S4.	1.5	50	1.7	650	0.54
S5.	9.8	230	1.5	3040	1.37
S6.	5.2	100	3.3	2140	1.52
S7.	0.6	35	3.3	290	0.31
S8.	2.2	55	3.2	960	0.87
S9.	4.6	105	1.8	1790	1.15
S10.	2.9	105	0.3	880	0.39
S11.	0.4	25	0.3	160	0.12

S12.	3.1	70	0.5	1150	0.68
S13.	4.9	250	1.5	1480	0.64
S14.	13.2	380	3	3890	1.64
S15.	5.6	110	2.8	2230	1.51
S16.	0.8	95	0.5	260	0.14
S17.	0.6	60	0.4	210	0.12
S18.	3.7	90	1.4	1450	0.94
S19.	0.3	35	1.5	130	0.12
S20.	0.8	55	1.4	350	0.26
S21.	1.8	60	1.4	730	0.53
S22.	4.0	120	1.1	1420	0.79
S23.	4.4	140	0.8	1430	0.70
S24.	4.0	110	1.3	1480	0.88
S25.	16.4	220	1.5	5160	2.37
S26.	14.3	180	1.7	4860	2.50
S27.	4.5	125	2.2	1730	1.08
S28.	4.1	90	1.5	1610	1.05
S29.	5.8	140	1.3	2020	1.09
S30.	5.0	155	0.9	1620	0.78
S31.	13.0	300	2.2	3920	1.71
S32.	5.3	210	3.8	1930	1.10
S33.	15.3	200	3.7	5560	3.22
S34.	2.0	90	5.1	870	0.70
S35.	1.8	105	3	730	0.51
S36.	1.4	80	1.8	560	0.39
S37.	2.8	135	3.2	1090	0.71
S38.	2.6	80	6.7	1160	1.05
S39.	4.4	120	2.9	1730	1.15
S40.	4.6	150	2.6	1710	1.03
S41.	2.7	105	3.9	1100	0.79
S42.	19.3	200	2.3	6620	3.48
S43.	0.7	65	1.2	300	0.21
S44.	2.1	95	1.2	790	0.49
S45.	12.4	300	2.5	3830	1.71
S46.	4.5	115	2.5	1770	1.17
S47.	2.4	105	2	930	0.60
S48.	16.0	625	2	3520	1.17
S49.	5.5	90	3.3	2290	1.67
S50.	2.3	97	2.9	930	0.65
S51.	0.8	64	2	340	0.26
S52.	31.7	616	2.3	7270	2.48
S53.	37.8	620	4.6	10030	3.84
S54.	2.8	115	5.2	1160	0.84
S55.	4.5	110	1.6	1710	1.06
S56.	12.1	200	1.5	3910	1.87
S57.	15.8	175	0.8	4840	2.14
S58.	10.5	115	0.8	3640	1.93
S59.	28.2	255	1.9	8790	3.98

S60.	6.8	150	0.3	1830	0.72
S61.	9.6	190	1.3	3090	1.47
S62.	3.5	155	2.1	1260	0.72
S63.	4.1	170	2	1440	0.79
S64.	6.1	200	0.5	1630	0.63
S65.	8.3	115	1.2	3030	1.74
S66.	14.0	200	2.2	4790	2.49
S67.	5.7	135	2.1	2140	1.29

The key for Figure 6-5 to Figure 6-8 is described within the brackets (Green outlined area = Stooping area, Red outlined area = Sub catchment area/berm, Yellow arrow symbol = Flow direction).

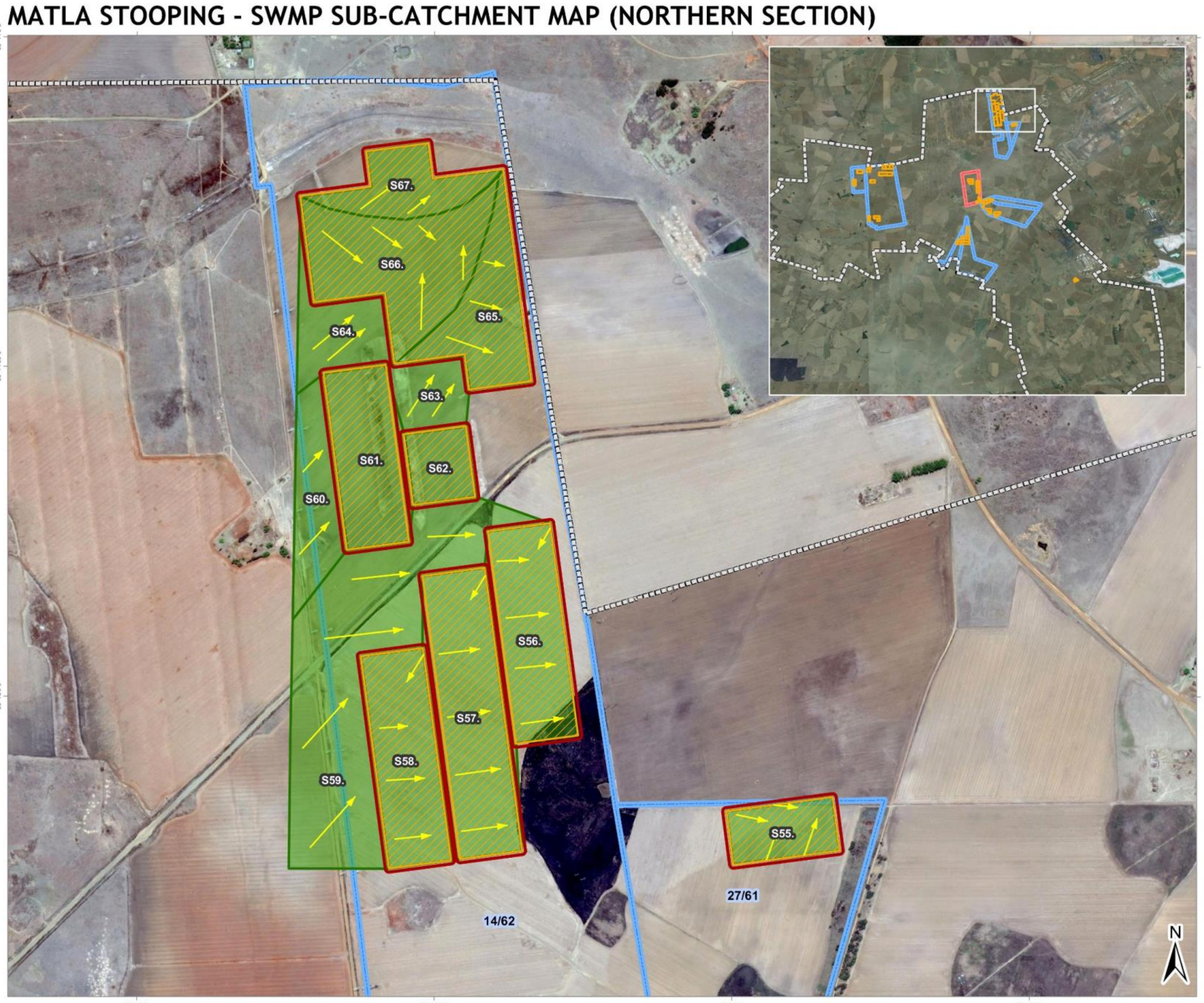

Figure 6-5 Summary of delineated catchment areas (Northern Section), (GCS, 2015)

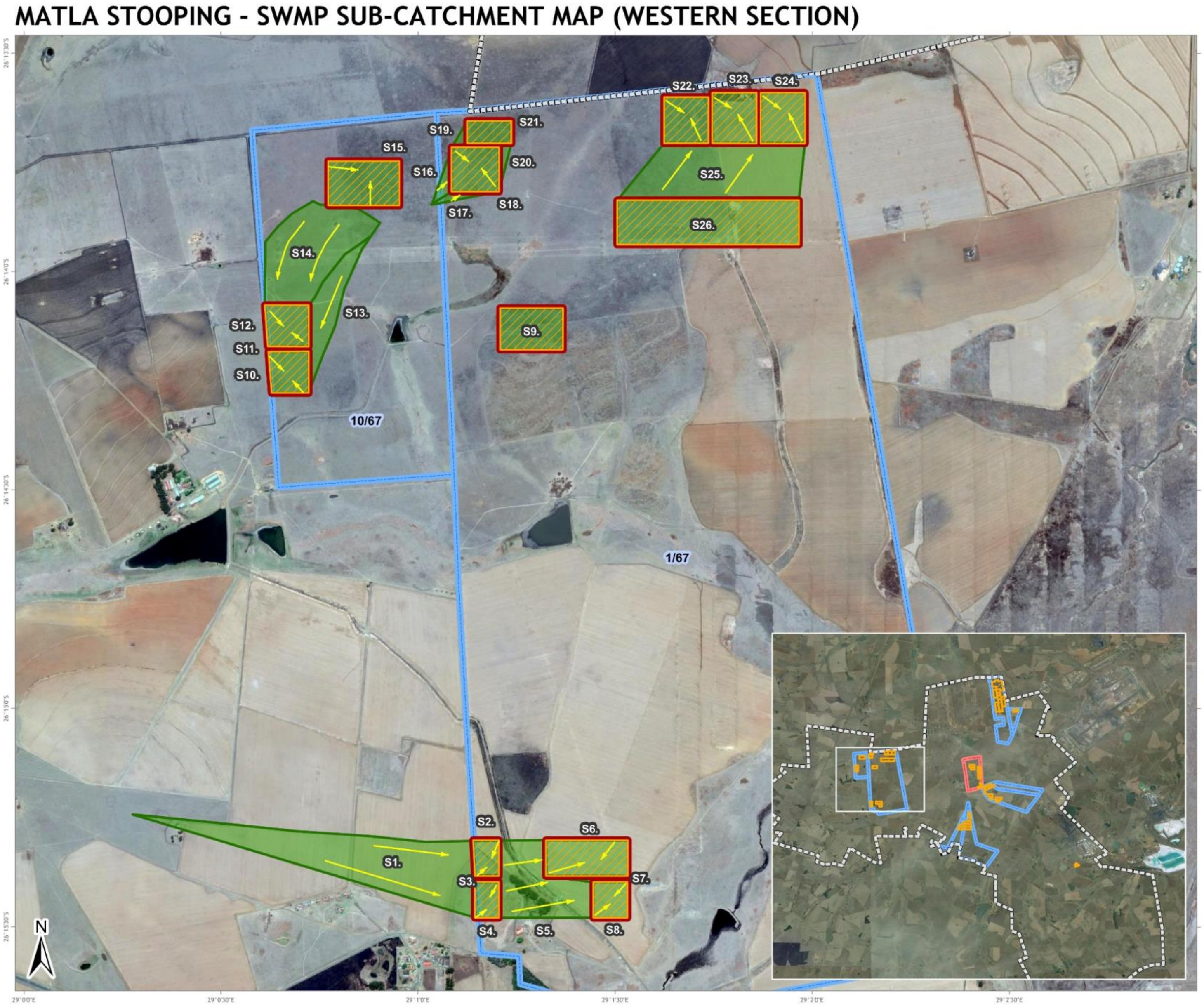

Figure 6-6 Summary of delineated catchment areas (Western Section), (GCS, 2015)

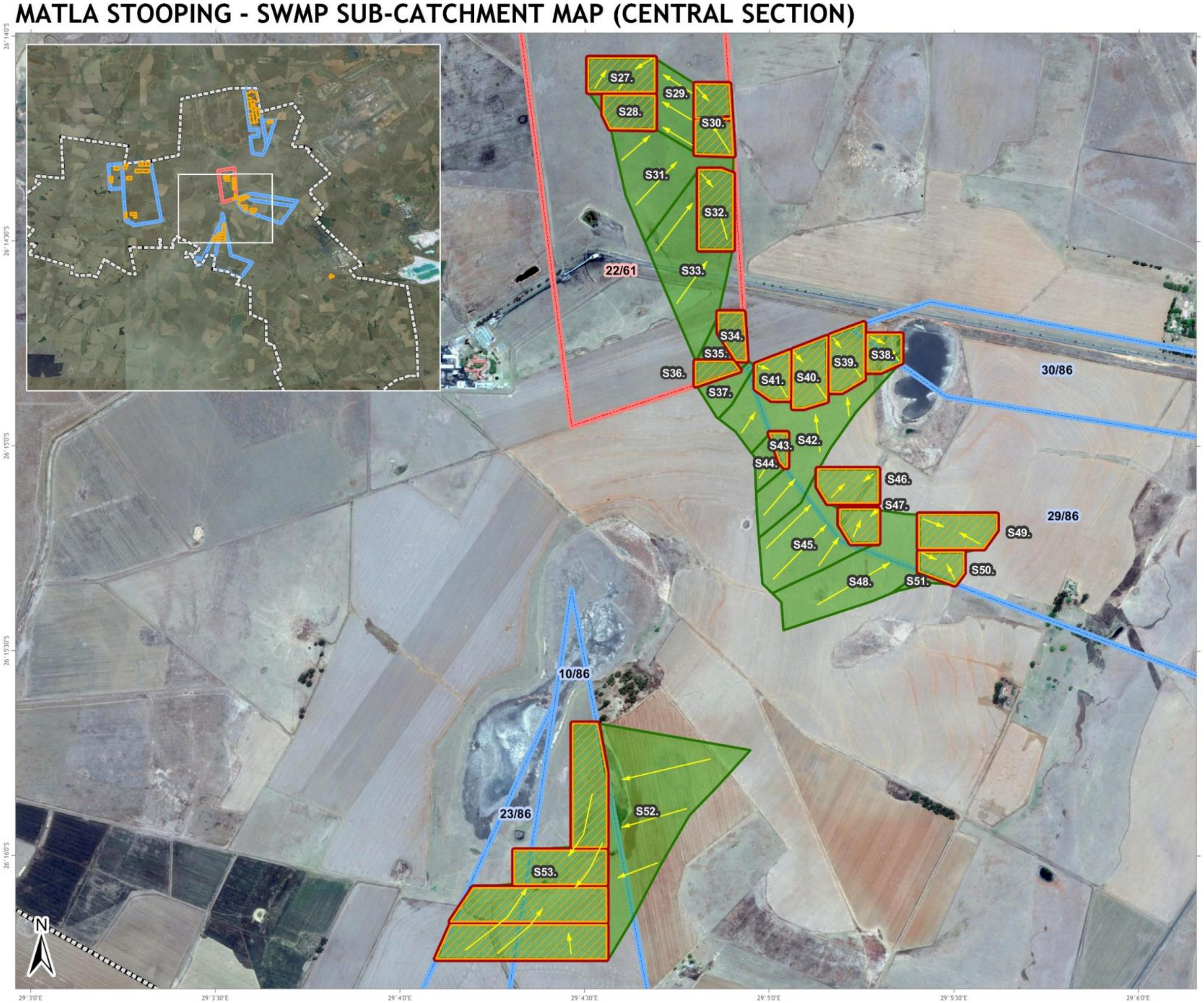

Figure 6-7 Summary of delineated catchment areas (Central Section), (GCS, 2015)

MATLA STOOPING - SWMP STRATEGY MAP (SOUTHEASTERN SECTION)

Figure 6-8 Summary of delineated catchment areas (South Eastern Section), (GCS, 2015)

6.3.2 Summary of channel sizing

The diversion channel has been sized to divert the runoff for the 50-year return period flood peak, as per GN704 (shown in Table 6-2). The proposed conceptual diversion channel layout can be seen in Figure 6-9 to Figure 6-12. The Manning's roughness assumed for the channels was 0.035 (vegetation-lined channels) (Hicks et al., 1998).

The results show that one of the channels (C42 and C53, as shown in Figure 6-9 to Figure 6-12) is at risk of eroding, due to the maximum velocity being 3 m/s. The high velocities are due to the steep catchment gradients present on the site. Therefore, additional lining may be required for the channels, such as riprap. This channel lining, when implemented, will greatly reduce the risk of erosion. Another option would be to implement energy dissipation devices. Energy dissipaters are devices designed to protect downstream areas from erosion by reducing the velocity of flow to acceptable limits (GCS, 2015).

Table 6-2 Summary of channel characteristics and results (GCS, 2015)

Name	Length (m)	Roughness	Cross-Section	Height (m)	Bottom Width (m)	Left Slope (1:H)	Right Slope (1:H)	Slope (m/m)	Max. Flow (m³/s)	Max. Velocity (m/s)
C1.	345	0.035	Trapezoidal	1	1	2	2	0.032	0.92	1.81
C2.	194	0.035	Trapezoidal	0.8	0.5	2	2	0.017	0.52	1.33
C3.	111	0.035	Trapezoidal	1	1	2	2	0.017	0.12	0.83
C4.	174	0.035	Trapezoidal	0.8	0.5	2	2	0.017	0.51	1.32
C5.	518	0.035	Trapezoidal	1	1	2	2	0.026	1.34	1.87
C6.	199	0.035	Trapezoidal	0.8	0.5	2	2	0.032	0.85	1.83
C7.	171	0.035	Trapezoidal	1	1	2	2	0.033	0.30	1.32
C8.	378	0.035	Trapezoidal	0.8	0.5	2	2	0.033	1.51	2.14
C9.	318	0.035	Trapezoidal	0.5	0.5	2	2	0.018	1.12	1.62
C10.	383	0.035	Trapezoidal	1	1	2	2	0.024	0.64	1.48
C11.	225	0.035	Trapezoidal	0.5	0.5	2	2	0.020	0.39	1.28
C12.	182	0.035	Trapezoidal	1	1	2	2	0.020	0.12	0.86
C13.	253	0.035	Trapezoidal	0.5	0.5	2	2	0.018	0.66	1.43
C14.	200	0.035	Trapezoidal	1	1	2	2	0.022	1.64	1.85
C15.	348	0.035	Trapezoidal	1	0.5	2	2	0.028	1.49	2.01
C16.	209	0.035	Trapezoidal	1	1	2	2	0.015	0.12	0.81
C17.	199	0.035	Trapezoidal	1	1	2	2	0.039	0.13	1.09
C18.	283	0.035	Trapezoidal	0.5	0.5	2	2	0.015	0.92	1.47
C19.	201	0.035	Trapezoidal	1	1	2	2	0.020	0.26	1.09
C20.	103	0.035	Trapezoidal	1	1	2	2	0.020	0.12	0.87
C21.	220	0.035	Trapezoidal	0.5	0.5	2	2	0.014	0.53	1.26
C22.	273	0.035	Trapezoidal	0.5	0.5	2	2	0.025	0.78	1.63
C23.	291	0.035	Trapezoidal	0.5	0.5	2	2	0.025	0.68	1.58
C24.	293	0.035	Trapezoidal	0.5	0.5	2	2	0.025	0.86	1.68
C25.	649	0.035	Trapezoidal	1	1	2	2	0.028	2.32	2.22
C26.	834	0.035	Trapezoidal	1	1	2	2	0.028	2.39	2.24
C27.	381	0.035	Trapezoidal	0.5	0.5	2	2	0.022	1.05	1.68
C28.	374	0.035	Trapezoidal	0.5	0.5	2	2	0.015	1.02	1.51
C29.	343	0.035	Trapezoidal	1	1	2	2	0.036	1.07	1.97

C30.	389	0.035	Trapezoidal	0.5	0.5	2	2	0.015	0.76	1.40
C31.	659	0.035	Trapezoidal	1	1	2	2	0.031	1.69	2.12
C32.	417	0.035	Trapezoidal	0.5	0.5	2	2	0.038	1.07	2.07
C33.	552	0.035	Trapezoidal	1	1	2	2	0.048	3.14	2.93
C34.	230	0.035	Trapezoidal	0.5	0.5	2	2	0.051	0.69	2.06
C35.	285	0.035	Trapezoidal	1	1	2	2	0.041	0.50	1.67
C36.	214	0.035	Trapezoidal	1	1	2	2	0.018	0.38	1.19
C37.	328	0.035	Trapezoidal	1	1	2	2	0.019	0.69	1.41
C38.	205	0.035	Trapezoidal	0.5	0.5	2	2	0.067	1.03	2.53
C39.	340	0.035	Trapezoidal	0.5	0.5	2	2	0.029	1.13	1.90
C40.	363	0.035	Trapezoidal	0.5	0.5	2	2	0.026	1.01	1.77
C41.	261	0.035	Trapezoidal	0.5	0.5	2	2	0.039	0.79	1.93
C42.	803	0.035	Trapezoidal	1	1	2	2	0.051	3.37	3.05
C43.	158	0.035	Trapezoidal	1	1	2	2	0.012	0.21	0.89
C44.	213	0.035	Trapezoidal	1	1	2	2	0.013	0.48	1.16
C45.	492	0.035	Trapezoidal	1	1	2	2	0.018	1.69	1.75
C46.	343	0.035	Trapezoidal	0.5	0.5	2	2	0.025	1.14	1.80
C47.	271	0.035	Trapezoidal	0.5	0.5	2	2	0.020	0.59	1.42
C48.	323	0.035	Trapezoidal	1	1	2	2	0.036	1.16	2.02
C49.	407	0.035	Trapezoidal	1	1	2	2	0.033	1.66	2.16
C50.	260	0.035	Trapezoidal	0.5	0.5	2	2	0.029	0.65	1.65
C51.	201	0.035	Trapezoidal	1	1	2	2	0.020	0.25	1.09
C52.	1104	0.035	Trapezoidal	1	1	2	2	0.016	2.38	1.86
C53.	365	0.035	Trapezoidal	1	1	2	2	0.047	3.83	3.06
C54.	286	0.035	Trapezoidal	1	1	2	2	0.052	0.84	2.11
C55.	361	0.035	Trapezoidal	0.5	0.5	2	2	0.016	1.03	1.54
C56.	697	0.035	Trapezoidal	1	1	2	2	0.022	1.80	1.90
C57.	865	0.035	Trapezoidal	1	1	2	2	0.022	2.07	1.97
C58.	673	0.035	Trapezoidal	1	1	2	2	0.022	1.84	1.91
C59.	1464	0.035	Trapezoidal	1	1	2	2	0.033	3.77	2.68
C60.	693	0.035	Trapezoidal	1	1	2	2	0.032	0.70	1.31
C61.	575	0.035	Trapezoidal	0.5	0.5	2	2	0.013	0.95	1.42
C62.	300	0.035	Trapezoidal	0.5	0.5	2	2	0.021	0.70	1.50
C63.	394	0.035	Trapezoidal	1	1	2	2	0.032	1.85	2.19
C64.	670	0.035	Trapezoidal	1	1	2	2	0.033	0.61	1.20
C65.	630	0.035	Trapezoidal	1	1	2	2	0.012	1.64	1.40
C66.	622	0.035	Trapezoidal	1	1	2	2	0.019	2.41	2.01
C67.	387	0.035	Trapezoidal	1	1	2	2	0.016	1.25	1.54
C68.	170	0.035	Trapezoidal	1	1	2	2	0.012	4.48	2.02

The key for Figure 6-9 to Figure 6-12 is described within the brackets (Light blue outlined area = Stooping area, Red outlined area = Sub catchment area/berm, Blue line with yellow arrow symbol = proposed channel showing flow direction, Red point = Junction, Green point = Outflow).

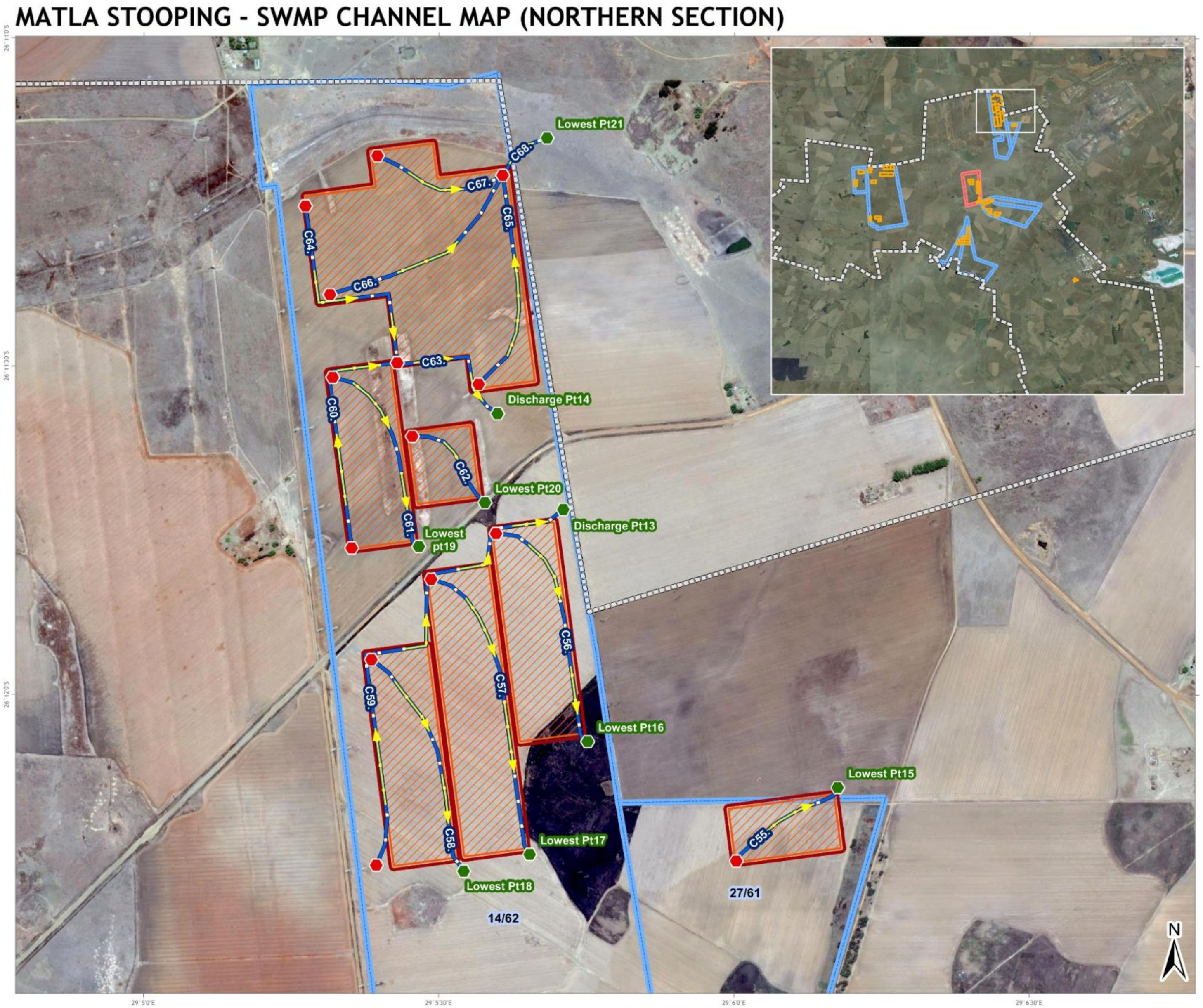

Figure 6-9 The proposed channel layout – Northern Section (GCS, 2015)

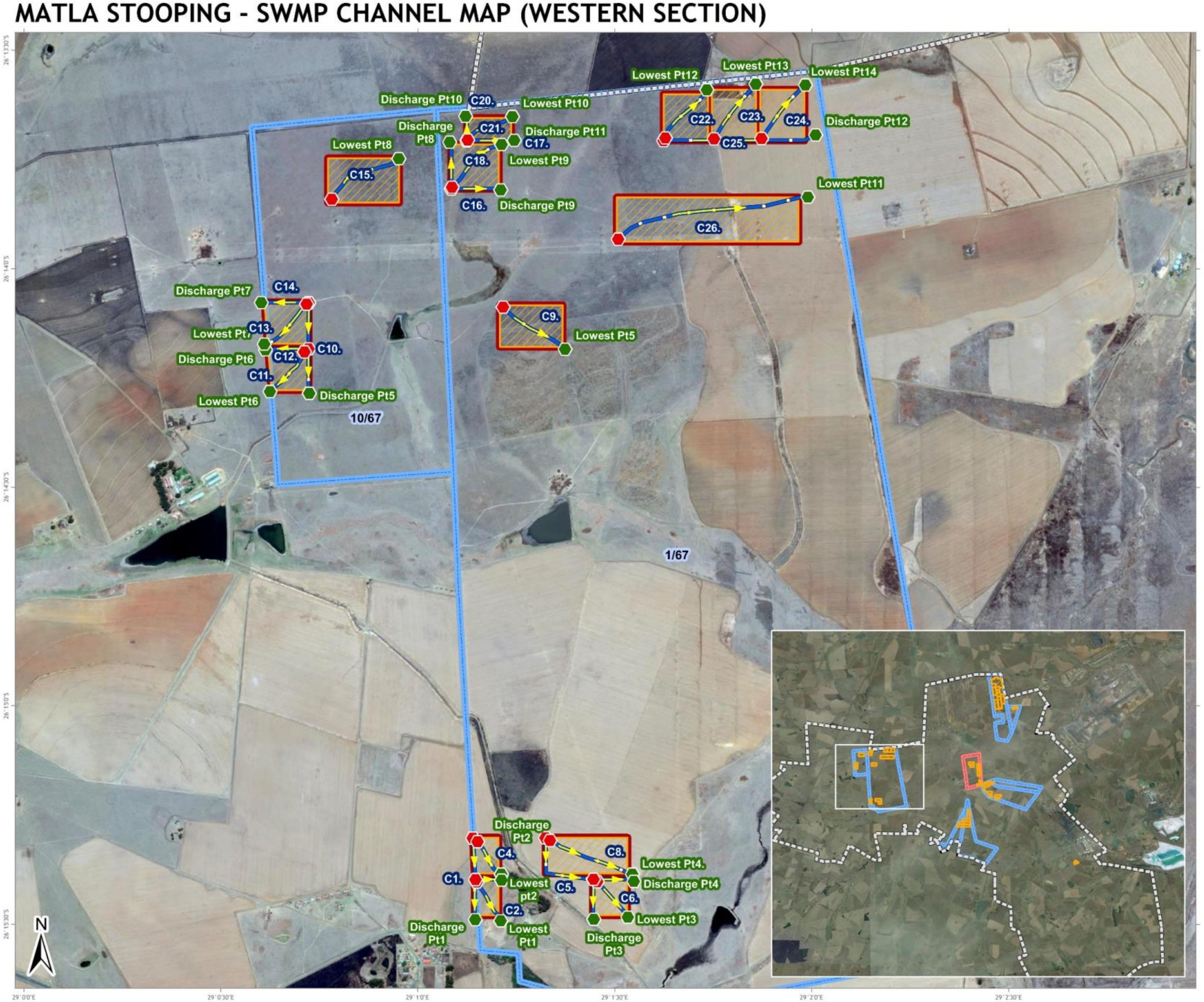

Figure 6-10 The proposed channel layout – Western Section (GCS, 2015)

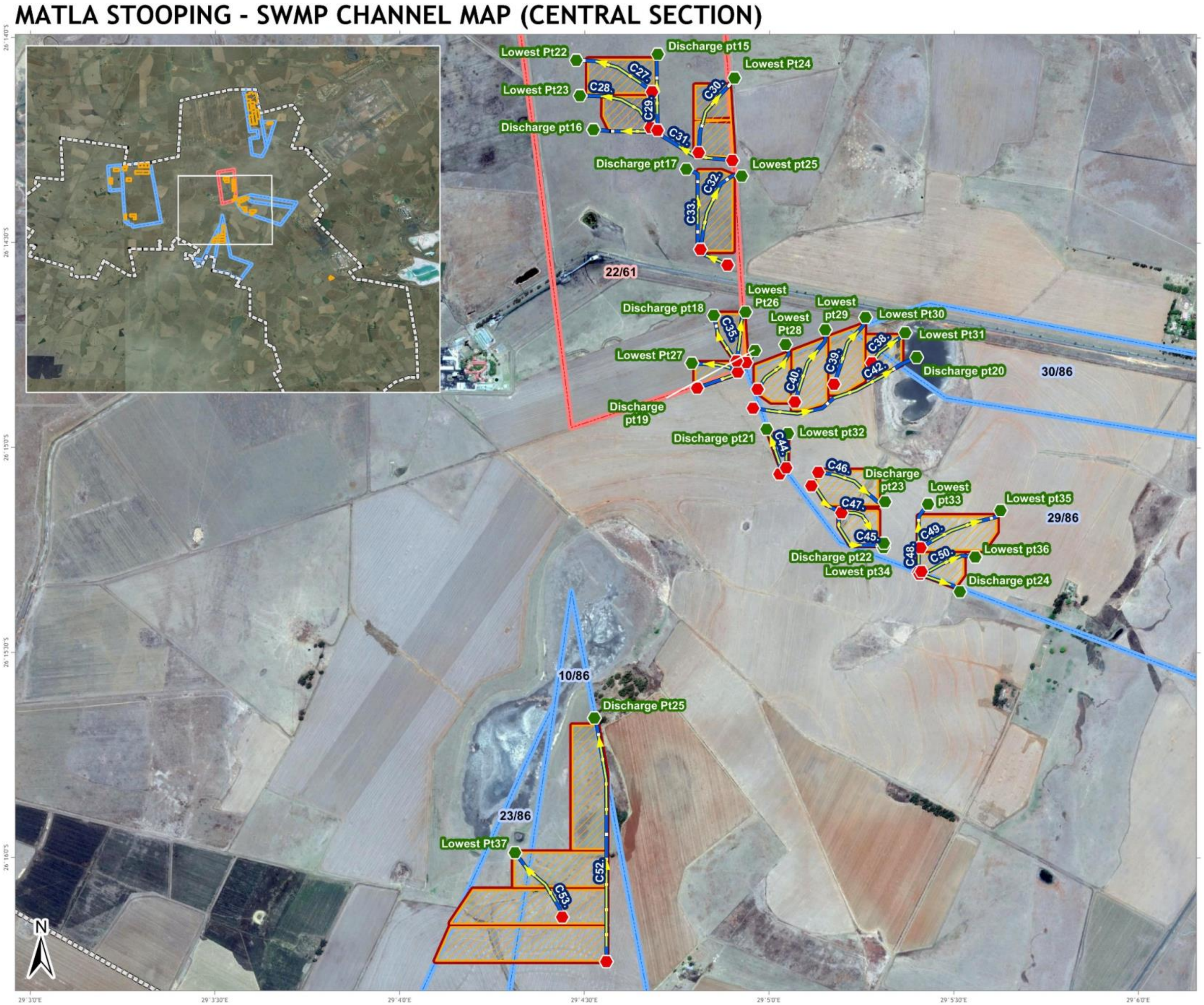

Figure 6-11 The proposed channel layout – Central Section (GCS, 2015)

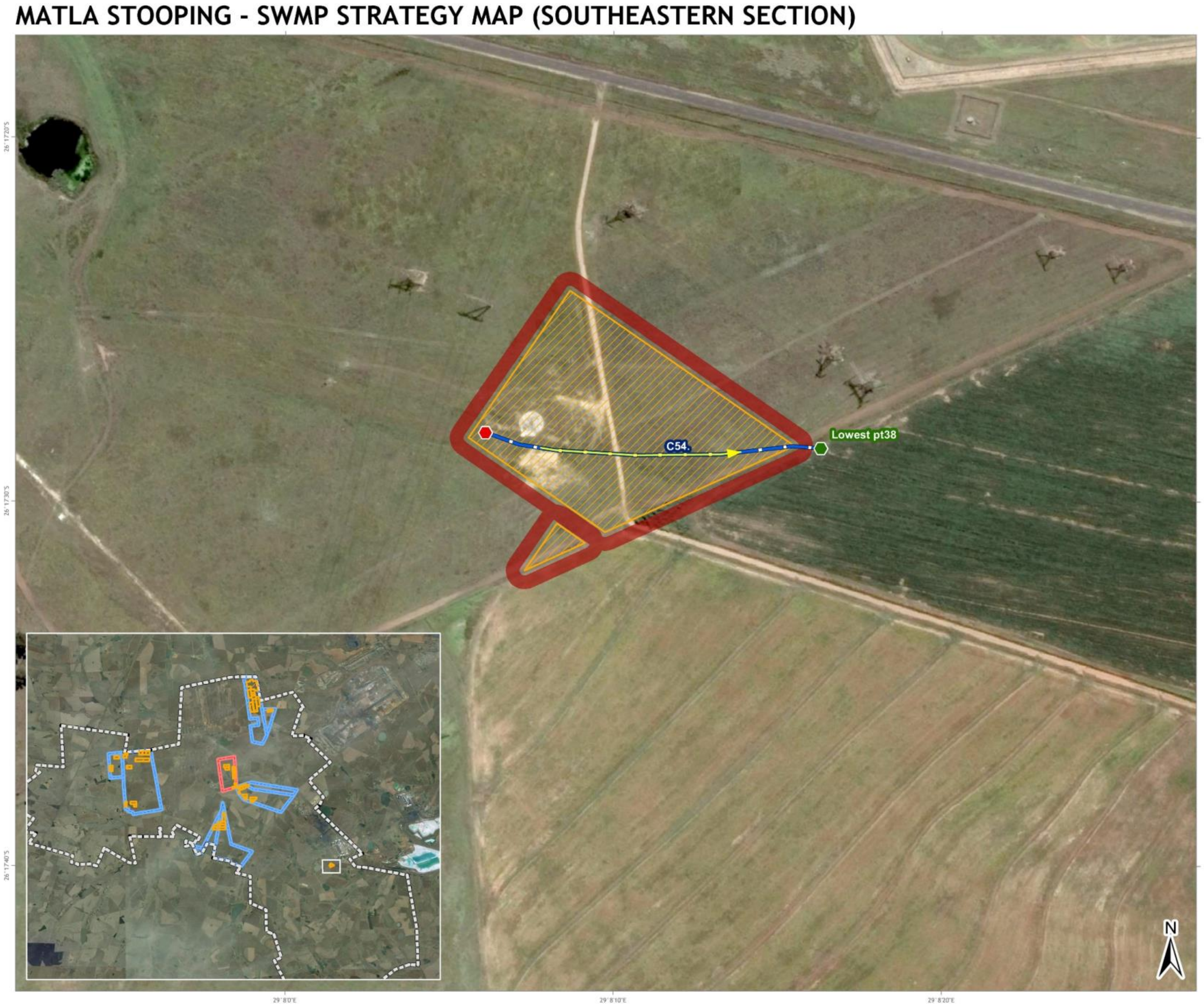

Figure 6-12 The proposed channel layout – South Eastern Section (GCS, 2015)

6.4 Stormwater Management for the New Mine 1 Area

6.4.1 Introduction

As mentioned a stormwater management plan is required as per GN 704 of the National Water Act no 36 of 1998, with the main objective of the proposed stormwater management plan being to ensure the separation of clean and dirty water during the proposed mining operation.

The section below details the proposed stormwater management

6.4.2 Conceptual sizing of clean and dirty water channels

Based on the project layout placement, the drainage direction within close proximity the New Mine 1 infrastructure areas occurs in a north west to south east direction. Therefore, all clean water runoff emanating from the upstream catchment boundary is to be diverted around the proposed infrastructure area to the nearest watercourse or clean water environment.

It is proposed that all clean water channels be unlined vegetated trapezoidal channels of which an example is shown below in Figure 6-13.

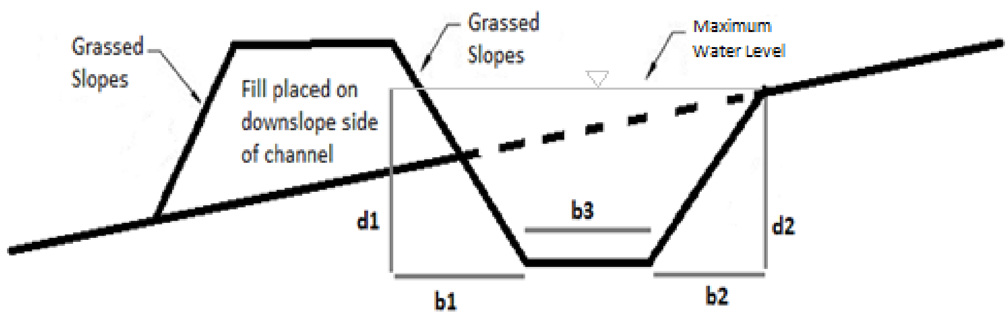

Figure 6-13 Clean water diversion channel conceptual design

All dirty water channels are based on a concrete lined trapezoidal channel, and will serve to capture all runoff from within the New Mine 1 area.

Summary of the catchment hydrology, peak flow estimations and conceptual sizing of the proposed channels are shown below in Table 6-3, Table 6-4, and Table 6-5 respectively.

Table 6-3 Summary of catchment hydrology

Name	Area (km^2)	Length of longest watercourse (m)	Height Difference (m)	Rainfall Intensity (Q_{50})	Tc (hours)	C-Factor
Catch A-B	0.0293	432	9.8	137	0.25	0.24
Catch C-D, E-F, F-D	0.0424	383	12.4	137	0.25	0.51
Catch G-H, I-H, I-J	0.0245	378	11.48	137	0.25	0.51
Catch K-L	0.0305	445	15.01	137	0.25	0.51
Catch M-L	0.0557	438	7.89	137	0.25	0.51

Table 6-4 Summary of peak flows for various recurrence intervals

Name	Summary of peak flows (m^3/s) for various recurrence intervals (years)					
	2 year	5 year	10 year	20 year	50 year	100 year
Catch A-B	0.06	0.09	0.12	0.15	0.22	0.30
Catch C-D, E-F, F-D	0.35	0.49	0.59	0.71	0.91	1.10
Catch G-H, I-H, I-J	0.20	0.28	0.34	0.41	0.53	0.64
Catch K-L	0.25	0.35	0.43	0.51	0.65	0.79
Catch M-L	0.46	0.64	0.78	0.93	1.19	1.45

Table 6-5 Summary of conceptual sizing of proposed channels

Channel Section	Length (m)	Q (m3/s)	left and right slope (m/m)	Bottom width (m)	Calculated Top width (m)	Calculated depth (m)	Velocity (m/s)	Design depth (m)	Type
A-B	351	0.22	0.3	1.0	1.14	0.24	0.85	1.0	Grassed Trapezoidal
C-D	413	0.91	N/A	1.0	1.00	0.40	2.26	1.0	Lined Rectangular
E-F	72	0.91	N/A	1.0	1.00	0.40	2.26	1.0	Lined Rectangular
G-H	105	0.53	N/A	1.0	1.00	0.27	1.93	1.0	Lined Rectangular
I-J	122	0.53	N/A	1.0	1.00	0.27	1.93	1.0	Lined Rectangular
K-L	379	0.65	N/A	1.0	1.00	0.31	2.07	1.0	Lined Rectangular
M-L	548	1.19	N/A	1.0	1.00	0.49	2.45	1.0	Lined Rectangular

6.4.3 Conceptual sizing of PCD

To calculate the amount of dirty water runoff captured via the infrastructure areas of New Mine 1, the Soil Conversation Services (SCS) method, described fully in Schmidt and Schulze (1987) is used. The SCS method is particularly suited to small catchments (less than 30 km^2) and takes into account most of the factors that affect runoff, such as quantity, time distribution and duration of rainfall, land use, soil type and size and characteristics of the generating catchment. It is based on the principle that runoff is caused by the rainfall that exceeds the cumulative infiltration of the soil. Soil types are divided into four hydrological groups, ranging from soils with low runoff potential (well-drained with high infiltration ability and permeability such as sand and gravel) to soils with high runoff potential (very low infiltration rates and permeability such as shallow soils with clay, peat or rock).

The method used a curve number (CN) which can be determined from observation of the characteristics of the catchment. The curve number expresses a catchments stormflow response to a rainfall event (Schulze et al. 1992). This response is dependent on the catchment characteristics such as hydrological soil properties, catchment slope and land use. For the project area, the adopted CN for all surface areas is estimated to be 70. The SCS storm flow depth equation is given below:

$$Q = \frac{(P - I_a)^2}{P - I_a + S} \quad \text{for } \boldsymbol{P > I_a}$$

where

Q	=	stormflow depth (mm),
P	=	daily rainfall depth (mm), usually input as a one-day design rainfall for a given return period,
S	=	potential maximum soil water retention (mm),
	≡	index of the wetness of the catchment's soil prior to a rainfall event,
I_a	=	initial losses (abstractions) prior to the commencement of stormflow, comprising of depression storage, interception and initial infiltration (mm)
	≡	0.1 S

Table 6-6 Summary of PCD sizing (m^3) for New Mine 1

Name	Summary of PCD volume (m^3) for various recurrence intervals (years)					
	2 year	5 year	10 year	20 year	50 year	100 year
New Mine 1 PCD	2411	4284	5783	7435	**9876**	11928

All runoff collected at the mid to lower catchment will be collected in a sump and pumped to the New Mine 1 PCD.

As indicated above the proposed PCD required to contain all the dirty water emanating from the New Mine 1 infrastructure area, should be sized so as to contain the 24 hour 1:50 year storm event. Based on the calculations, the total volume of the PCD is estimated at 9876 m^3.

The overall infrastructure and summary of the stormwater management plan for the New Mine 1 area is shown below in Figure 6-14 and Figure 6-15 respectively.

Figure 6.18

TITLE : Overall Layout of the New Mine 1 Infrastructure Area

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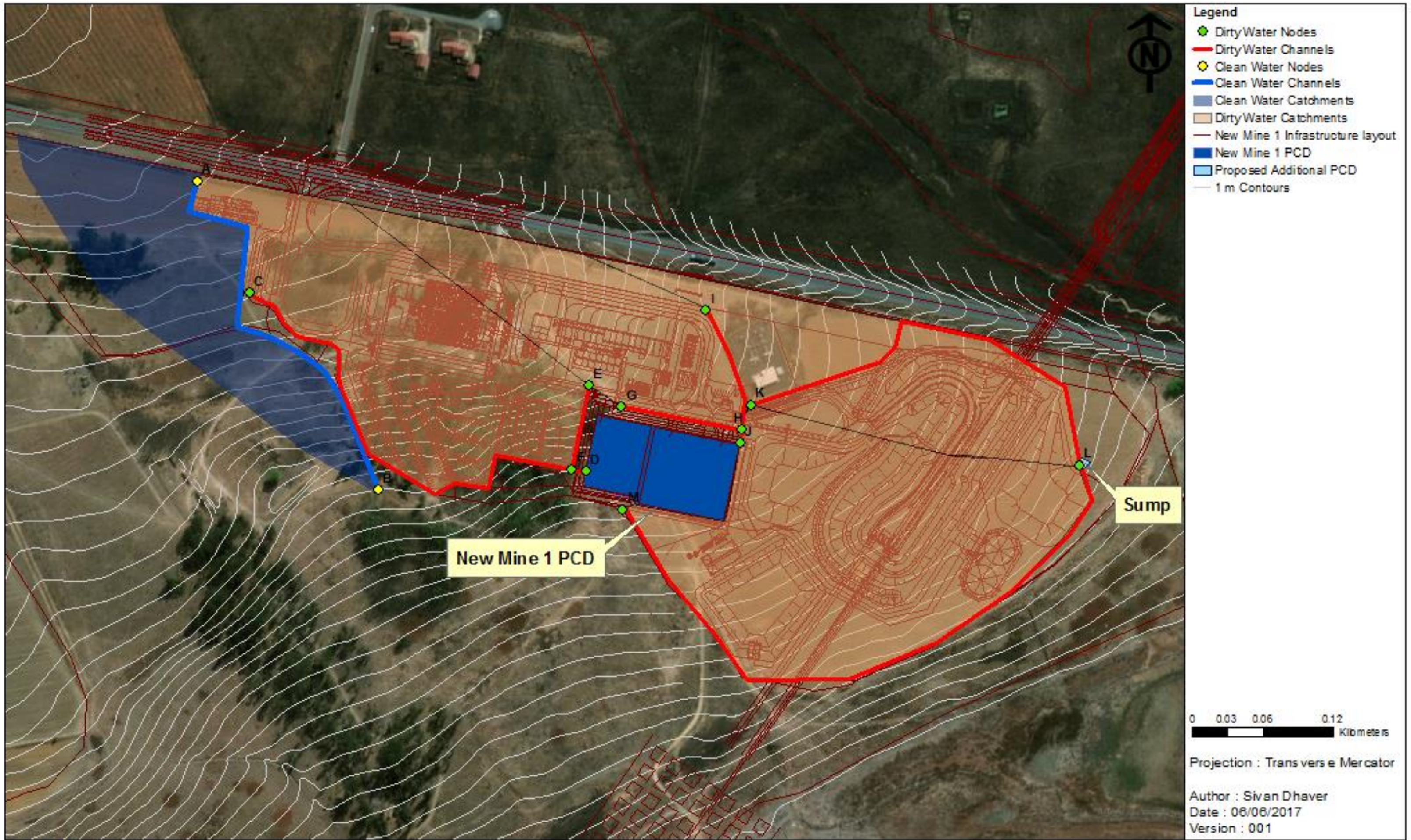

Figure 6.19

TITLE : Summary of Stormwater Management Plan for the New Mine 1 Area

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7 Floodline Modelling

7.1 Introduction

The HEC-RAS hydraulic programme was used for the purposes of routing the peak flows resulting from the 1:50 year and 1:100 year storm event through the identified watercourses/rivers. 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. The software is used worldwide and has consequently been thoroughly tested through numerous case studies.

HEC-GeoRAS is an extension of HEC-RAS which utilises the ArcGIS environment. The HEC-GeoRAS extension is used to extract the cross sections and river profiles from a Digital Elevation Model (DEM) for export into HEC-RAS for modelling, and is used again to project the modelled flood levels back onto the DEM to generate the extent of flooding.

Floodline for the Matla project area where undertaken by GSC (GCS, 2015) and is indicated below in Figure 7-1. Additional floodlines adjacent to the New Mine 1 Area was undertaken for the drainages flowing along the north eastern boundary (see Figure 7-2) by Golder (Golder, 2013).

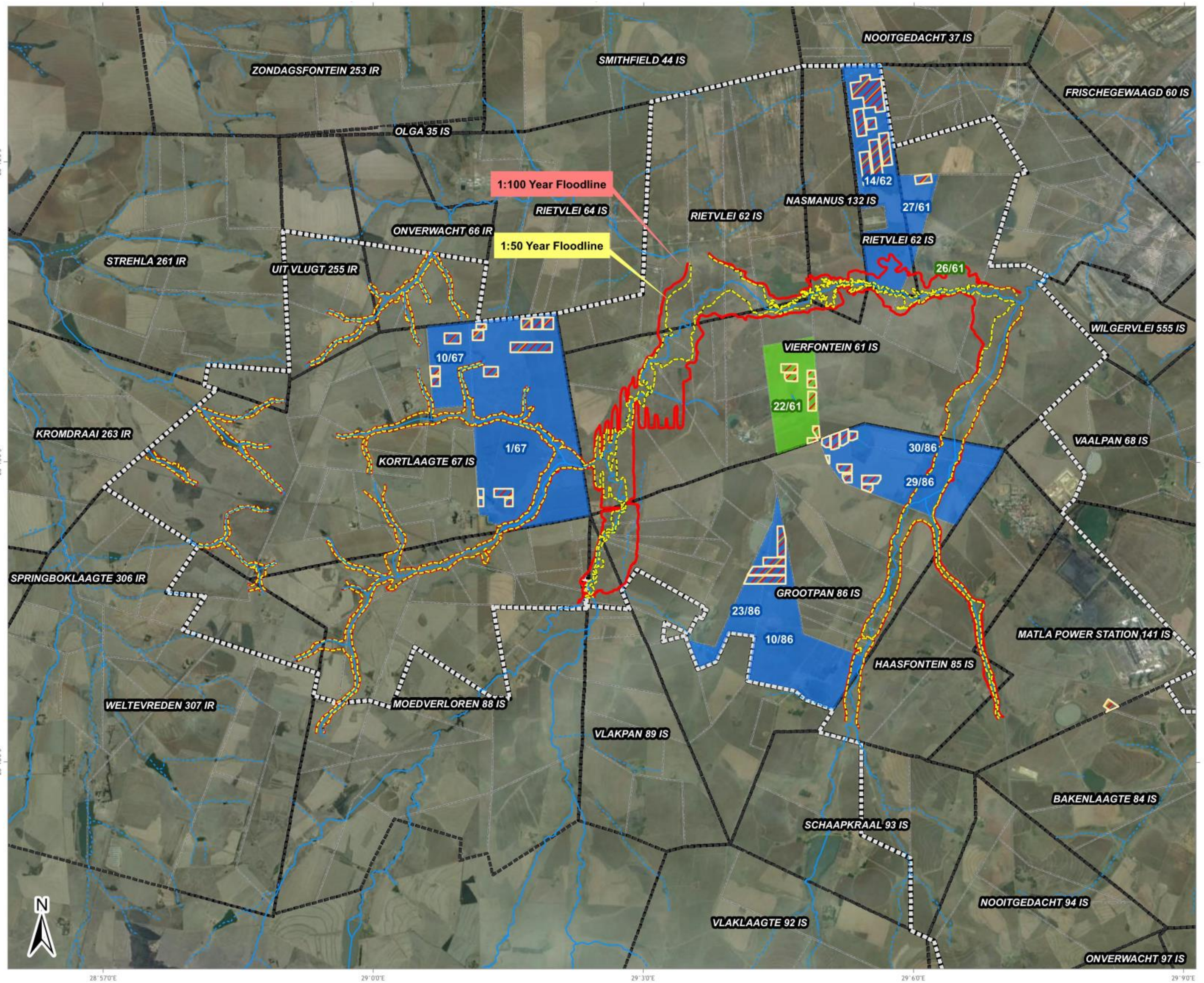

Figure 7-1 Summary of floodlines completed (GCS, 2015)

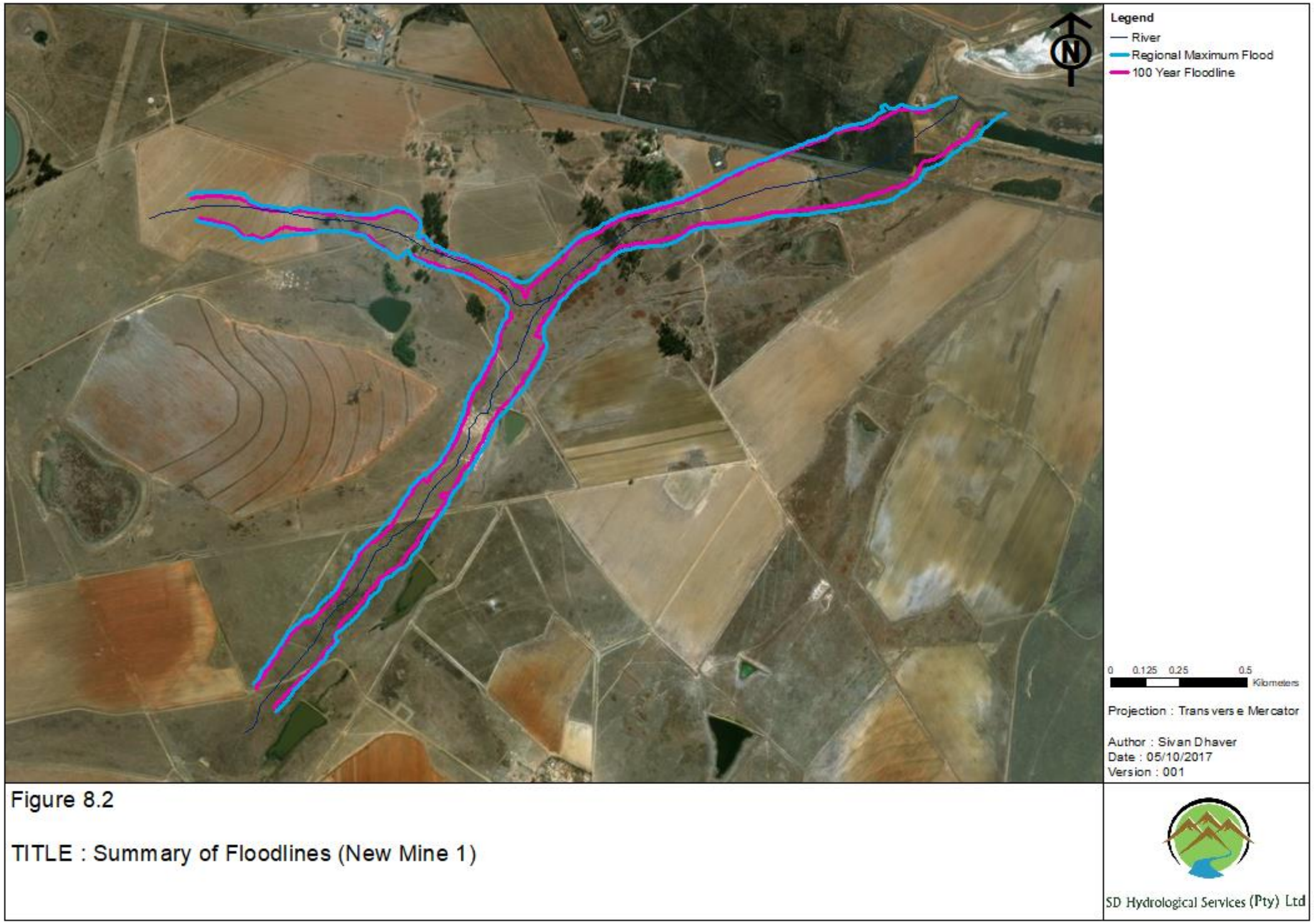

Figure 7-2 Summary of floodlines (New Mine 1), (Golder, 2013)

8 Surface Water Monitoring

8.1 Introduction

The primary source of information used in this section is the study undertaken by GCS (Surface and groundwater quality consolidation report – Matla Colliery for the period 2008-2016, GCS, 2017). The section below details all the surface water quality monitoring undertaken over the period 2008 to 2016 within the Matla project area.

Summary of the water quality statistical results are shown in Appendix B, whilst Summary of the water quality monitoring locations are shown Figure 8-29.

8.2 Summary of Surface Water Quality Results

For each zone the pH, iron, sulphate and sodium concentrations will be analysed to identify annual trends and whether or not the parameter exceeds the South African Water Quality Guidelines. Not all pH graphs are included as pH is normally within the SAWQG Limit (GCS, 2017).

A total of 9 arbitrary zones where used to group the various water quality monitoring locations throughout the Matla Mine lease boundary. The allocated zones are named **Zone 1 – 9**.

Surface water monitoring points are located in all the mentioned zones with the exception of **Zone 1** and **Zone 9**. Therefore in the sections to follow they are intentionally left out.

8.2.1 Zone 2 Surface Water Quality

In Zone 2 there is only one surface monitoring point (see Table 8-1), Box Cut Dam. The pH remained within the monitoring limits throughout the monitoring period. The sodium, Figure 8-2, and sulphate, Figure 8-3, annually peak in September/October with the most noteworthy increase occurring in 2015. Iron concentration, Figure 8-1, varies dramatically and consistently, throughout the monitoring period, exceeds the SAWQG Limit (GCS,2017).

Table 8-1 Summary of surface water monitoring points – Zone 2

Zone	Monitoring point ID	Coordinates		Locality description
		X	Y	
Zone 2	247 Box cut dam	S26°13'04.92"	E029°04'39.48"	Box cut dam located North of 288 OCM 5(S)

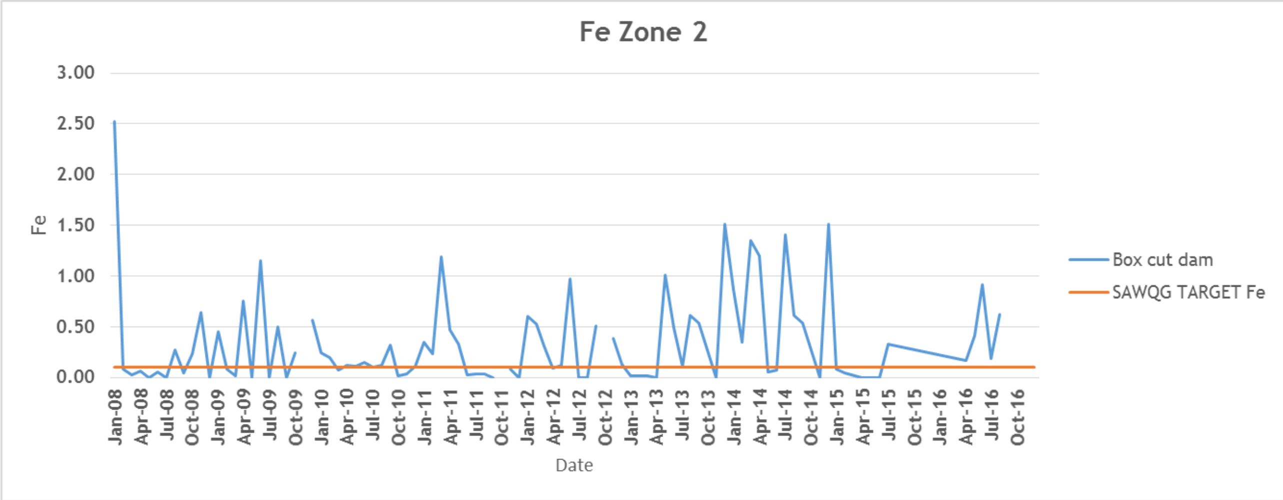

Figure 8-1 Iron Concentration, Zone 2, Box Cut Dam (GCS, 2017)

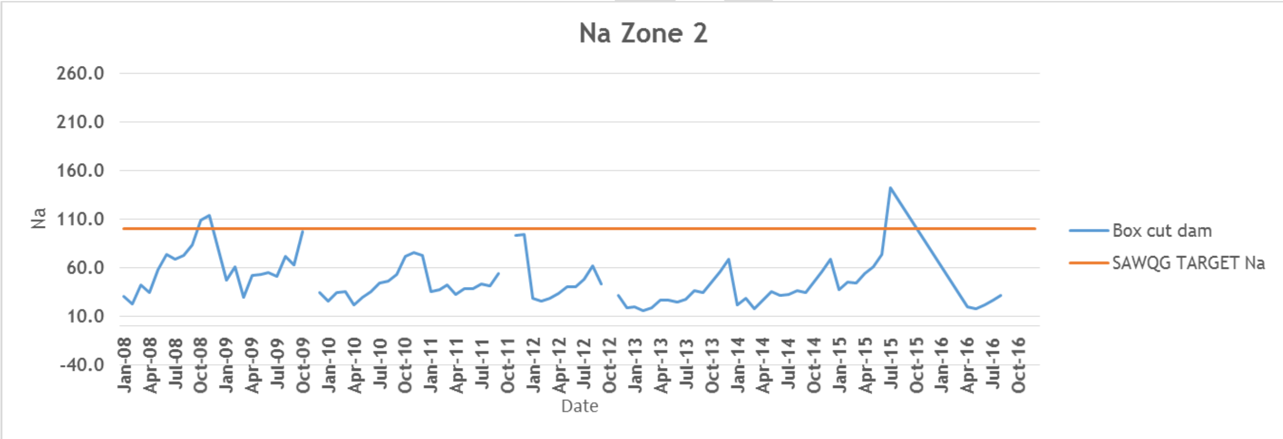

Figure 8-2 Sodium Concentration, Zone 2, Box Cut Dam (GCS, 2017)

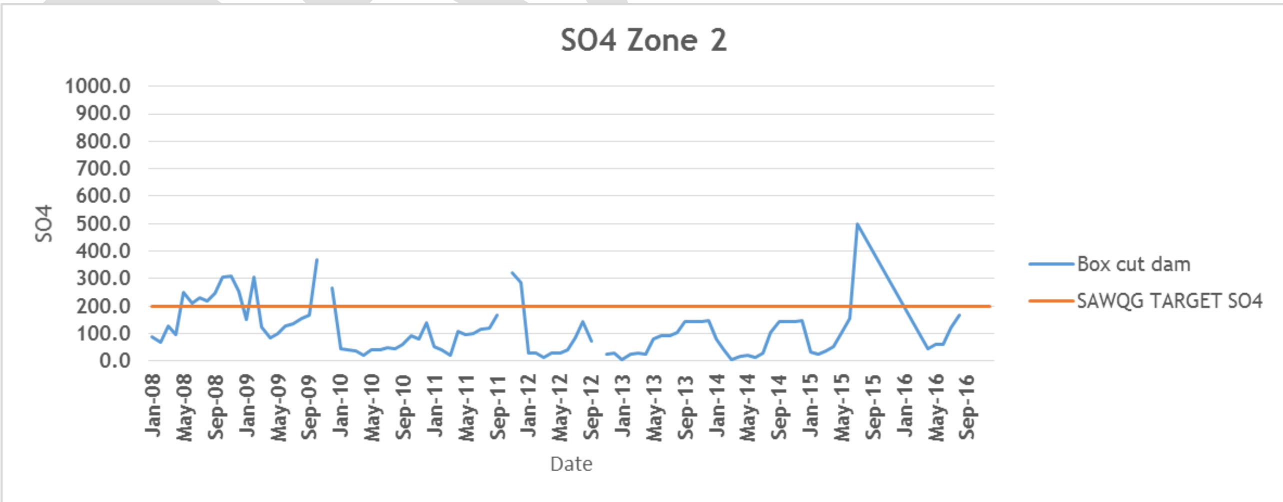

Figure 8-3 Sulphate Concentration, Zone 2, Box Cut Dam (GCS, 2017)

8.2.2 Zone 3 Surface Water Quality

A total of 10 surface water monitoring locations covering zone 3 are presented in Table 8-2. The pH, Figure 8-4, for 2 Mine Pan, Discharge 8 and Rietspruit 7 was satisfactory and within SAWQG Limits.

Rietspruit 6 also had satisfactory pH with the exception of a sudden decrease in the beginning of 2016. The pH in 2 Mine Dam was elevated in the beginning of the monitoring period but has decreased. Sodium and sulphate concentration, Figure 8-6 and Figure 8-7, in 2 Mine Dam and 2 Mine Pan follow the same trend; with the concentration of both decreasing throughout the monitoring period in 2 Mine Dam. Sodium and sulphate concentrations in Discharge 8 and Rietspruit 6 and 7 were initially high but decreased and currently remain within SAWQG Limits but are increasing. Rietspruit 6 had high iron concentration, Figure 8-5, in the beginning of the monitoring period but had decreased. Rietspruit 7 and Discharge 8 show varied iron concentrations exceeding the SAWQG Limit (GCS, 2017).

Table 8-2 Summary of surface water monitoring points – Zone 3

Zone	Monitoring point ID	Coordinates		Locality description
		X	Y	
Zone 3	233 2 Mine dam	S26°13'08.52"	E029°06'09.72"	Dam at Mine 2 located North of Matla 2776 Rietspruit 6
	234 2 Mine U/S	S26°13'21.48"	E029°06'11.28"	Located upstream of Mine 2
	235 2 Mine effluent into river	S26°13'19.68"	E029°06'16.14"	North of Rietspruit River downstream of Mine 2
	236 2 Mine D/S	S26°13'25.44"	E029°07'12.72"	Close to Rietspruit River downstream of 235 2 Mine effluent into river
	259 2 Mine pan	S26°12'28.86"	E029°06'59.94"	Located North of pan in Mine 2
	260 3 Mine drinking water	S26°12'47.46"	E029°06'23.16"	Located North of 233 2 Mine dam
	Matla 2776 Rietspruit 6	S26°13.345'	E029°06.181'	Located downstream of Matla 2777 Discharge 8
	Matla 2777 Discharge 8	S26°13.326'	E029°05.738'	Located upstream of Matla 2776 Rietspruit 6
	Matla 2779 Rietspruit 7	S26°13.378'	E029°06.785'	Located downstream of Matla 2776 Rietspruit 6
	258 Between 234 235	S26°13.338'	E029°06.235'	Located between 234 2 Mine U/S and 235 2 Mine effluent into river

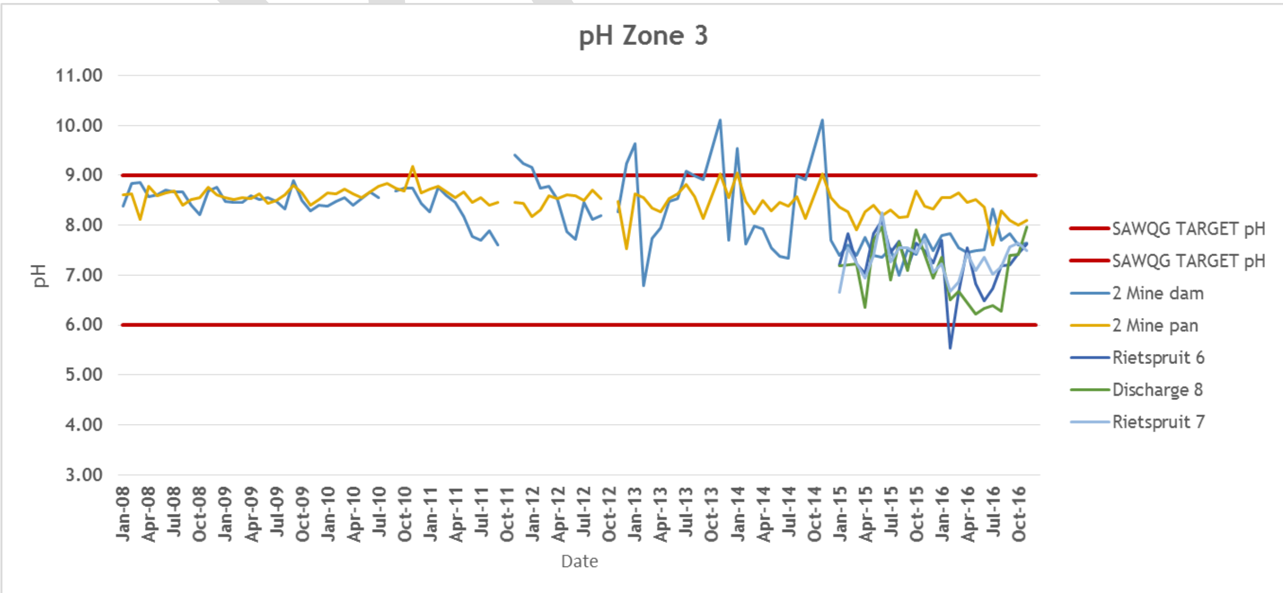

Figure 8-4 pH in surface water monitoring points, Zone 3 (GCS, 2017)

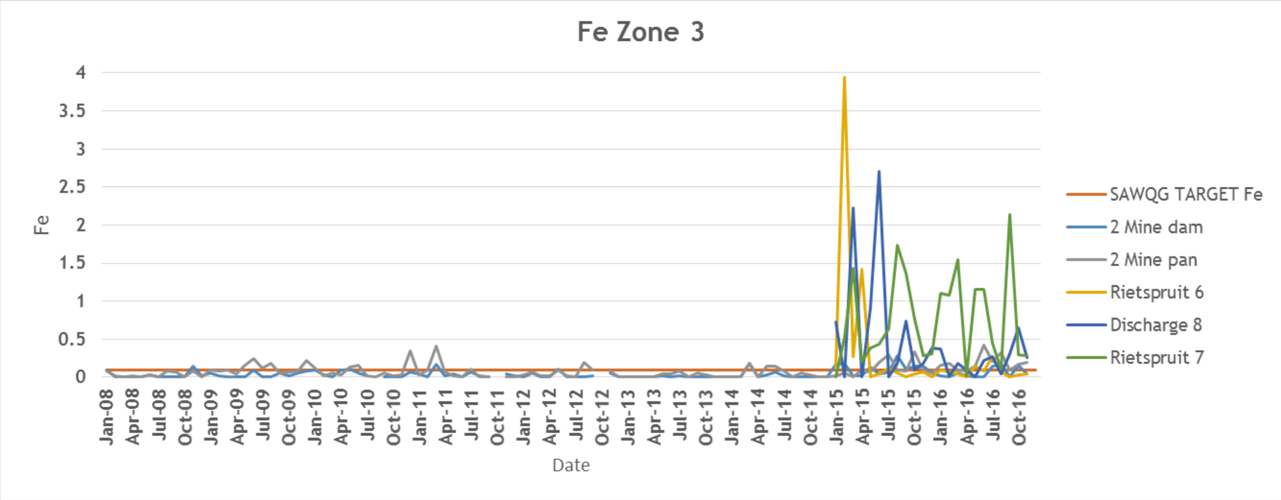

Figure 8-5 Iron concentration in surface water monitoring points, Zone 3 (GCS, 2017)

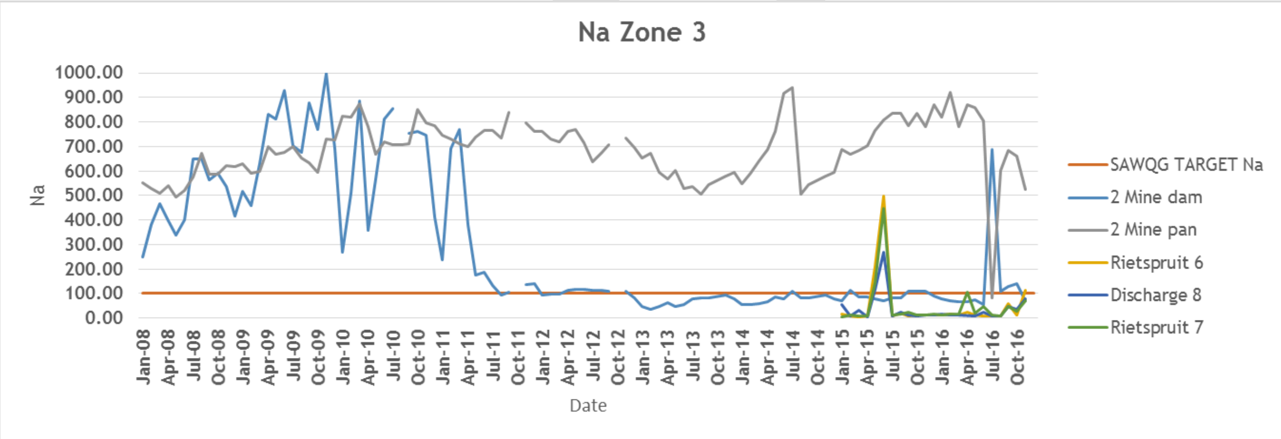

Figure 8-6 Sodium concentration in surface water monitoring points, Zone 3 (GCS, 2017)

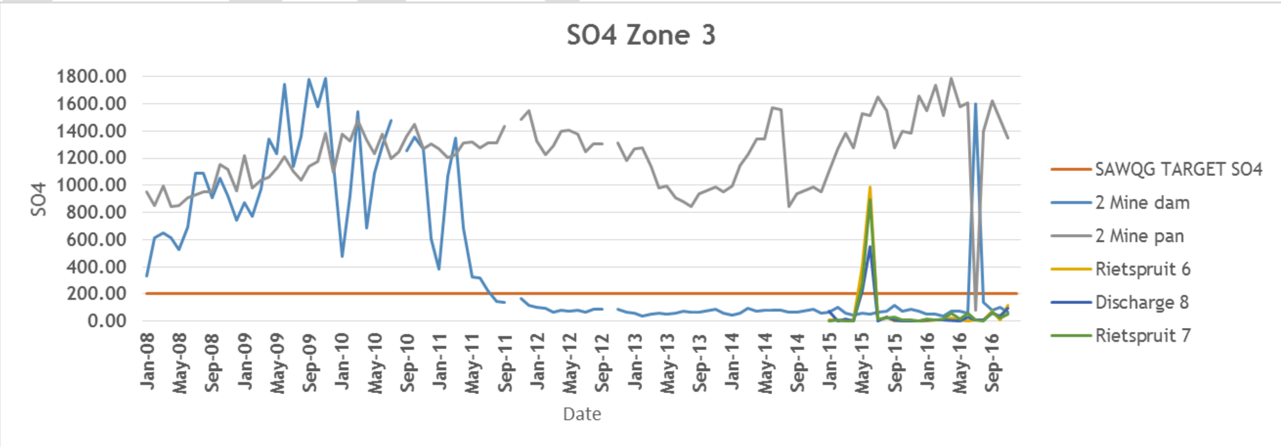

Figure 8-7 Sulphate concentration in surface water monitoring points, Zone 3 (GCS, 2017)

8.2.3 Zone 4 Surface Water Quality

A total of 3 surface water monitoring locations covering zone 4 are presented in Table 8-3.The water quality in 3 Mine silo is consistently poor throughout the monitoring period with an elevated pH, increasing sodium and sulphate and varying iron concentrations with the most notable spike occurring in April 2012 with an iron concentration of 47.6 mg/l. Water quality in 3 Mine Final Dam at Shaft has progressively become poorer with pH, sodium, sulphate and iron concentrations increasing throughout the monitoring period. The water quality in 3 Mine Settling Pond has remained consistent with iron, pH and sulphate remaining constant and only sodium increasing and consistently exceeding the SAWQG Limit. Water quality for Zone 4 is depicted in Figure 8-8 to Figure 8-11 (GCS, 2017).

Table 8-3 Summary of surface water monitoring points – Zone 4

Zone	Monitoring point ID	Coordinates		Locality description
		X	Y	
Zone 4	262 3 Mine settling pond	S26°14'38.88"	E029°04'05.70"	Located South-west of 264 3 Mine silo dam, East of settling pond
	263 3 Mine final dam @ shaft	S26°14'38.82"	E029°04'05.58"	Located South-west of 264 3 Mine silo dam
	264 3 Mine silo dam	S26°14'25.74"	E029°04'32.88"	Located North-east of 3 Mine settling pond

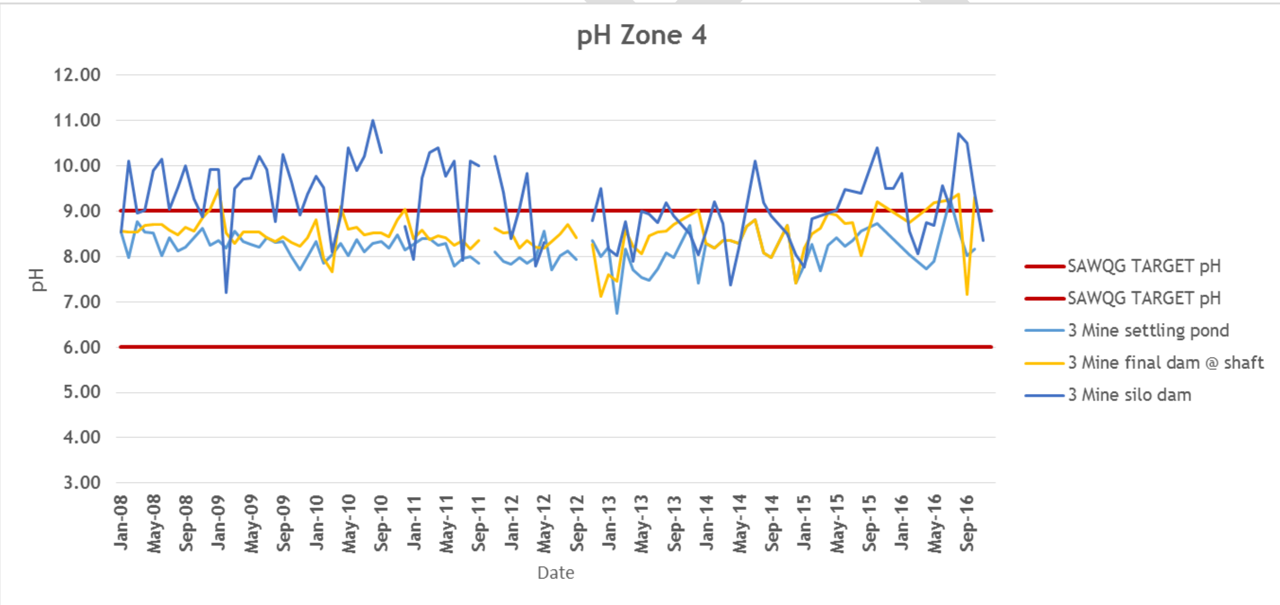

Figure 8-8 pH in surface water monitoring points, Zone 4 (GCS,2017)

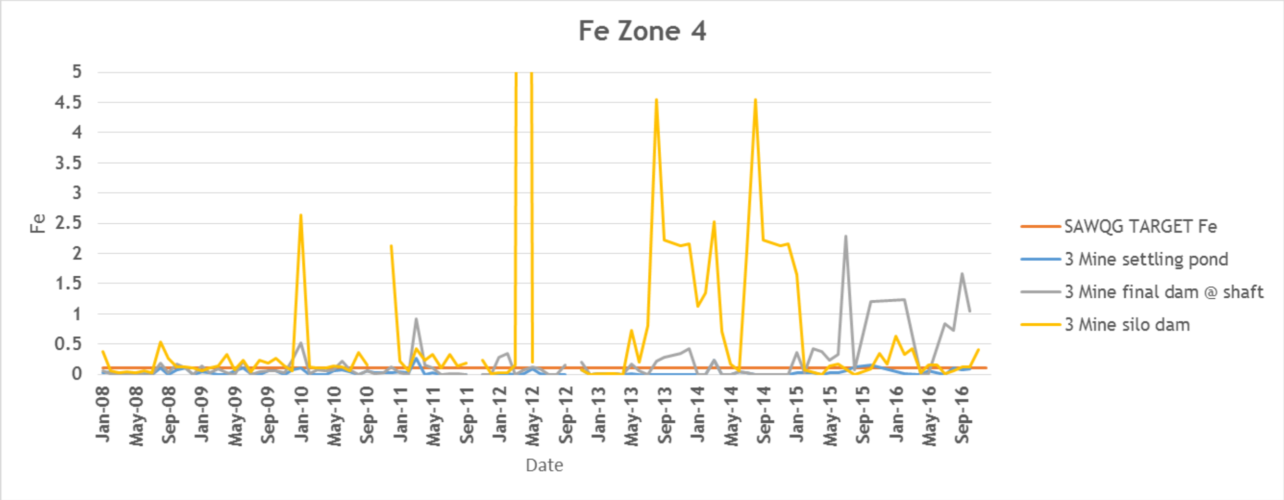

Figure 8-9 Iron concentration in surface water monitoring points, Zone 4 (GCS, 2017)

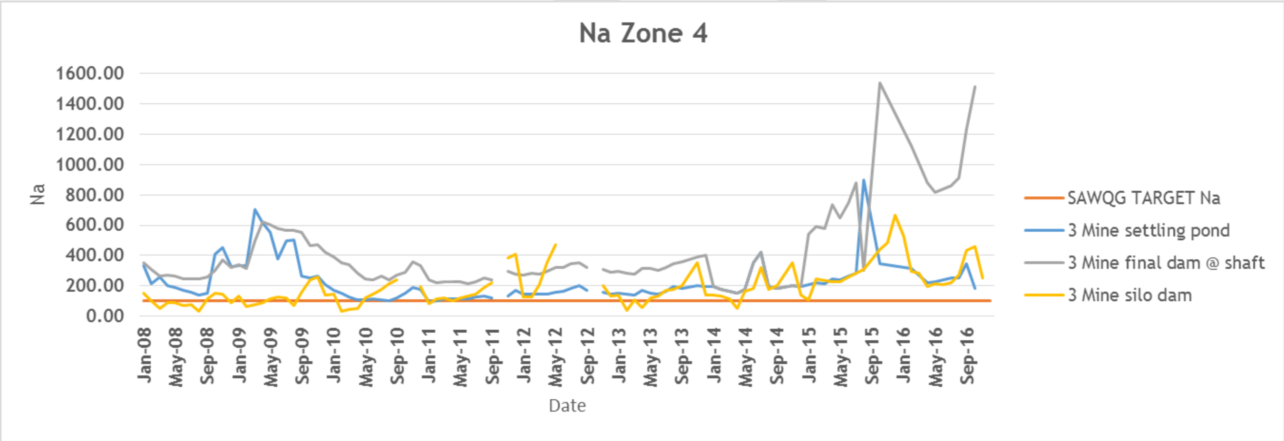

Figure 8-10 Sodium concentration in surface water monitoring points, Zone 4 (GCS, 2017)

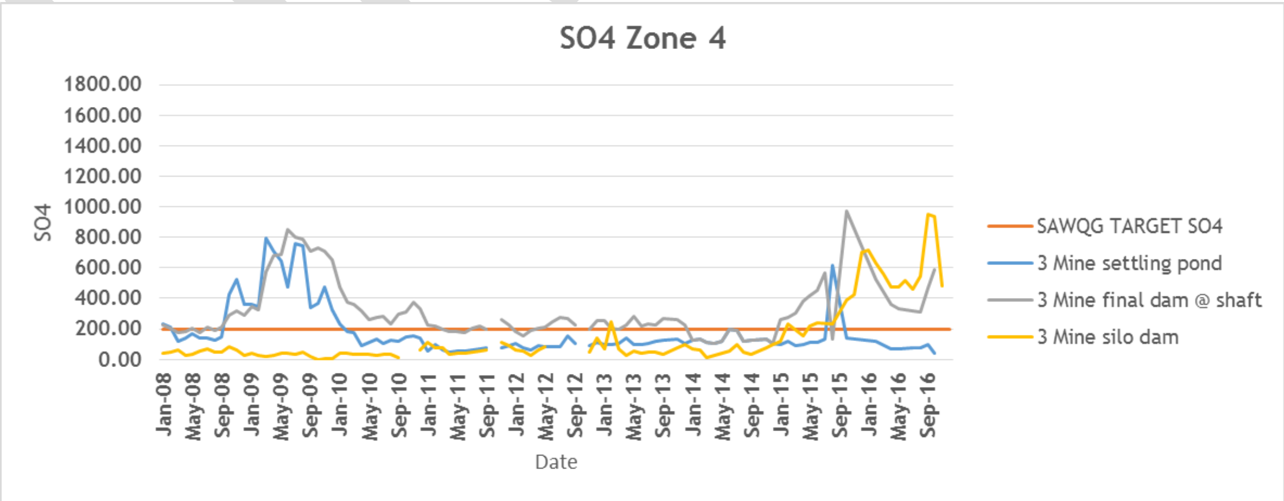

Figure 8-11 Sulphate concentration in surface water monitoring points, Zone 4 (GCS, 2017)

8.2.4 Zone 5 Surface Water Quality

Only one surface water monitoring locations covering zone 5 is presented in Table 8-4. Monitoring commenced in 2015 and large variation is seen in water quality over the two monitoring years. There was a decrease in pH, Figure 8-12, from September 2015 to March 2016 but has since increased to within the SAWQG Limit range. Iron concentration, Figure 8-13, has decreased during the monitoring period but exceeds the SAWQG Limit. Sodium concentration, Figure 8-14, has decreased but still remains above the limit whereas sulphate concentration, Figure 8-14, also exceeds the limit and has an annual spike during August/July (GCS, 2017).

Table 8-4 Summary of surface water monitoring points – Zone 5

Zone	Monitoring point ID	Coordinates		Locality description
		X	Y	
Zone 5	Matla 2780 Tributary 4 Up Stream	S26°14.582'	E029°06.532'	Located upstream in Rietspruit tributary

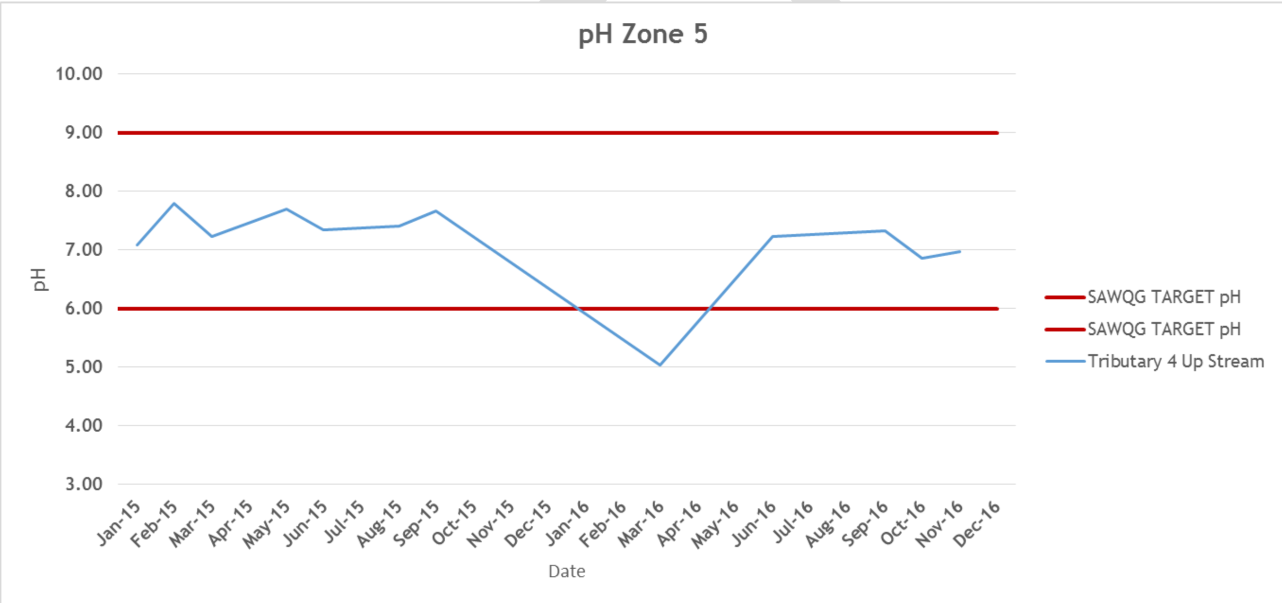

Figure 8-12 pH in surface monitoring pint, Zone 5 (GCS, 2017)

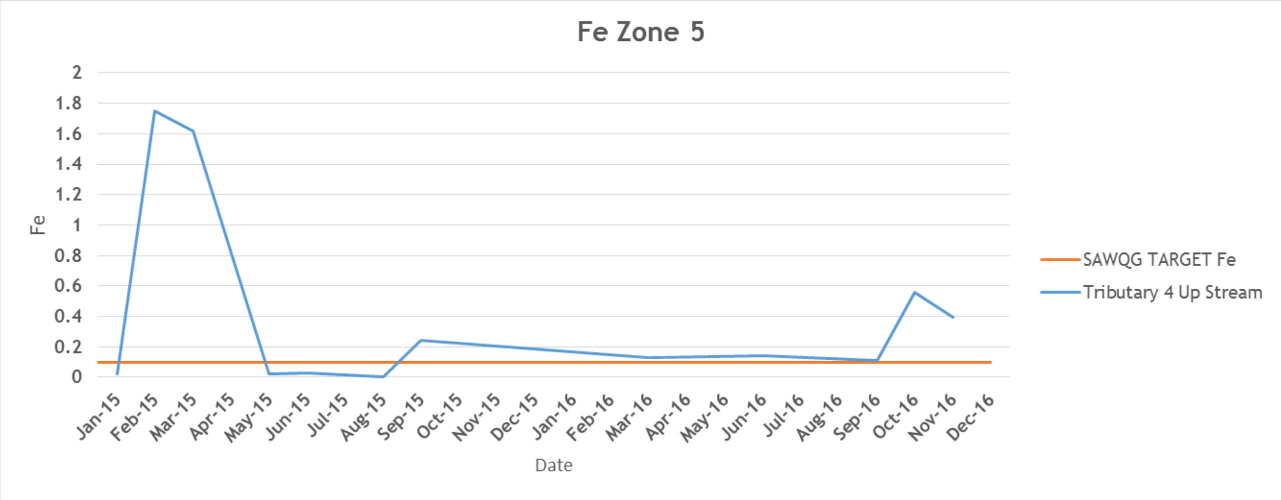

Figure 8-13 Iron concentration in surface water monitoring point, Zone 6 (GCS, 2017)

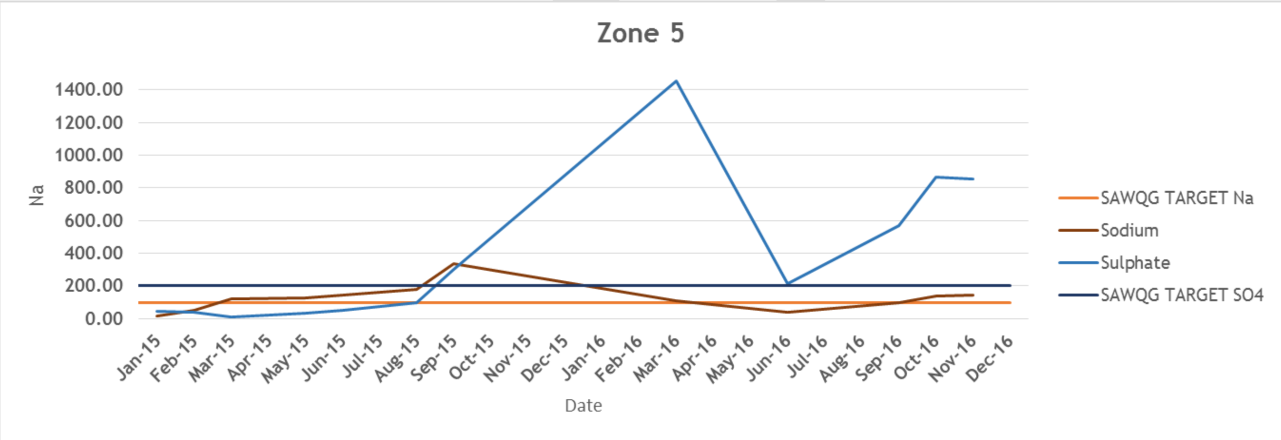

Figure 8-14 Sodium and sulphate concentration in surface water monitoring point, Zone 5 (GCS, 2017)

8.2.5 Zone 6 Surface Water Quality

A total of 4 surface water monitoring locations covering zone 6 are presented in Table 8-5. Sodium and sulphate concentrations, Figure 8-16, in 1 Mine Settling Pond 1 and 2 were increasing gradually until a sudden increased occurred in 2015 whereas the concentrations remains constant in Pan 3, Figure 8-17. All three surface monitoring points do however exceed the SAWQG Limits for sodium and sulphate. Iron concentration, Figure 8-15, varies drastically in 1 Mine Settling Pond 1 and 2 with a slight increase occurring in Pan 3 (GCS, 2017).

Table 8-5 Summary of surface water monitoring points – Zone 6 (GCS, 2017)

Zone	Monitoring point ID	Coordinates		Locality description
		X	Y	
Zone 6	200 1 Mine drinking water	S26°15'30.48"	E029°07'01.20"	Drinking water sampled east of Pan at Mine 3
	201 1 Mine settling pond 1	S26°15'49.74"	E029°07'16.26"	Located at settling pond East of 202 1 Mine settling pond 2
	202 1 Mine settling pond 2	S26°15'35.82"	E029°06'55.68"	Located West of 201 1 Mine settling pond 1
	Matla 2778 Pan 3	S26°15.814'	E029°08.107'	Located on the eastern side of pan in mine 3

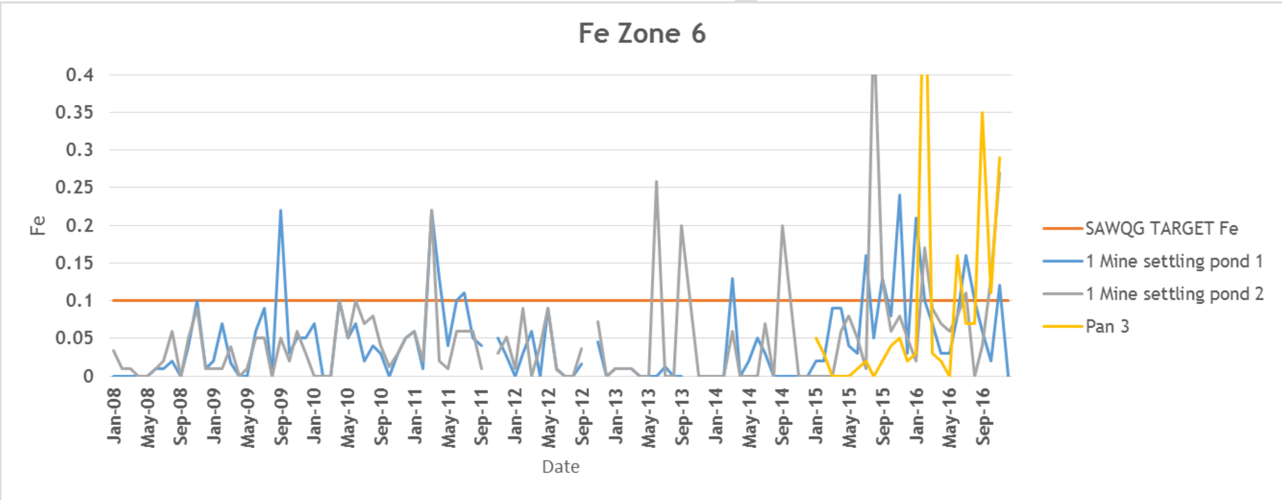

Figure 8-15 Iron concentration in surface water monitoring point, Zone 6 (GCS, 2017)

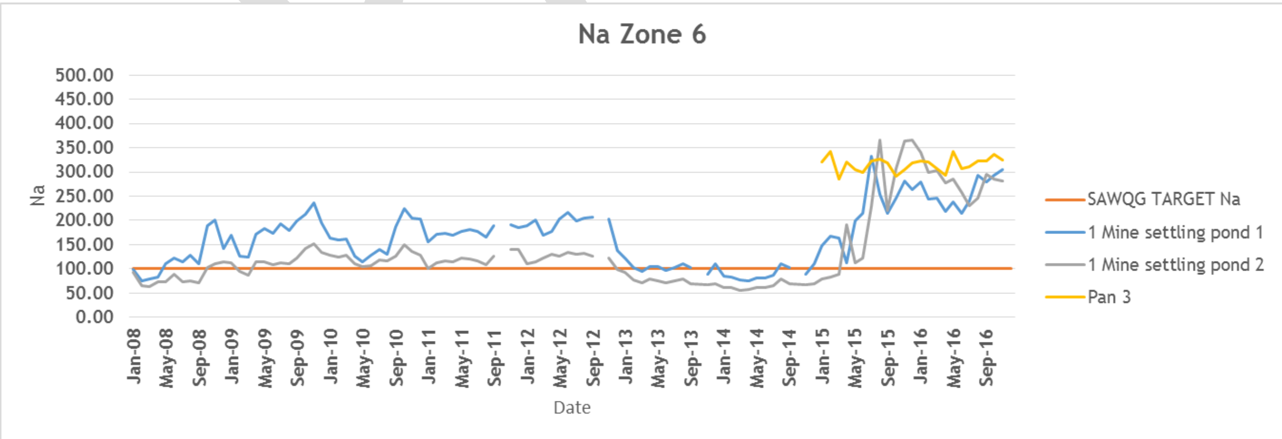

Figure 8-16 Sodium concentration in surface water monitoring point, Zone 6 (GCS, 2017)

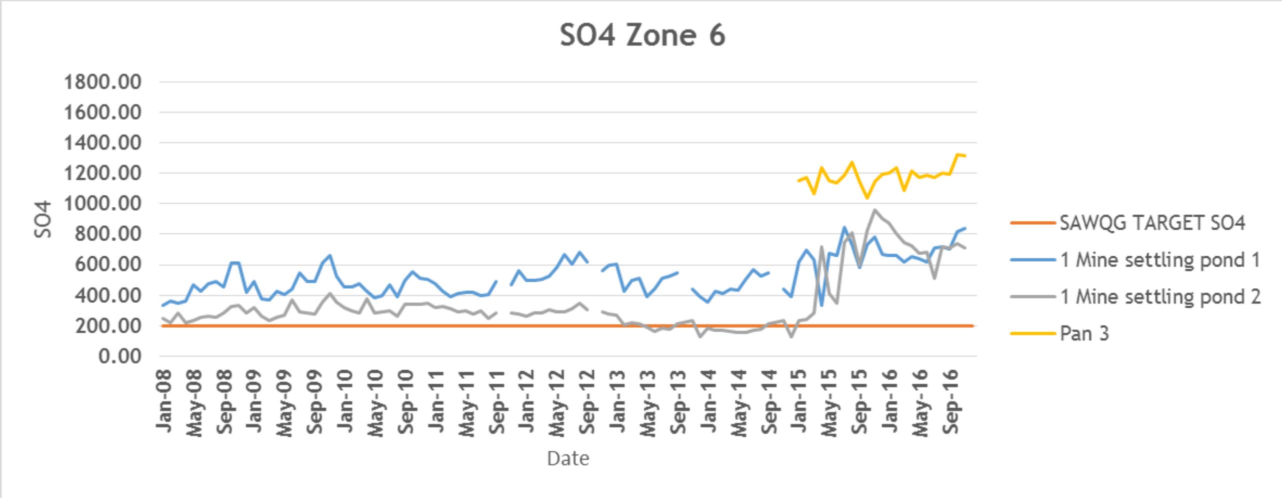

Figure 8-17 Sulphate concentration in surface water monitoring point, Zone 6 (GCS, 2017)

8.2.6 Zone 7 Surface Water Quality

A total of 3 surface water monitoring locations covering zone 7 are presented in Table 8-6. The sulphate, Figure 8-20, and sodium, Figure 8-19, concentration in New Shaft Dam 2 has gradually been increasing with sulphate exceeding the SAWQG Limits. Of all three dams New Shaft Dam 1 has the highest and most varied iron concentrations, Figure 8-18. Sodium in New Shaft Dam 1 decreased for most of the monitoring period but since September 2016 has started increasing slightly whereas sulphate concentrations were constant until a decrease occurred in July 2016. The iron concentration, New Shaft Dam 3, remained constant for most of the monitoring period until a sudden increased occurred in October 2016. The sodium and sulphate concentrations, of New Shaft Dam 3, follow the same trend increasing and decreasing at the same time (GCS, 2017).

Table 8-6 Summary of surface water monitoring points – Zone 7 (GCS, 2017)

Zone	Monitoring point ID	Coordinates		Locality description
		X	Y	
Zone 7	Matla 2634 New Shaft Dam 1	S26°17.739'	E029°09.524'	Located South-west of number 1 shaft
	Matla 2636 New Shaft Dam 2	S26°18.153'	E029°08.722'	Located South-west of number 1 shaft
	Matla 2637 New Shaft Dam 3	S26°18.153'	E029°08.862'	Located South-west of number 1 shaft

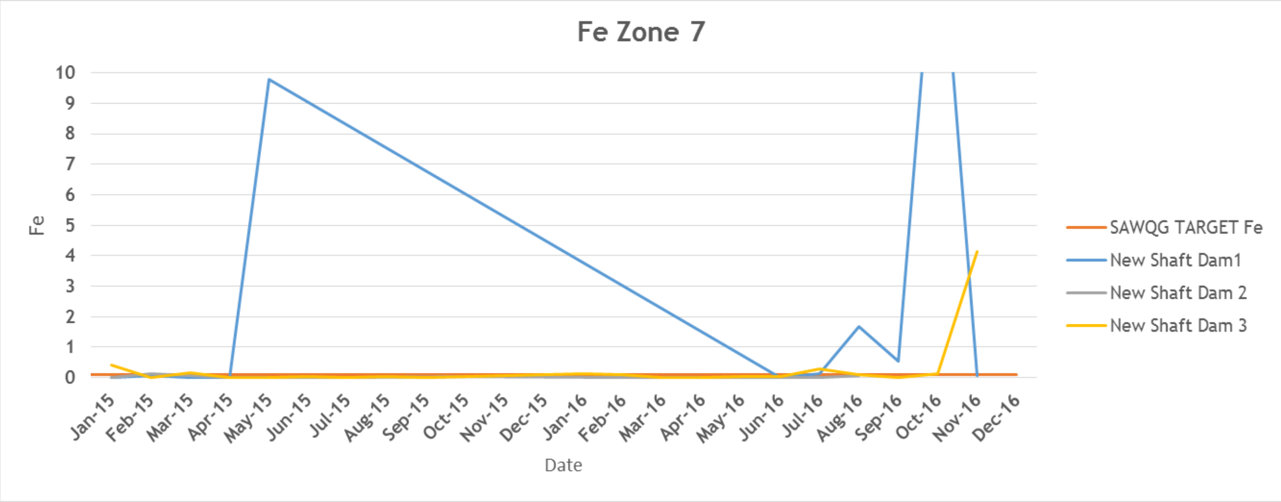

Figure 8-18 Iron concentration in surface water monitoring points, Zone 7 (GCS, 2017)

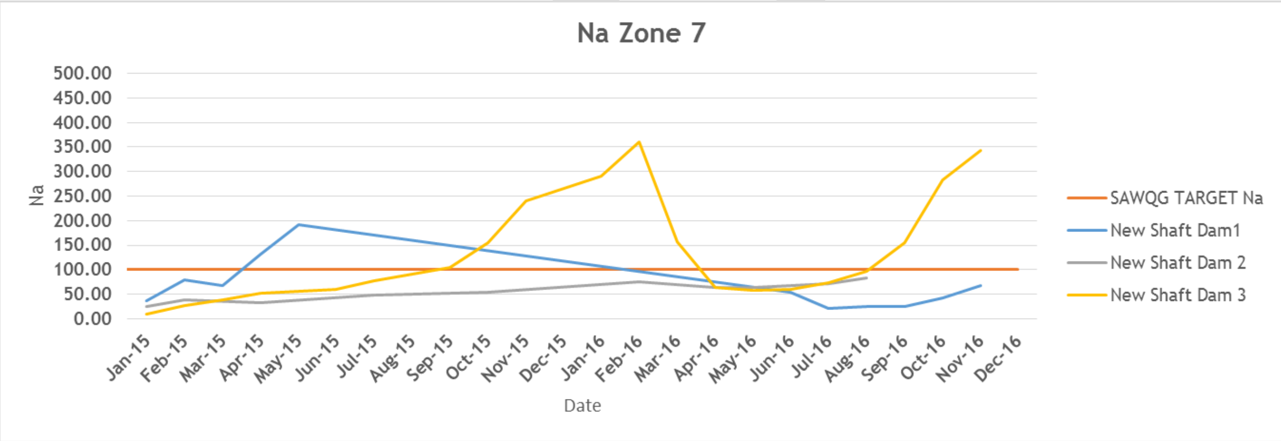

Figure 8-19 Sodium concentration in surface water monitoring points, Zone 7 (GCS, 2017)

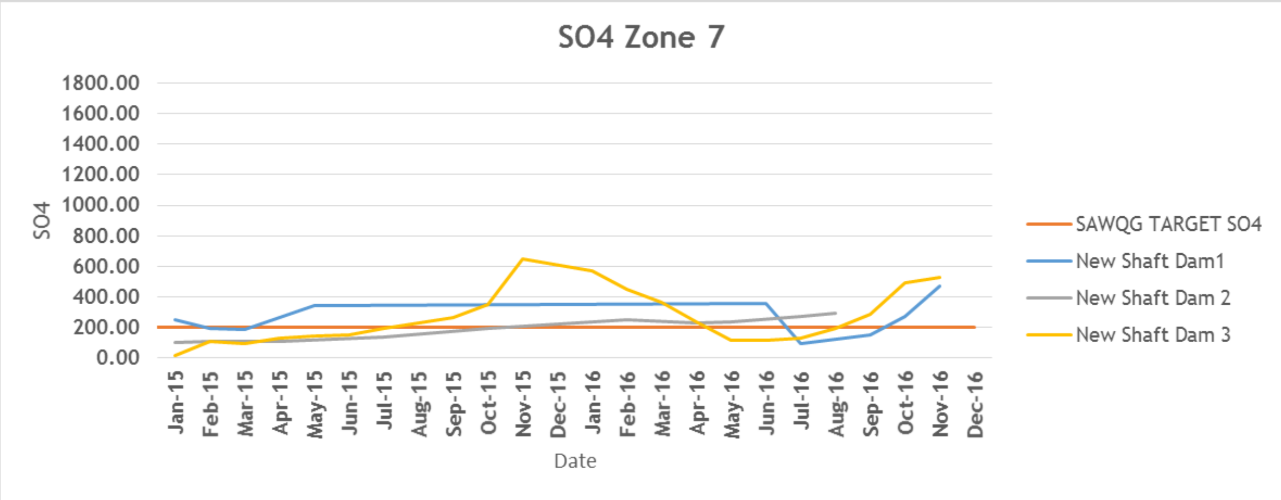

Figure 8-20 Sulphate concentration in surface water monitoring points, Zone 7 (GCS, 2017)

8.2.7 Zone 8 Surface Water Quality

Only one surface water monitoring locations covering zone 8 is presented in Table 8-7. Zone 8 has one surface water monitoring point, 2 Mine U/P. The iron concentration, Figure 8-21, varies greatly and consistently exceeds the SAWQG Limit. Sodium and sulphate concentrations, Figure 8-22, also vary following similar trends with an irregular increase occurring in 2016.

Table 8-7 Summary of surface water monitoring points – Zone 8 (GCS, 2017)

Zone	Monitoring point ID	Coordinates		Locality description
		X	Y	
Zone 8	265 3 Mine U/S	S26°16'22.80"	E029°02'24.54"	Located West of 209 MGW 24

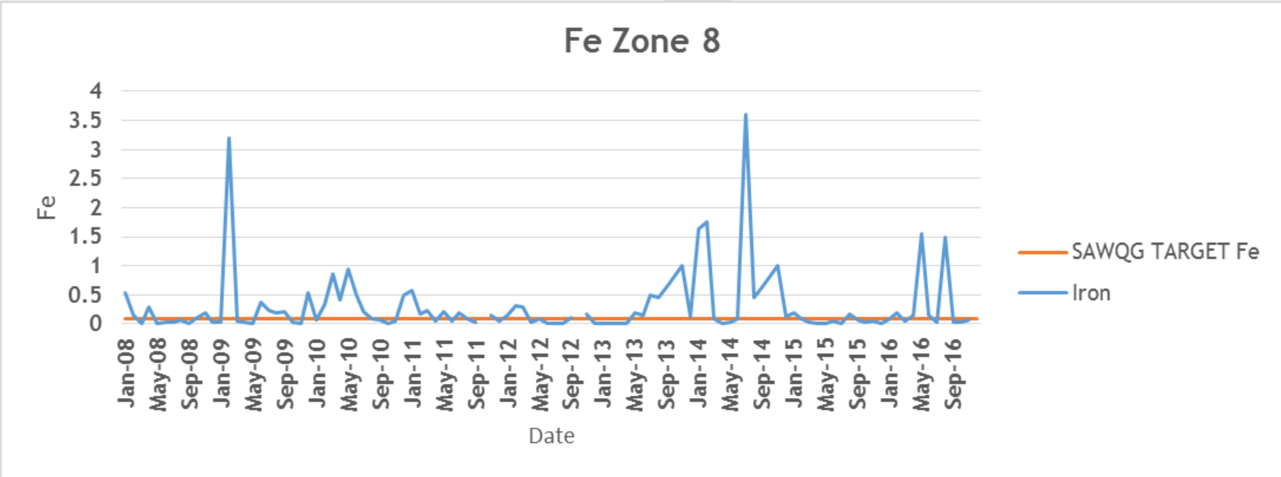

Figure 8-21 Iron concentration in surface water monitoring point, Zone 8 (GCS, 2017)

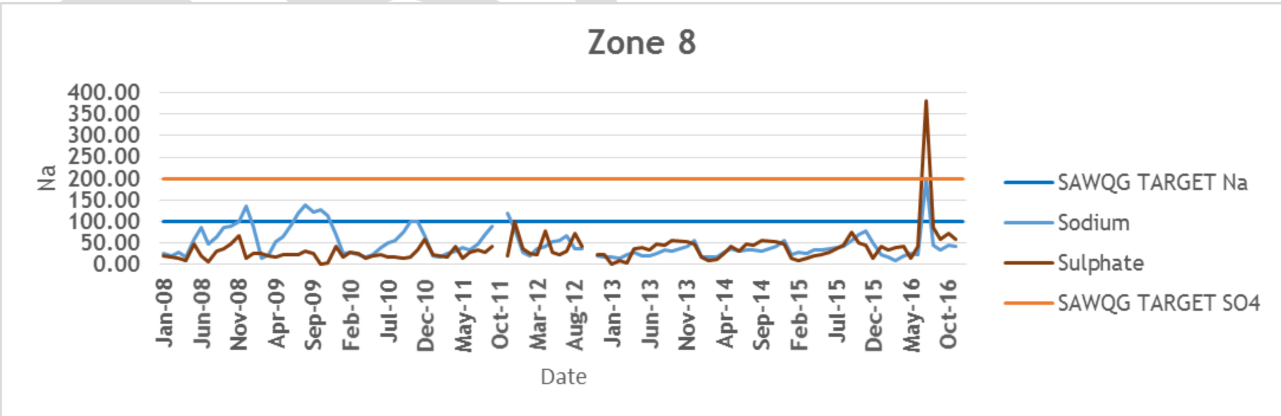

Figure 8-22 Sulphate and sodium concentrations in surface water monitoring point, Zone 8 (GCS, 2017)

8.2.8 Drinking Water Monitoring Point

The drinking water samples were not included in their respective zones to allow for a better comparison. 1 Mine Drinking Water and 3 Mine Drinking Water are located in Zone 1 and 3 respectively and 2 Mine Drinking Water is not in an allocated zone. The pH, Figure 8-23, and iron concentration, Figure 8-24, in all three drinking water samples is satisfactory. Turbidity, Figure 8-25, varies in all three drinking water samples but has shown a decrease over the monitoring period (GCS, 2017).

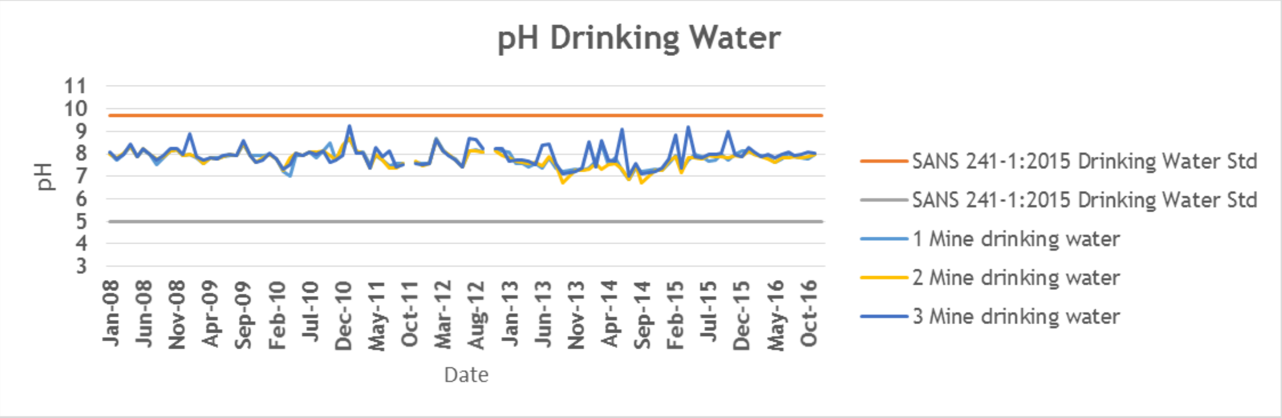

Figure 8-23 pH of all drinking water sampled (GCS, 2017)

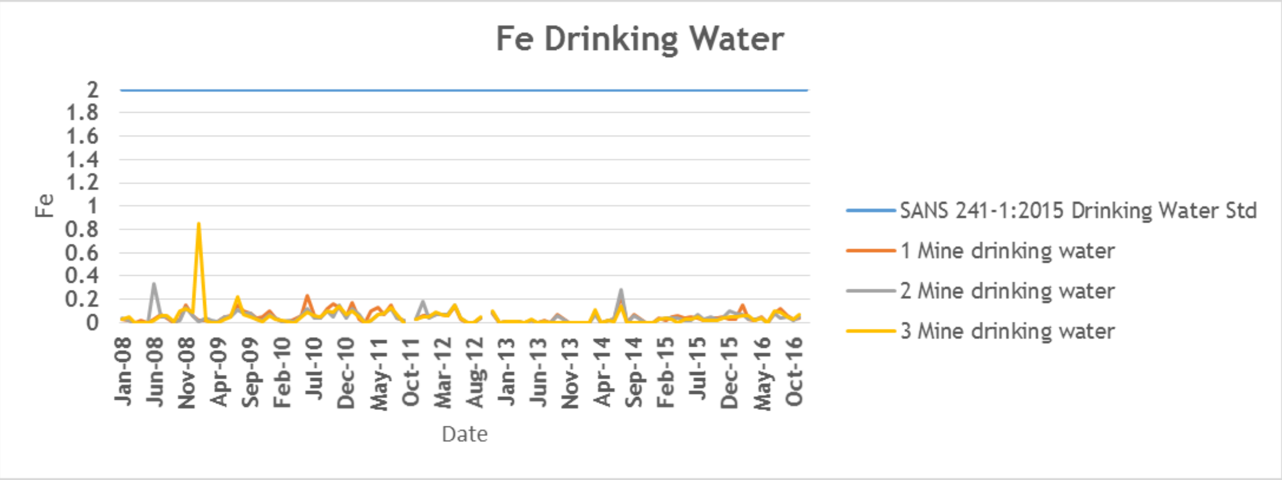

Figure 8-24 Iron concentration of drinking water samples (GCS, 2017)

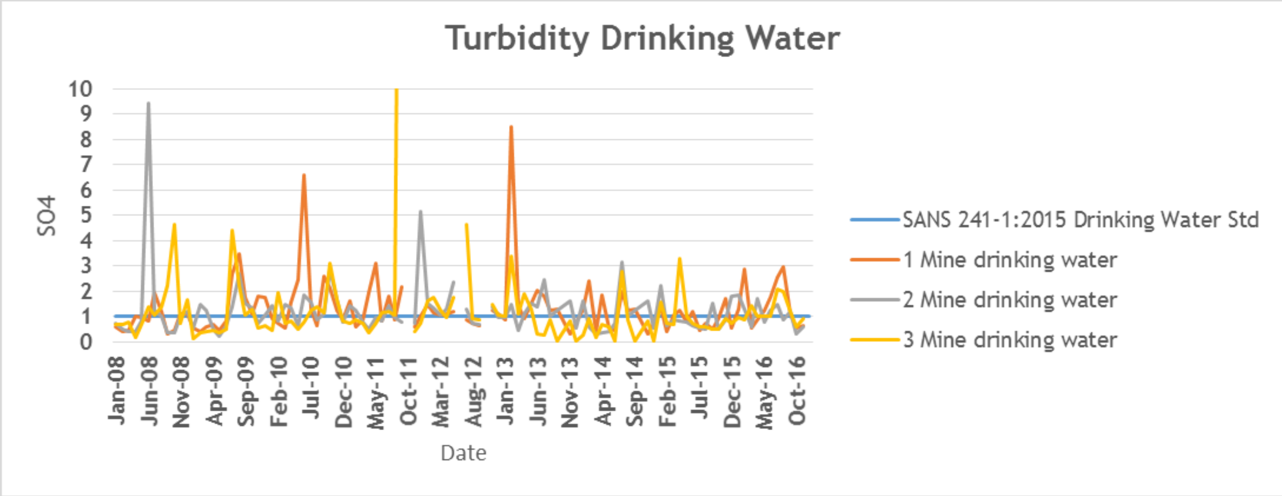

Figure 8-25 Turbidity of drinking water samples (GCS, 2017)

8.2.9 Surface Water Quality with No Allocated Zones

A total of 4 surface water monitoring locations covering areas with no allocated zones are presented in Table 8-8. A decrease is observed in the sodium, iron and sulphates concentrations of the Flow from Power Station. The Rietspruit Dam showed consistent low sodium and sulphate concentrations with varies iron concentrations. The sampling point, Kriel Ogies Road, is located downstream east of the Matla Coal Mine and shows varying iron, that has increased in 2016 and a decrease in sulphates has also occurred over the monitoring period. The iron, sodium and sulphate concentration, for Kriel Ogies Road monitoring point, can be seen in Figure 8-26 to Figure 8-28 (GCS, 2017).

Table 8-8 Summary of surface water monitoring points – no Allocated Zones (GCS, 2017)

Zone	Monitoring point ID	Coordinates		Locality description
		X	Y	
No zone allocated	212 Rietspruit dam	S26°10'10.26"	E029°13'42.48"	Located East of Rietspruit Dam
	230 2 Mine drinking water	S26°16'00.00"	E029°06'00.00"	Located East of Grootpan between tributaries of Rietspruit
	255 Kriel Ogies road	S26°11'33.96"	E029°10'57.12"	Sampled at Rietspruit at Kriel Ogies road
	229 Flow from Power station	S26°13.871'	EO29°08.228'	Located South of power station

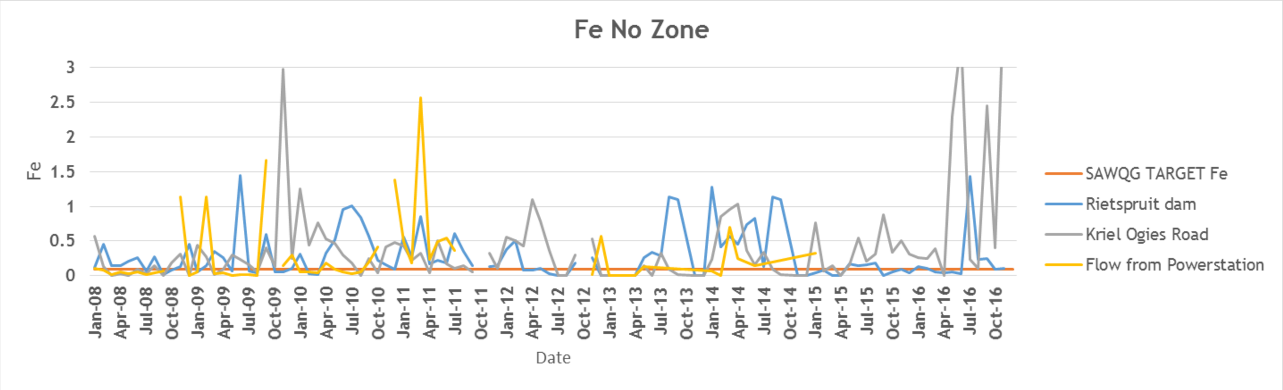

Figure 8-26 Iron concentration in varies unzoned monitoring points (GCS, 2017)

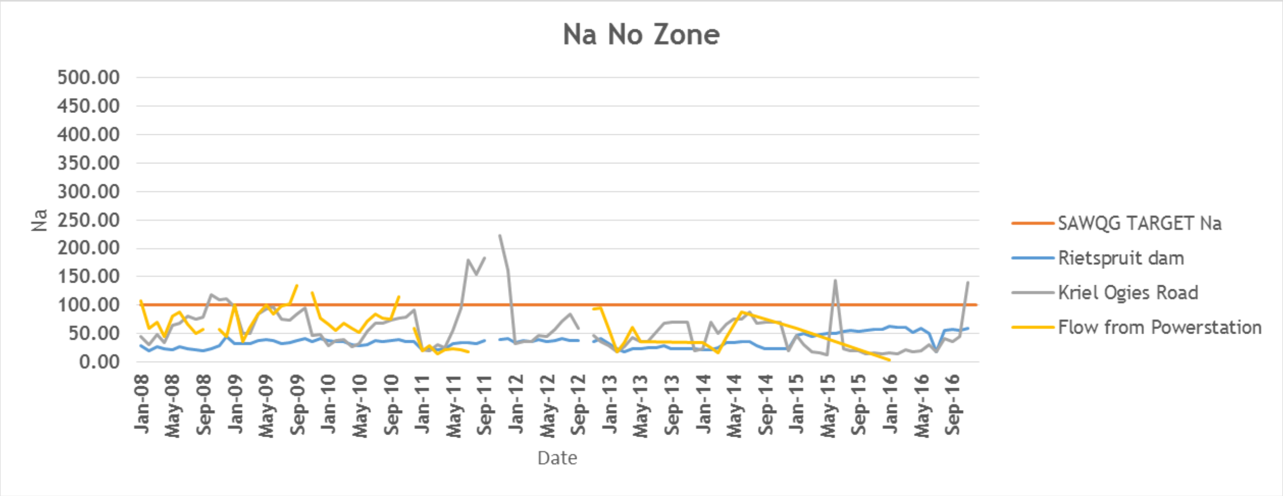

Figure 8-27 Sodium concentration in varies unzoned monitoring points (GCS, 2017)

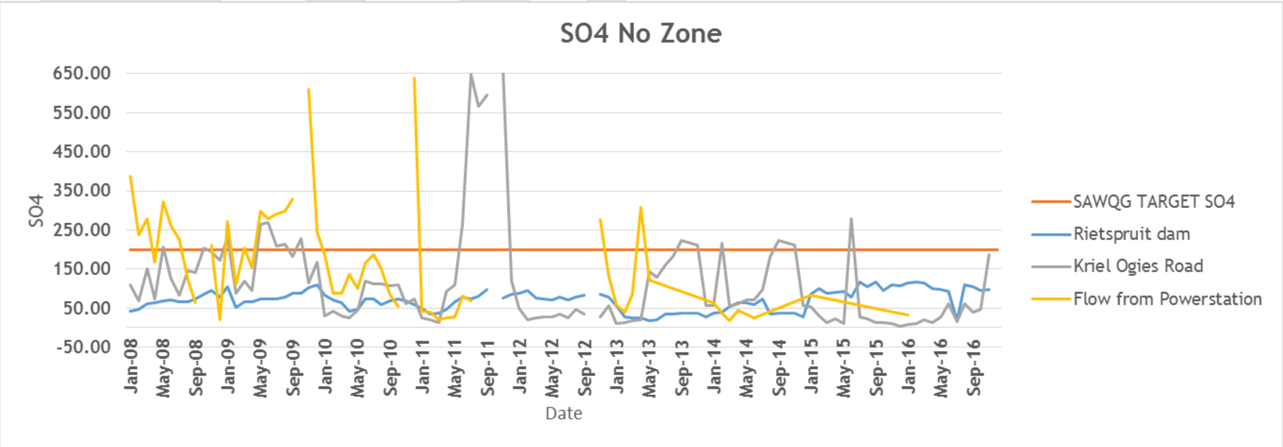

Figure 8-28 Sulphate concentration in varies unzoned monitoring points (GCS, 2017)

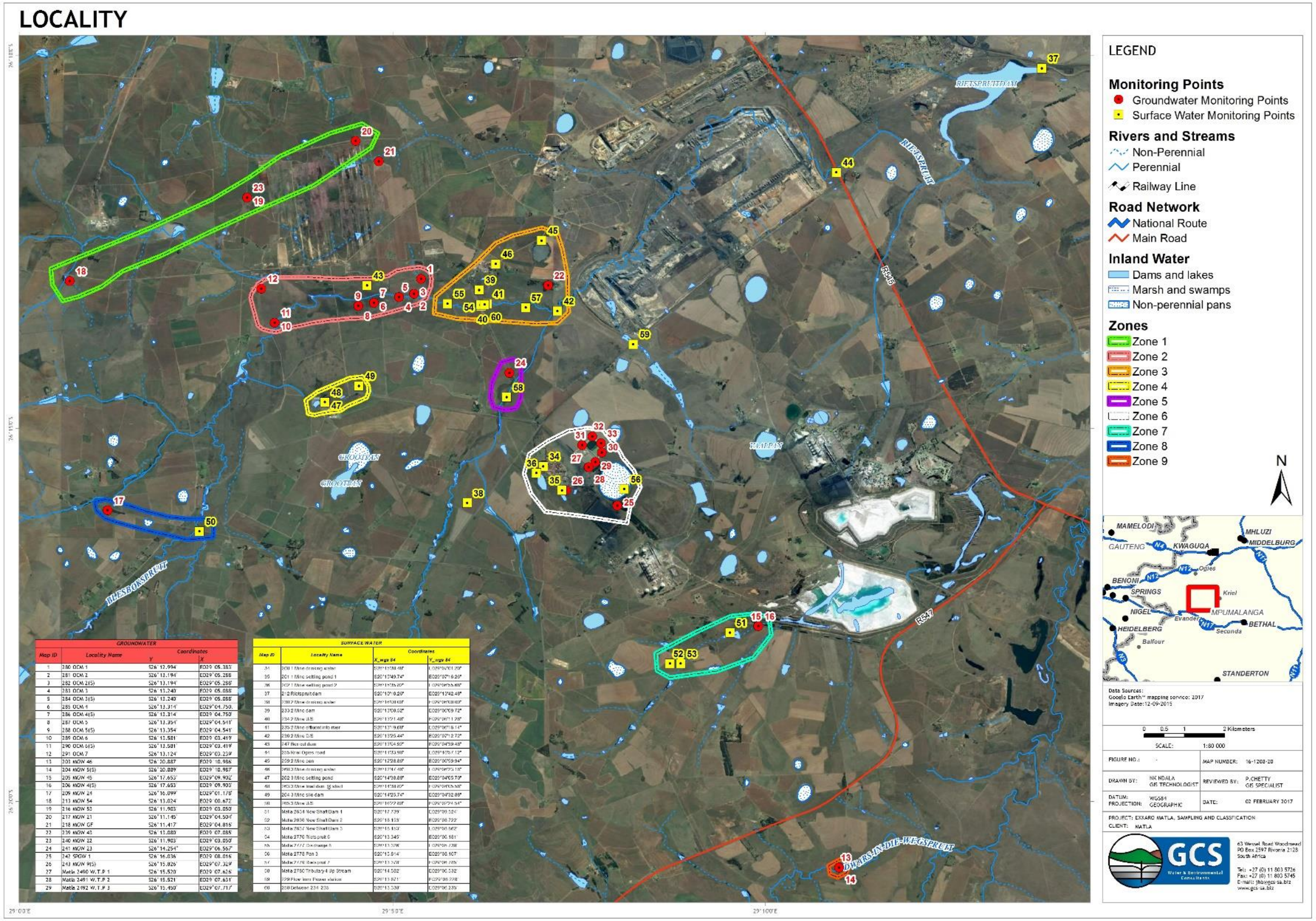

Figure 8-29 Summary of Water Quality Zones (GCS, 2017)

8.3 Conclusions of Surface Water Monitoring

The following is concluded:

- In Zone 2, the iron concentration in Box Cut Dam varies and decreased towards the end of the monitoring period. Sodium and sulphate follows the same trends in Box Cut Dam (GCS, 2017).
- In Zone 3, the iron concentrations decreased in Rietspruit 6 and Discharge 8, remains low in 2 Mine Dam and 2 mine pan and remained consistently elevated in Rietspruit 7. Sodium concentration decreased in 2 Mine Dam and remained consistently elevated in 2 Mine pan. Sulphate concentrations decreased in 2 Mine Dam and slightly increased in 2 Mine pan (GCS, 2017).
- In Zone 4, iron concentrations decreased in 3 Mine silo dam since 2015 and increased in 3 Mine final dam @ shaft in 2015. Sodium concentration increased in all three surface monitoring points during the monitoring period. Sulphate concentration decreased in 3 Mine settling pond whereas it increased in 3 Mine final dam @ shaft and 3 Mine silo dam (GCS, 2017).
- In Zone 5, Tributary 4 up stream, showed a decrease in both iron and sodium concentrations and an increase in sulphate concentration
- In Zone 6, iron concentrations increased in all three surface monitoring points. Sodium and sulphate concentration increased in 1 Mine settling pond 1 and 1 Mine settling pond 2. Sodium and sulphate concentration remained constant in Pan 3 (GCS, 2017).
- In Zone 7, iron concentration started increasing in 2016 in New Shaft Dam 3 and varies greatly in New Shaft Dam 1. Sulphate concentration increased in all three surface monitoring points. Sodium increased in New Shaft Dam 3, decreased in New Shaft Dam 1 and showed a slight increase in New Shaft Dam 2 (GCS, 2017).
- In Zone 8, in 3 Mine U/S iron concentration decreased and sodium and sulphates concentrations remained constant. (GCS, 2017)
- In the Unzoned Localities, a decrease is observed in the sodium, iron and sulphates concentrations of the Flow from Power Station. The Rietspruit Dam showed consistent low sodium and sulphate concentrations with variations in iron concentrations. Kriel Ogies Road shows varying iron, that has increased in 2016 and a decrease in sulphates has also occurred (GCS, 2017)

9 Surface Water Impact Assessment

The aim of this section is to identify the potential surface water impacts that are likely to arise as a result of the proposed project.

9.1 Impact Assessment Methodology

The methodology for identification of potential impacts of the proposed project was based on:

- Study of the project description;
- Review of historic baseline studies and impact assessments for proposed project area; and
- Research work from similar established projects.

The potential impacts associated with this project have been evaluated using an impact rating system that takes into account a number of assessment criteria, namely: status of impact (positive, neutral or negative impact); magnitude (amount); duration (time scale); scale (special extent); probability (likelihood of occurrence). Assessed criteria are scored (as shown in Table 9-1) and the values are totalled. The resulting value is assigned an impact ranking of low, medium and high for each impact as shown in Table 9-2 (GCS, 2015).

Table 9-1 Impact Assessment Ratings

Status of Impact	
+: Positive (A benefit to the receiving environment)	
N: Neutral (No cost or benefit to the receiving environment)	
-: Negative (A cost to the receiving environment)	
Magnitude:=M	***Duration:=D***
10: Very high/don't know	5: Permanent
8: High	4: Long-term (ceases with the operational life)
6: Moderate	3: Medium-term (5-15 years)
4: Low	2: Short-term (0-5 years)
2: Minor	1: Immediate
0: Not applicable/none/negligible	0: Not applicable/none/negligible
Scale:=S	***Probability:=P***
5: International	5: Definite/don't know
4: National	4: Highly probable
3: Regional	3: Medium probability
2: Local	2: Low probability
1: Site only	1: Improbable
0: Not applicable/none/negligible	0: Not applicable/none/negligible

Table 9-2 Impact Ranking

Significance	*Environmental Significance Points*	*Colour Code*
High (positive)	>60	H
Medium (positive)	30 to 60	M
Low (positive)	<30	L
Neutral	0	N
Low (negative)	>-30	L
Medium (negative)	-30 to -60	M
High (negative)	<-60	H

9.2 Identified Impacts

The following potential were identified and further assessed for the following project phases:

- Construction Phase;
- Operational Phase, and the
- Post-closure Phase.

9.2.1 Construction Phase

There are no anticipated surface water impacts to the proposed Matla Stooping Project (Phase 1) during the construction phase as the existing facilities on the adjacent site will be used and no surface activities are planned to take place.

9.2.2 Operational Phase

The following section describes the potential impacts associated with the operational phase of the proposed project, as summarised in Table 9-3 below.

- The proposed operations proposed within the Matla Stooping Project (Phase 1) will marginally reduce the runoff volume reporting to the local streams. The maximum anticipated subsidence of 1.53m will result in surface depressions capable of collecting surface water runoff, therefore reducing the catchment area contributing runoff to the streams. Streamflow reduction will be a consequence of the reduction in catchment area. The impact of catchment reduction depends on the percentage of a particular area to be isolated and the consequence of isolating the area. Catchments with an isolated area in excess of 10% can be considered to have an influence on the flow patterns and volumes in the receiving catchment. A review of the current catchment showed that the catchment flow would be reduced by up to 5%. A reduction in catchment flow of less than 10% can be deemed fairly small, and these values are therefore not likely to be significant. The project's influence on downstream catchment flows, however, should be monitored and investigated at a later stage once the infrastructure footprint develops. The impact was ranked as **medium** due to the loss of contributing catchment area. With the mitigation measures in place the impact ranking is reduced to **low** (GCS, 2015).
- The maximum anticipated subsidence of 1.53m will result in steep slopes being generated on the perimeter of the proposed stooping areas, and, owing to the tendency of steep slopes to erode, it is likely that soils could be regularly mobilised with extreme rainfall events. This could

result in a deterioration of land capability, as well as the accumulation of sediment in the various water resources. The ranking will be reduced from **medium** to **low** if correct storm water management measures are installed (GCS, 2015).

Table 9-3 Significance rating results of the identified risks for the operational phase (GCS, 2015)

POTENTIAL ENVIRONMENTAL IMPACT	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION							ACTION PLAN	PHASE	PERSON	ANNUAL MANAGEMENT COST
		M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP				
OPERATIONAL ACTIVITIES																				
HYDROLOGY																				
Catchment reduction	The stooping operations will result in subsidence which will isolate portions of the stream catchments. Ultimately this will reduce the catchment area that feeds the adjacent streams. The surface water runoff that reports to the local streams will be reduced.	6	3	3	3	36	-	M	Effective diversion of clean storm water, by implementation of the proposed storm water management plan should reduce the impacts of reduced catchment runoff.	6	2	2	2	20	-	L	Adhere to Storm Water Management Plan. The use of standard erosion control measures, such as interception drains, contour planting, silt fences, establishment of groundcover species, optimal drainage construction, and silt ponds should be applied where appropriate.	Operational	Health, Safety, Environmental and Community Manager (HSEC) Manager	Included in operational costs
Erosion and sediment accumulation in the surface depressions (subsided areas)	The maximum anticipated subsidence of 1.53m will result in steep slopes being generated on the perimeter of the proposed stooping areas, and, owing to the tendency of steep slopes to erode, it is likely that soils could be regularly mobilised with extreme rainfall events.	6	2	3	3	33	-	M	Rehabilitate open areas as soon as practically possible. Vegetate open areas as soon as practically possible. Manager storm water systems and runoff.	4	2	1	2	14	-	L	Adhere to Storm Water Management Plan. The use of standard erosion control measures, such as interception drains, contour planting, silt fences, establishment of groundcover species, optimal drainage construction, and silt ponds should be applied where appropriate.	Operational	Health, Safety, Environmental and Community Manager (HSEC) Manager	Included in operational costs

9.3 Closure Phase

The following section describes the potential impacts associated with the closure phase of the proposed project, as summarised in Table 9-4 below.

All aspects of potential operational phase water quality modifications discussed are equally applicable to works associated with the decommissioning of Matla Stooping Project (Phase 1).

Table 9-4 Significance rating results of the identified risks for the closure phase (GCS, 2015)

POTENTIAL ENVIRONMENTAL IMPACT	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION							ACTION PLAN	PHASE	PERSON	ANNUAL MANAGEMENT COST
		M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP				
CLOSURE ACTIVITIES																				
HYDROLOGY																				
Catchment reduction	The stooping operations will result in subsidence which will isolate portions of the stream catchments. Ultimately this will reduce the catchment area that feeds the adjacent streams. The surface water runoff that reports to the local streams will be reduced.	6	3	3	3	36	-	M	Effective diversion of clean storm water, by implementation of the proposed storm water management plan should reduce the impacts of reduced catchment runoff.	6	2	2	2	20	-	L	Adhere to Storm Water Management Plan. The use of standard erosion control measures, such as interception drains, contour planting, silt fences, establishment of groundcover species, optimal drainage construction, and silt ponds should be applied where appropriate.	Closure	Health, Safety, Environmental and Community Manager (HSEC) Manager	Included in closure costs
Erosion and sediment accumulation in the surface depressions (subsided areas)	The maximum anticipated subsidence of 1.53m will result in steep slopes being generated on the perimeter of the proposed stooping areas, and, owing to the tendency of steep slopes to erode, it is likely that soils could be regularly mobilised with extreme rainfall events.	6	2	3	3	33	-	M	Rehabilitate open areas as soon as practically possible. Vegetate open areas as soon as practically possible. Manager storm water systems and runoff.	4	2	1	2	14	-	L	Adhere to Storm Water Management Plan. The use of standard erosion control measures, such as interception drains, contour planting, silt fences, establishment of groundcover species, optimal drainage construction, and silt ponds should be applied where appropriate.	Closure	Health, Safety, Environmental and Community Manager (HSEC) Manager	Included in closure costs

10 Conclusions and Recommendations

The following is concluded:

- The stormwater management plan undertaken for Mine 2 and 3 (WSP, 2012), ensures that all dirty water reports to the downstream dirty water containment facility. Currently all recommendations and conceptual designs of the mentioned controls are being implemented.
- The Matla stooping phase, minor impact identified include catchment reduction and, erosion and sedimentation depositions occurring in the surface depressions.
- Although the actual reduction in catchment cannot be avoided, stormwater controls are proposed which will ensure that the upstream clean water is diverted to the downstream environment. It should be noted that the loss of the clean water catchment due to the proposed stooping activities are minimal and is considered negligible.
- To mitigate the erosions and sedimentation deposit occurring at the local depressions, stormwater controls are required, and include silt traps, interception drains, together with the vegetation of the open areas.

The following is recommended:

- To ensure stormwater controls function effectively a stormwater maintenance plan needs to be developed, which should cover scheduled periods of maintenance, and should focus specifically before the onset of the wet season.

Prepared by

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Sivan Dhaver, (*Pr Sci Nat*)

Hydrologist

11 References

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Appendices

Appendix A: Stormwater Management Plan

Mine 1

Table A: Mine 1 Catchment Characteristics

	M1-K1	M1-K2	M1-K3	M1-K4	M1-K5	M1-K6	M1-K7	M1-K8	M1-K9	M1-K10	M1-K11	M1-K12	M1-K13	M1-K14	M1-K15	M1-K16
Area (km^2)	0.009	0.006	0.015	0.006	0.004	0.007	0.007	0.009	0.012	0.008	0.021	0.013	0.005	0.003	0.017	0.030
Catchment Length (m)	0.095	0.076	0.088	0.103	0.088	0.113	0.178	0.105	0.144	0.147	0.074	0.088	0.078	0.012	0.096	0.840
Average Slope (m/m)	0.014	0.004	0.002	0.013	0.014	0.019	0.016	0.011	0.025	0.012	0.021	0.005	0.047	0.014	0.015	0.018
Runoff Coefficient	0.31	0.90	0.90	0.90	0.90	0.90	0.48	0.90	0.40	0.90	0.51	0.47	0.95	0.95	0.47	0.50
50 year Peak Flow (L/s)	147	298	743	300	182	318	169	454	256	390	571	326	262	178	427	536

Mine 2

Table B: Mine 2 Catchment Characteristics

	M2-K1	M2-K2	M2-K3	M2-K4	M2-K5	M2-K6	M2-K7	M2-K8	M2-K9	M2-K10	M2-K11	M2-K12	M2-K13	M2-K14	M2-K15	M2-K16
Area (km2)	0.053	0.002	0.009	0.008	0.002	0.020	0.006	0.007	0.007	0.008	0.010	0.012	0.002	0.006	0.079	0.021
Catchment Length (m)	0.417	0.0664	0.174	0.092	0.08	0.157	0.234	0.082	0.122	0.182	0.179	0.182	0.115	0.297	0.203	0.231
Average Slope (m/m)	0.011	0.008	0.012	0.011	0.007	0.021	0.026	0.025	0.042	0.025	0.015	0.02	0.045	0.01	0.105	0.074
Runoff Coefficient	0.3356	0.9	0.8	0.9	0.9	0.45	0.9	0.404	0.248	0.9	0.9	0.9	0.326	0.326	0.52696	0.52696
50 year Peak Flow (L/s)	475	81	366	410	104	493	272	141	89	410	461	596	38	101	2236	596

Mine 3

Table C: Mine 3 Catchment Characteristics

	M3-K1	M3-K2	M3-K3	M3-K4	M3-K5	M3-K6	M3-K7	M3-K8	M3-K9	M3-K10	M3-K11
Area (km2)	0.004	0.007	0.014	0.006	0.008	0.006	0.027	0.008	0.005	0.002	0.010
Catchment Length (m)	0.102	0.189	0.216	0.131	0.188	0.104	0.188	0.056	0.101	0.07	0.179
Average Slope (m/m)	0.01	0.014	0.013	0.016	0.012	0.013	0.011	0.02	0.012	0.004	0.015
Runoff Coefficient	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.9	0.9	0.9
50 year Peak Flow (L/s)	157	331	659	296	408	298	1299	223	259	98	461

Plant

Table D: Plant Catchment Characteristics

Catchment	PL-K1
Area (km2)	0.006
Catchment Length (m)	0.121
Average Slope (m/m)	0.033
Runoff Coefficient	0.9
50 year Peak Flow (L/s)	264

Appendix B: Water Quality Statistical Results

ZONE 2	247 Box Cut Dam					Matla 2780 Tributary 4 Up Stream			
	Min	Max	Geo-mean	Average		Min	Max	Geo-mean	Avg
pH (Laboratory)	6.85	8.98	7.69	7.71		5.04	7.79	7.10	7.14
Calcium	13.40	103.00	34.52	39.17	**Z**	20.50	278.00	66.70	92.40
Chloride	9.16	165.94	34.69	40.80	**O**	13.20	549.00	100.94	144.99
Magnesium	8.80	58.10	18.91	20.92	**N**	6.55	101.00	35.47	45.41
Nitrate	0.01	4.59	0.14	0.33	**E**	0.52	0.94	0.68	0.70
Potassium	2.57	19.20	7.97	8.77		7.01	64.20	28.78	35.67
Sodium	16.20	142.00	41.42	46.44	**5**	14.00	334.24	97.75	124.67
Sulphate	5.17	499.00	75.33	109.96		11.78	1454.00	152.01	378.56
Aluminium	0.01	3.85	0.14	0.43		0.01	0.92	0.13	0.24
Fluoride	0.18	1.15	0.48	0.52		0.36	1.57	0.82	0.93
Iron	0.01	2.52	0.20	0.41		0.02	1.75	0.17	0.46

ZONE 4	262 3 Mine Settling Pond				263 3 Mine Final dam @ Shaft				264 3 Mine Silo Dam			
	Min	Max	Geo-mean	Average	Min	Max	Geo-mean	Avg	Min	Max	Geo-mean	Avg
pH (Laboratory)	6.75	9.26	8.15	8.16	7.12	9.48	8.48	8.49	7.21	11.00	9.17	9.20
Calcium	29.84	88.90	52.43	53.74	11.40	86.69	40.10	42.66	5.23	101.54	16.22	19.40
Chloride	63.45	718.50	166.72	185.52	115.68	1528.11	272.92	330.36	9.96	404.00	84.99	110.96
Magnesium	7.70	70.31	20.22	21.19	7.79	111.14	26.72	28.91	1.93	68.65	15.48	19.54
Nitrate	0.01	3.33	0.16	0.32	0.01	7.43	0.16	0.47	0.00	0.71	0.12	0.21
Potassium	5.35	29.56	9.72	10.65	5.54	50.40	11.03	13.19	0.50	49.30	5.75	9.47
Sodium	94.80	898.43	198.66	224.44	150.00	1537.30	352.34	405.90	29.00	667.00	154.55	187.62
Sulphate	38.40	796.31	137.76	180.69	102.00	970.95	270.04	310.58	3.69	949.00	72.42	143.79
Aluminium	0.01	0.53	0.06	0.10	0.01	4.64	0.16	0.48	0.01	65.80	0.30	1.71
Fluoride	0.22	6.43	1.25	1.47	0.14	11.99	2.38	2.89	0.13	9.00	2.41	3.00
Iron	0.01	0.27	0.04	0.06	0.01	2.28	0.10	0.26	0.01	47.60	0.20	1.08

ZONE 3	233 2 Mine Dam				234 2 Mine U/S				235 2 Mine Effluent into River				236 2 Mine D/S				259 2 Mine Pan			
	Min	Max	Geo-mean	Average	Min	Max	Geo-mean	Avg	Min	Max	Geo-mean	Avg	Min	Max	Geo-mean	Avg	Min	Max	Geo-mean	Avg
pH (Laboratory)	6.78	10.10	8.25	8.27	6.16	9.58	7.91	7.94	6.82	8.56	7.69	7.70	6.93	9.20	7.82	7.84	7.53	9.17	8.49	8.50
Calcium	18.90	110.18	41.08	43.26	0.27	77.10	15.56	27.57	13.10	60.30	20.29	20.87	0.74	77.00	17.77	25.78	35.10	117.00	52.93	54.81
Chloride	16.10	114.00	41.94	46.61	2.28	415.94	45.18	89.81	17.50	151.92	65.25	69.43	4.73	208.52	36.31	50.14	16.54	69.03	39.73	40.61
Magnesium	8.21	93.23	19.14	21.27	0.11	59.09	11.38	20.39	4.77	32.80	12.18	12.59	0.61	36.00	11.20	15.23	13.71	94.20	42.82	44.96
Nitrate	0.01	6.30	0.24	0.51	0.01	4.63	0.15	0.35	0.02	14.90	3.59	4.57	0.00	4.72	0.15	0.34	0.01	1.77	0.17	0.31
Potassium	3.00	16.23	6.44	6.90	0.06	17.10	3.70	5.39	4.02	12.80	6.61	6.82	0.44	21.40	5.50	7.28	6.82	18.76	9.97	10.23
Sodium	36.00	1000.00	181.18	293.05	3.95	781.00	61.71	106.22	22.00	902.00	82.22	96.82	9.15	190.00	51.19	63.24	81.70	940.00	669.76	686.17
Sulphate	35.47	1789.00	208.89	464.97	0.04	1314.60	42.24	107.07	24.91	1743.67	56.67	90.65	3.48	302.91	60.94	89.14	78.19	1790.00	1189.24	1231.10
Aluminium	0.01	0.65	0.06	0.12	0.01	3.29	0.18	0.48	0.01	2.12	0.05	0.10	0.01	3.19	0.24	0.59	0.01	1.09	0.14	0.24
Fluoride	0.08	3.77	0.78	1.17	0.01	2.83	0.49	0.64	0.01	3.07	0.19	0.30	0.11	1.08	0.46	0.54	0.40	6.36	2.93	3.17
Iron	0.01	0.28	0.04	0.06	0.01	2.22	0.17	0.43	0.01	1.20	0.04	0.09	0.01	3.18	0.22	0.51	0.01	0.42	0.07	0.10

ZONE 3	260 3 Mine Drinking Water				Matla 2776 Rietspruit 6				Matla 2777 Discharge 8				Matla 2779 Rietspruit 7				258 Between 234 235			
	Min	Max	Geo-mean	Average	Min	Max	Geo-mean	Avg	Min	Max	Geo-mean	Avg	Min	Max	Geo-mean	Avg	Min	Max	Geo-mean	Avg
pH (Laboratory)	7.03	9.27	7.94	7.95	5.54	8.09	7.23	7.25	6.22	7.97	7.07	7.10	6.66	8.25	7.30	7.31	6.55	9.24	7.96	7.99
Calcium	10.70	25.45	17.93	18.15	0.17	39.82	1.33	3.55	0.13	26.80	1.54	3.84	0.40	35.63	2.21	4.56	0.21	91.90	13.92	27.42
Chloride	10.76	21.70	15.01	15.18	1.65	39.80	6.29	8.55	0.69	27.80	7.03	9.98	1.95	118.00	11.03	16.63	1.37	587.91	43.28	92.52
Magnesium	7.79	16.10	11.41	11.53	0.05	46.11	0.76	3.80	0.04	25.40	0.95	3.29	0.40	42.17	1.64	4.07	0.19	80.10	11.05	21.93
Nitrate	0.01	1.91	0.21	0.35	0.07	0.47	0.23	0.30	0.04	0.49	0.16	0.25	0.42	1.38	0.66	0.74	0.01	4.90	0.16	0.43
Potassium	0.65	7.25	3.56	3.64	0.12	7.77	0.59	1.08	0.05	4.72	0.63	1.23	0.18	9.90	1.00	1.62	0.16	24.70	3.79	5.77
Sodium	9.36	53.20	15.05	15.63	5.74	496.29	17.34	47.80	4.83	270.00	19.97	37.27	4.94	447.00	21.89	47.70	4.15	963.00	64.89	125.35
Sulphate	7.01	115.34	29.04	30.52	1.29	985.94	12.78	79.13	2.54	551.03	14.74	56.26	0.30	892.61	16.46	70.23	0.04	1777.17	47.94	148.20
Aluminium	0.01	1.90	0.08	0.13	0.01	1.53	0.10	0.23	0.01	3.09	0.27	0.67	0.04	2.70	0.81	1.14	0.01	2.51	0.22	0.45
Fluoride	0.02	0.84	0.19	0.21	0.09	1.62	0.22	0.32	0.10	0.94	0.21	0.26	0.09	1.47	0.22	0.28	0.10	2.71	0.50	0.66
Iron	0.01	0.85	0.04	0.07	0.03	3.94	0.11	0.39	0.01	2.71	0.26	0.55	0.02	2.14	0.53	0.79	0.01	1.89	0.21	0.39

ZONE6	200 1 Mine Drinking Water				201 1 Mine Settling Pond 1				202 1 Mine Settling Pond 2				Matla 2778 Pan 3			
	Min	Max	Geo-mean	Average	Min	Max	Geo-mean	Avg	Min	Max	Geo-mean	Avg	Min	Max	Geo-mean	Avg
pH (Laboratory)	6.88	8.71	7.80	7.81	7.10	8.61	8.02	8.02	7.05	9.84	8.21	8.22	7.47	8.62	8.00	8.01
Calcium	12.60	24.60	17.54	17.72	85.10	180.98	122.77	124.69	54.00	150.00	80.39	81.80	243.00	307.00	274.16	274.57
Chloride	10.53	27.30	15.04	15.27	28.25	98.04	57.81	60.62	33.25	97.80	51.85	53.60	179.00	209.00	190.97	191.16
Magnesium	8.06	16.52	11.51	11.64	33.60	64.05	48.74	49.43	16.60	63.80	34.86	36.14	11.30	44.70	23.14	25.00
Nitrate	0.01	0.99	0.25	0.37	0.01	3.71	0.17	0.42	0.01	1.90	0.18	0.34	0.37	1.00	0.58	0.60
Potassium	0.96	8.14	3.56	3.63	5.48	15.60	8.08	8.31	5.46	17.40	8.14	8.46	35.70	75.08	61.06	61.81
Sodium	9.52	51.70	15.42	16.10	74.40	332.00	155.72	166.79	56.50	366.76	117.26	133.27	285.00	343.08	315.36	315.72
Sulphate	5.20	101.69	29.56	31.49	331.00	847.00	510.17	523.15	127.00	957.00	312.67	352.18	1038.20	1322.00	1180.92	1182.80
Aluminium	0.01	0.42	0.08	0.11	0.01	0.56	0.07	0.11	0.01	0.47	0.05	0.08	0.03	0.99	0.19	0.30
Fluoride	0.05	0.56	0.19	0.20	0.25	4.14	1.62	1.80	0.59	2.33	1.30	1.36	0.11	0.59	0.30	0.32
Iron	0.01	0.23	0.05	0.06	0.01	0.24	0.04	0.06	0.01	0.47	0.04	0.07	0.01	0.60	0.06	0.11

ZONE 7	Matla 2634 New Shaft Dam 1				Matla 2636 New Shaft Dam 2				Matla 2637 New Shaft Dam 3			
	Min	Max	Geo-mean	Average	Min	Max	Geo-mean	Avg	Min	Max	Geo-mean	Avg
pH (Laboratory)	6.07	7.65	6.98	6.99	7.15	8.90	7.73	7.74	6.70	8.14	7.59	7.59
Calcium	23.00	101.00	51.16	56.79	31.60	81.30	54.51	57.44	11.50	116.00	47.14	53.70
Chloride	19.30	165.00	44.14	55.23	32.30	90.20	60.55	64.15	10.00	376.00	82.04	118.42
Magnesium	9.41	44.70	20.51	22.83	12.70	39.10	25.27	27.05	5.67	74.17	26.88	31.42
Nitrate	0.14	1.15	0.36	0.49	0.05	0.78	0.25	0.40	0.07	1.63	0.53	0.75
Potassium	11.30	36.80	20.35	22.07	17.10	53.70	33.51	36.78	5.98	56.30	24.56	28.75
Sodium	20.40	192.00	53.20	67.44	24.60	82.72	52.15	55.61	8.81	360.17	92.08	129.49
Sulphate	94.92	472.00	223.00	246.50	102.33	295.00	179.51	193.10	15.70	649.00	203.98	263.75
Aluminium	0.03	0.44	0.08	0.11	0.01	0.13	0.06	0.07	0.03	3.58	0.15	0.35
Fluoride	0.26	2.04	0.79	1.06	0.84	2.25	1.36	1.41	0.79	4.40	1.63	1.81
Iron	0.01	16.40	0.28	3.19	0.01	0.12	0.03	0.04	0.01	4.14	0.07	0.32

ZONE8	265 3 Mine U/S			
	Min	Max	Geo-mean	Average
pH (Laboratory)	7.18	8.64	7.87	7.87
Calcium	7.19	77.50	25.76	28.25
Chloride	3.08	356.51	35.78	55.71
Magnesium	4.37	43.50	17.17	18.67
Nitrate	0.01	18.01	0.19	0.57
Potassium	2.52	17.80	6.69	7.15
Sodium	7.81	198.00	39.64	48.80
Sulphate	0.28	381.00	26.69	35.56
Aluminium	0.01	4.88	0.12	0.34
Fluoride	0.12	2.07	0.49	0.55
Iron	0.01	3.60	0.12	0.33

No Zone Allocated	212 Rietspruit dam				230 2 Mine drinking water				255 Kriel Ogies road				229 Flow from Power station			
	Min	Max	Geo-mean	Average	Min	Max	Geo-mean	Avg	Min	Max	Geo-mean	Avg	Min	Max	Geo-mean	Avg
pH (Laboratory)	6.90	9.67	7.95	7.96	6.70	8.68	7.78	7.79	6.96	9.49	7.87	7.89	4.17	8.23	7.30	7.33
Calcium	1.86	33.70	21.46	22.24	11.90	25.60	17.62	17.80	1.54	105.00	19.68	28.75	12.59	155.00	40.95	47.09
Chloride	11.28	40.00	24.80	25.88	10.42	23.20	14.95	15.14	6.17	173.79	31.68	40.76	2.58	187.00	41.28	48.18
Magnesium	2.00	18.00	12.30	12.73	8.32	16.70	11.49	11.60	1.91	91.00	12.70	17.84	3.78	50.60	17.58	20.51
Nitrate	0.01	1.98	0.17	0.31	0.01	1.33	0.24	0.38	0.01	7.88	0.16	0.45	0.01	2.11	0.16	0.26
Potassium	1.93	12.60	7.68	7.94	0.82	5.57	3.54	3.60	0.98	21.30	6.12	7.67	1.01	55.50	14.76	17.72
Sodium	17.69	62.10	34.32	36.12	9.30	53.90	15.17	15.80	11.80	222.00	47.48	58.87	3.85	134.00	51.79	61.60
Sulphate	18.16	118.00	65.20	70.87	7.05	108.29	29.31	30.97	3.91	657.29	65.84	####	16.90	638.83	113.51	164.76
Aluminium	0.01	2.81	0.21	0.40	0.01	0.51	0.07	0.10	0.01	6.33	0.25	0.63	0.01	1.29	0.03	0.08
Fluoride	0.13	1.71	0.54	0.57	0.09	2.14	0.20	0.23	0.12	1.77	0.49	0.57	0.12	1.89	0.77	0.85
Iron	0.01	1.44	0.17	0.32	0.01	0.33	0.04	0.06	0.01	4.11	0.22	0.47	0.01	2.57	0.10	0.28