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HYDROLOGICAL STUDY FOR THE EXPANSION OF RAILWAY LINES AT PYRAMID SOUTH YARD, PRETORIA, SOUTH AFRICA.

3424302.022S

F.M005.1.3/Rev01

YOUR FUTURE IN SAFE HANDS

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Report no	Date	Status
KIM-ENV-2017-118	15 January 2018	Final

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1 INTRODUCTION

1.1 Background

Kimopax Pty Ltd is has been appointed by Transnet SOC Ltd to conduct a hydrology specialist study for the proposed railway lines expansion project in pyramid South in line with the National Environmental Management Act, 1998 (Act 107 of 1998) as amended and the Environmental Impact Assessment Regulations of April 2017 as well as all relevant regulations promulgated in terms thereof .

Transnet's Pyramid South railway yard is located in the Onderstepoort, Bon Accord in Pretoria North, Gauteng Province. The site is situated along the old Warmbaths road (R101) in the Northern part of Rooiberg Asphalt Pyramid in Pretoria North on farm Doornpoort 295 JR within City of Tshwane Metropolitan Municipality.

1.2 Project Description

The proposed project forms part of the Transnet Waterberg rail corridor expansion programme between Ermelo in Mpumalanga Province, and Lephalale in the Limpopo Province. The railway line is a key corridor to Transnet for the transportation of various commodities, including coal, chrome, ferrochrome, cement, lime, granite, iron ore, containers and general freight. The construction activities focus specifically on the upgrades required for the coal expansion of the lines as key priority in Government's National Development Plan and has been identified as part of Strategic Infrastructure Projects (SIP 1) by the Presidential Infrastructure Coordinating Commission (PICC). Transnet has developed a programme for expansion of railway infrastructure between Lephalale in the Limpopo province and Pyramid South in Gauteng which will ultimately feed the heavy haul Coal Line for increased coal exports through the Port of Richards Bay and deliver coal to several power stations along the existing rail route.

The scope of the project includes the expansion of the existing railway lines in the yard. The yard is a switching yard which switches from 25 kV AC to 3 kV DC. The yard expansion will be undertaken within the Transnet servitude therefore no additional land will be acquired; however, it will require construction of new culverts, extension of culverts and new surface drains.

This study focuses on the expansion of railway lines at Pyramid South railway yard located in Gauteng province, South Africa excluding design work.

The location of the project site is shown in Figure 3-1.

2 SCOPE OF WORK

The study included the following:

- Assessment of the impacts of the project on surface water with a reference to the closest water course to the site during construction.
  - Reviewing baseline information for the water course based on existing flow records and hydrological reports.
  - Sampling water quality upstream and downstream of the river, and analyzing for a full suite parameter including volatile organic compounds and heavy metals.
  - Determining the location and status of any other seasonal drainage channels affected by the flow lines.
  - Reviewing field evidence of remaining surface water quality impact caused by the existing flow line crossing (erosion, sedimentation caused by previous flow line construction).
- To assess the risk to surface water of a major catastrophic oil spill during construction and operation with reference to the crossing of the river.
  - Determining baseline conditions in the river.
  - Determining the suitable construction depth of the railway line formation.

3 BASELINE HYDROLOGY

3.1 Introduction

To inform the impacts and risk assessments presented by the proposed project, an understanding of baseline hydrology is required. This section presents a comprehensive review of various information sources and defines the baseline climatic and hydrological conditions of the site and surroundings.

3.2 Climatic Conditions

3.2.1 Rainfall and Evaporation

The project area has warm to hot, rainy summers and cold, dry winters.

Figure 3-1 presents the locality of the site including the South African Weather Services (SAWS) and Department of Water and Sanitation (DWS) weather stations selected to characterise rainfall and evaporation at the site.

The rainfall station selected to represent the project site is SAWS station 513337_W, which is located approximately 3 km south west of the site with a rainfall record length of 70 years. The rainfall records show a mean annual precipitation (MAP) of 659 mm, which will be adopted for the site.

The evaporation station selected to represent the project site is DWS station A2E007, which is located 10 km east of the site and has a record length of 22 years (excluding years with estimates and missing records). S-Pan evaporation was converted to open water evaporation using evaporation coefficients from WR1990[1]. The evaporation records show a mean annual lake evaporation of 1108mm, which will be adopted for the site. Table 3-3-1 presents the average monthly rainfall and evaporation adopted for the site.

Table 3-3-1: Average Monthly Rainfall and Evaporation

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall	112	93	80	47	16	7	5	5	17	61	106	110	659
Lake Evaporation	170	154	149	117	99	80	86	111	142	167	161	174	1108

3.2.2 Return Period Rainfall Depths

The data taken from the six nearest rain stations (to the central point on site) was used to estimate the 24 hour design rainfall depth duration frequency (DDF) using the Design Rainfall Estimation

[1] Surface Water Resources of South Africa 1990 - Volume 1 Appendices - Appendix 3.3.1. WRC Report 298/1.1/94

(DRE) in South Africa (Smithers and Schulze, 2003). A summary of the input stations is presented in Table 3-3-2.

Table 3-3-2: Summary of Weather Stations Used for Generating Rainfall DDF for the Site

Station Name	SAWS Number	Distance from site (km)	Record Length (years)	Mean Annual Precipitation (mm)	Altitude (m AMSL)
BON ACCORD DAM	0513337_W	4	72	678	1200
ONDERSTEPOORT-VET	0513309_W	6.5	90	731	1220
HAAKDOORNBOOM	0513245_W	7.4	53	645	1220
PRETORIA-MAYVILLE	0513312_W	11.4	60	708	1240
PRETORIA-P.W.D. KWEKERY	0513374_W	12.6	53	688	1310
PRETORIA-CAPITAL PARK	0513343_W	12.7	38	700	1260

The Smithers and Schulze method of DDF rainfall estimation is considered more robust than previous single site methods. WRC Report No. K5/1060 provides further detail on the verification and validation of the method.

Table 3-3-3 presents DDF rainfall estimates that were derived from the Smithers and Schulze method. According to the national water Act

Table 3-3-3: Depth Duration Frequency Estimates for the Site

Duration (hours)/ days	Rainfall Depth (mm)						
	1:2yr	1:5yr	1:10yr	1:20yr	1:50yr	1:100yr	1:200yr
0.08	10.1	13.9	16.9	19.9	24.5	28.2	32.4
0.167	15	20.7	25.1	29.7	36.4	42	48.2
0.25	18.9	26.2	31.6	37.4	45.9	53	60.8
0.5	24	33.1	40	47.4	58.1	67.1	77
0.75	27.5	38	46	54.4	66.7	77.1	88.4
1	30.4	41.9	50.7	60	73.6	85	97.5
1.5	34.9	48.2	58.2	68.9	84.5	97.6	112
2	38.5	53.1	64.2	76	93.2	107.6	123.5
4	45.7	63.1	76.3	90.3	110.7	127.9	146.7

Duration (hours)/ days	Rainfall Depth (mm)						
	1:2yr	1:5yr	1:10yr	1:20yr	1:50yr	1:100yr	1:200yr
6	50.6	69.8	84.4	99.9	122.5	141.5	162.3
8	54.3	75	90.7	107.3	131.6	151.9	174.4
10	57.4	79.3	95.8	113.4	139.1	160.6	184.3
12	60.1	82.9	100.3	118.7	145.5	168.1	192.9
16	64.5	89.1	107.7	127.5	156.3	180.5	207.2
20	68.2	94.2	113.9	134.8	165.3	190.9	219
24	71.4	98.6	119.2	141	172.9	199.7	229.2
2 days	73.2	101.1	122.2	144.6	177.4	204.8	235
3 days	82.8	114.2	138.1	163.5	200.5	231.5	265.7
4 days	90.4	124.9	151	178.7	219.1	253	290.3
5 days	96.9	133.8	161.7	191.4	234.7	271	311
6 days	102.5	141.5	171.1	202.5	248.3	286.7	329
7 days	107.5	148.4	179.4	212.4	260.4	300.7	345.1

3.3 Hydrology Setting

3.3.1 Introduction

The project area is located within the Limpopo WMA 01 with the major rivers catchment being the Crocodile River. All runoff from the project area is eventually drained north into the Crocodile River and eventually Limpopo River.

3.3.2 Regional Hydrology

The project site is located in the east of the secondary catchment A2 specifically within the A23E quaternary catchment drained by the Apies River. The project is located in the Upper Crocodile/Pienaars /Apies River system. The surface water attributes of the A23E quaternary catchment are summarised in Table 3-3-4. This includes the Mean Annual Precipitation (MAP), Mean Annual Runoff (MAR), and Mean Annual Evaporation (MAE) as obtained from the Water Resources of South Africa 2012 Study (WR2012). Figure 3-1 presents the hydrology setting.

Table 3-3-4 : Summary of the Surface Water Attributes of the A23E Quaternary Catchment

Quaternary Catchment	Catchment Area km^2	MAE (mm)	Evaporation Zone	Rainfall Zone	MAP (mm)	MAR (Mm^3)*
A23E	490	1752	3A	A2H	674	13.27

*Mm^3 refers to a Million cubic metres

3.3.3 Local Hydrology

The project site is within the Apies River catchment more than 2km away from the Apies River and intersected by a perennial and several non-perennial tributaries to the river.

The railway yard crosses a single perennial stream, two (2) non-perennial streams, canals and several wetlands comprised of both un-channeled and channelled valley bottom wetlands FEPA wetlands (SANBI, 2011), both natural and artificial (due to modified surface) as depicted in Figure 3-1. The watercourse and canals crossings are also depicted on Figure 3-1.

The canals in the vicinity present an altered surface drainage patterns on the surface, however, existing culverts allow for the drainage of water through the railway yard. Only two (2) canals cross the railway line.

The headwaters of the unnamed drainage pathways originate flow from the Magaliesburg Mountain ranges (south of the proposed project infrastructure) which are characterized by rough terrain with a network of narrow valleys. Downstream of the site, the watercourses have less defined channels with wider flood plains/ wetlands. Two of the wetlands identified for the project site are National Freshwater Ecosystems Priority Areas (NFEPA) wetlands.

The Apies River originates within the town of Pretoria, in Gauteng Province within the catchment A23A, flowing northwards and through the Bon Accord Dam, joined by the unnamed tributary draining the project site approximately 5km downstream.

3.3.4 Topography and Vegetation

The topography of the site is characterised by gentle slope terrain from the west towards the eastern side which flattens towards the east. The low relief along the existing railway line is characterised by embankments and channels. The rest of the area surrounding the railway yard, is covered mostly in grasses and sparsely shrubs and bushveld trees.

The water courses which flow through the Pyramid South Railway yard through existing culverts, originated from the Magaliesburg, which is an area of elevated topography, situated 9 km south of the project infrastructure and through a valley between inselbergs/ hills/ koppies (Halls Hill on the Right and an unnamed hill on the left). The hills peaks reach elevations of 1309m and 1359m respectively, peaking from plains of 1200m.

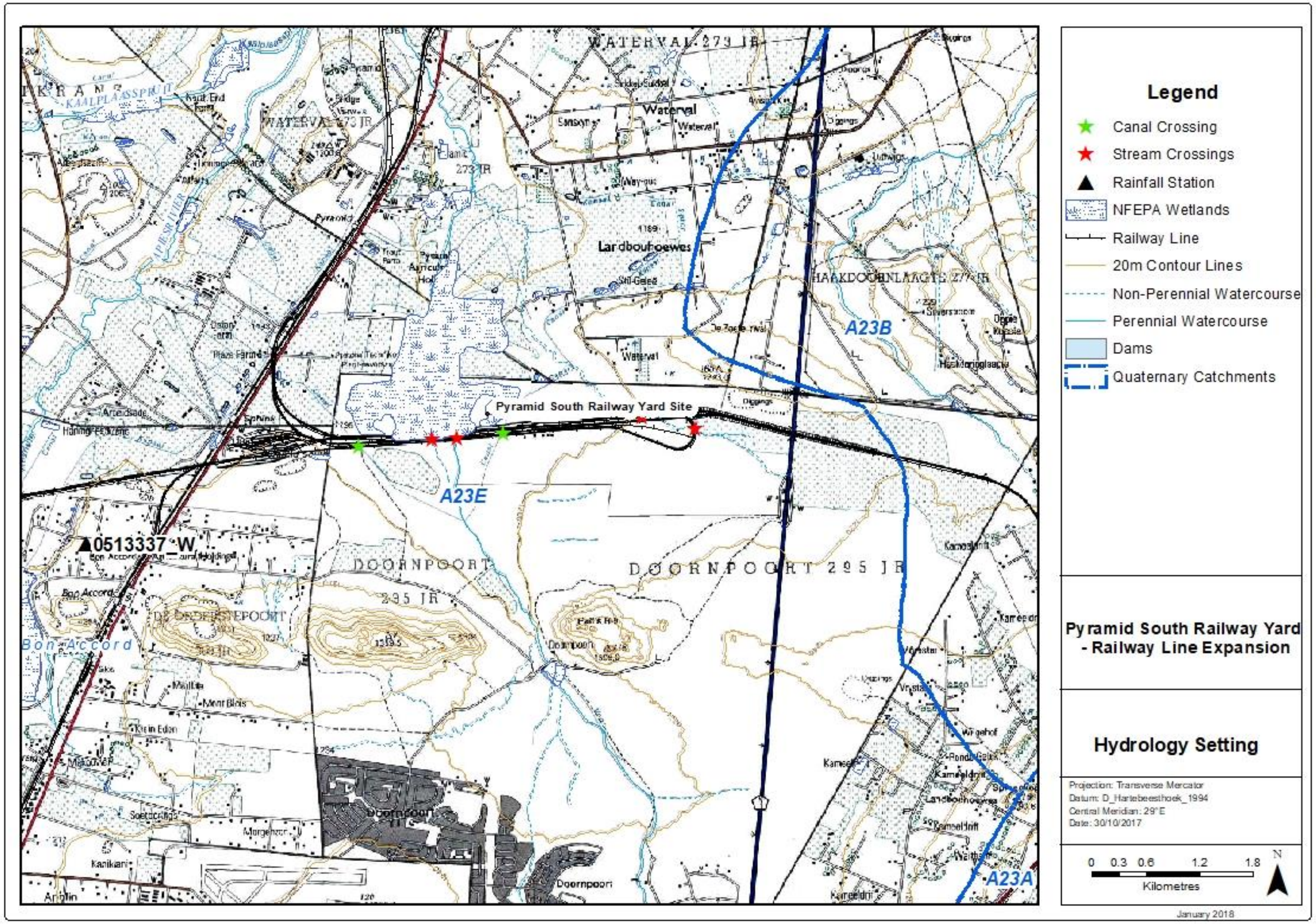

Figure 3-1:Location and Hydrology Setting of Pyramid South Yard

4 SURFACE WATER QUALITY

Water quality assessments were undertaken on the surface water from the two wetlands identified on site. Two water samples were collected in September 2017. The water samples collected and analysed will be used as a baseline surface water chemistry during the construction and operational phases of this project. The water chemistry results showed a once off analysis.

The two water samples were submitted to WATERLAB (Pty) Ltd, which is SANS-accredited in Pretoria for analysis as per the South African Bureau of Standards (SABS) water analysis procedures and protocols. The water chemistry results were compared to four different guidelines, namely:

- Department of Water Sanitation (DWS) South African Water Quality Guidelines Volume 1 for Domestic Use (1996a);
- DWA South African Water Quality Guidelines Volume 5 for Livestock Watering (1996b); and
- DWA South African Water Quality Guidelines Volume 7 for Aquatic Ecosystems (1996c)
- South African Bureau of Standards (SABS) SANS 241-1:2015 Drinking Water Standards;

In this study, the drinking water guidelines were used as they are the most comprehensive set of standards and provide for a worst case scenario where the water is unintentionally used for consumption by humans. Both the DWS and the SABS standards for drinking water were referred to in this report. The water samples were sampled from two wetlands identified on sites and as such Aquatic Ecosystem guidelines were included although the guidelines do not have a comprehensive list of standards. The two wetlands that were sampled is currently being used by local livestock in the farms nearby for drinking water, thus the DWA water quality guidelines for Livestock Watering were also referred to.

4.1 Water quality results

Table 4.1. 1 Water quality results

Parameters measured	Wetland 1	Wetland 2	SANS Standards -241 – 1: 2015 Ed 2 Standard Limits
pH	7.4	7.3	≥5.0 to ≤9.7

Parameters measured	Wetland 1	Wetland 2	SANS Standards -241 – 1: 2015 Ed 2 Standard Limits
Dissolved Oxygen (DO)	7.1	6.1	--
Turbidity as N.T.U.	316	531	Operational ≤ 1.0 – Aesthetic ≤ 5.0
TDS (mg/L)	394	526	≤1200
Total alkalinity as $CaCO_3$	340	300	25⁰C
Chloride as Cl	41	83	≤300
EC	67.9	78.7	≤170
Sulphate as SO_4	26	38	≤250
Nitrate as N	0.1	0.2	≤11
Nitrite as N	<0.05	<0.05	≤0.9
Ortho Phosphate as P	<0.1	<0.1	---
Faecal Coliform Bacteria	610	36	---
E.coli	440	24	---
Free and saline Ammonia as N	1.2	4.0	≤1.5
Sodium as Na	29	42	≤200
Potassium as K	4.8	13.8	----
Calcium as Ca	43	59	---
Magnesium as Mg	47	37	---

From the Table 4.1.1 above, ammonium is above the drinking limit requirement. The results above should be used as background data and compared with the monitoring data during the construction of the railway line project.

5 IMPACT ASSESSMENT

5.1 Introduction

Informed by the baseline hydrology and project description, the potential impacts of the proposed activities which may impact the surface water receptors as well as sensitivity of the surface water resources are discussed in this section.

The Impact Assessment process is not to provide an incontrovertible rating of the significance of various aspects, but rather to provide a structured, traceable and defendable methodology of rating the relative significance of impacts in a specific context. This gives the project proponent a greater understanding of the impacts of his project and the issues which need to be addressed by mitigation and give the regulators information on which to base their decisions.

5.2 Impact Assessment Methodology

Based on international guidelines and South African legislation, the following criteria are taken into account when examining potentially significant impacts:

- Nature of impacts (direct/indirect, positive/ negative);
- Duration (short/medium/long-term, permanent(irreversible) / temporary (reversible), frequent/seldom);
- Extent (geographical area, size of affected population/habitat/species);
- Intensity (minimal, severe, replaceable/irreplaceable);
- Probability (high/medium/low probability); and
- Possibility to mitigate, avoid or offset significant adverse impacts.

5.2.1 Impact Types and Definitions

An impact is any change to a resource or receptor brought about by the presence of a project component or by the execution of a project related activity. The evaluation of baseline data provides crucial information for the process of evaluating and describing how the project could affect the biophysical and socio-economic environment positive and negative impacts are defined below.

- Positive - An impact that is considered to represent an improvement on the baseline or introduces a positive change.

- Negative- An impact that is considered to represent an adverse change from the baseline, or introduces a new undesirable factor.

5.2.2 Impact Rating

Impacts are described in terms of 'significance'. Significance is a function of the magnitude of the impact and the likelihood of the impact occurring. Impact magnitude (sometimes termed severity) is a function of the extent, duration and intensity of the impact. The criteria used to determine significance are summarised in Table 5-5-1. The impact rating process is designed to provide a numerical rating of the various environmental impacts identified by use of the Input-Output model.

Table 5-5-1:Significance Criteria

Impact Magnitude	
Extent	On-site – impacts that are limited to the boundaries of the development site. Local – impacts that affect an area in a radius of 20km around the development site. Regional – impacts that affect regionally important environmental resources or are experienced at a regional scale as determined by administrative boundaries, habitat type/ecosystem. National – impacts that affect nationally important environmental resources or affect an area that is nationally important/ or have macro-economic consequences
Duration	Temporary – impacts are predicted to be of short duration and intermittent/occasional. Short-term – impacts that are predicted to last only for the duration of the construction period. Long-term – impacts that will continue for the life of the Project, but ceases when the project stops operating. Permanent – impacts that cause a permanent change in the affected receptor or resource (e.g. removal or destruction of ecological habitat) that endures substantially beyond the project lifetime.
Intensity	BIOPHYSICAL ENVIRONMENT: Intensity can be considered in terms of the sensitivity of the biodiversity receptor (i.e. habitats, species or communities). Negligible – the impact on the environment is not detectable. Low – the impact affects the environment in such a way that natural functions and processes are not affected. Medium – where the affected environment is altered but natural functions and processes continue, albeit in a modified way. High – where natural functions or processes are altered to the extent that they will temporarily or permanently cease. Where appropriate, national and/or international standards are to be used as a measure of the impact. Specialist studies should attempt to quantify the magnitude of impacts and outline the rationale used
	SOCIO-ECONOMIC ENVIRONMENT: Intensity can be considered in terms of the ability of people/communities affected by the Project to adapt to changes brought about by the Project. Negligible – there is no perceptible change to people's livelihood. Low - people/communities are able to adapt with relative ease and maintain pre-impact livelihoods. Medium – people/communities are able to adapt with some difficulty and maintain pre-impact livelihoods but only with a degree of support. High - affected people/communities will not be able to adapt to changes or continue to maintain-pre impact livelihoods.
Likelihood - the likelihood that hat an impact will occur	
Unlikely	The impact is unlikely to occur
Likely	The impact is likely to occur under most conditions.
Definite	The impact will occur

5.2.3 Assessing Significance

Once an assessment is made of the magnitude and likelihood, the impact significance is rated through a matrix process and the following matrix can be used to determine the impact significance.

Table 5-5-2:Significance Rating Matrix

Significance				
		Likelihood		
Magnitude		**Unlikely**	**Likely**	**Definite**
	Negligible	Negligible	Negligible	Minor
	Low	Negligible	Minor	Minor
	Medium	Minor	Moderate	Moderate
	High	Moderate	Major	Major

5.3 Receptors sensitivity

This study determined surface water receptors as the watercourses passing through the rail yard which are considered as sensitive areas. The 1:50, 1:100-year flood-lines and the 100m horizontal buffer were not delineated in this study for the water courses crossing the rail line, as the railway infrastructure is already existing with culverts already constructed.

Sensitive areas are the watercourses both perennial and non-perennial as well as associated wetlands which are considered as a very sensitive area. To this effect, potential impacts to these water resources should be prevented and managed.

5.4 Impact Assessment and Mitigation measures

The impacts of the proposed activities and infrastructure are assessed based on the impact's magnitude, as well as the receptor's sensitivity, culminating in impact significance for the most important impacts that require management.

Based on a review of the project description and activities, the project will be located in existing servitude with no additional land clearings however, the following project activities are likely to cause an impact to surface water during the construction and operational phases:

- Site clearing, including the removal of existing railway lines for upgrade;

- Construction of culverts and the railway lines; and
- Operation of the railway lines in the yard.

The proposed project design includes various mitigation by design measures in terms of surface drainage. Theoretically without these measures the drainage impacts on the environment would be much higher. Upgrading and new drainage structures such as culverts and drains is anticipated to improve drainage of water through the railway yard based on the proposed upgrades thereby implying a limited source for water quantity impacts limited to construction phase.

Water quality however remains at risk of impacts during construction and operation stages of the project. In terms of potential surface water quality, oil spills could prove catastrophic as the site is crossing several drainage channels as detailed in the scope of work, without compliance with current best practice and relevant industry guidelines.

The potential unmitigated impacts (unrealistic worst-case scenario), and residual water impacts of the project after considering the design mitigation measures proposed are qualitatively assessed in this section and presented together with proposed mitigation in Table 5-5-3.

All measures implemented for the mitigation of impacts, should be regularly reviewed as best practice and as compliance with various licences issued on site by authorities including Water Use Licences (WULs).

Table 5-5-3: Rating of the Potential Impacts during the Construction Phase

Impact	Pre-mitigation:					Recommended mitigation	Post-mitigation:				
	Duration	Extent	Intensity	Likelihood	Significance		Duration	Extent	Intensity	Probability	Significance
Water pollution from mobilised sediment material during preparation for construction, by removal of railway lines and disturbance of the surface	Short term	Local	Moderate - negative	Unlikely	Negligible - negative	- Ensure erosion control measures are in place and collect eroded water for settling from the construction sites by ensuring the use of silt traps - Prevent water from flowing through the areas under construction by temporary diversion as well as undertaking the work in the dry season if possible	Short term	Limited	Low - negative	Improbable	Negligible - negative
Hydrocarbon contamination on surface water during construction of rail lines in event of catastrophic spillage	Beyond project life	Municipal Area	High - negative	Likely	Moderate - negative	- The construction vehicles should regularly undergo maintenance - Where the storage of materials is on site, the storage areas should be on bunded with 110% containment capacity, impermeable surfaces with collection points.	Project Life	Limited	Moderate - negative	Unlikely	Negligible - negative

Impact	Pre-mitigation:					Recommended mitigation	Post-mitigation:				
	Duration	Extent	Intensity	Likelihood	Significance		Duration	Extent	Intensity	Probability	Significance
Temporary impedance of surface water flow during construction and extension of culvert and drains	Short term	Local	Moderate - negative	Highly probable	Minor - negative	- Ensure that the identified stream crossings by the rail or river have the bridges/culverts of sufficient capacity to drain in extreme design flood events -ensure that the construction of culvert is carried out in relatively dry periods where there is no storm flow, alternatively done in phases to allow temporary diversion of flow during construction -Ensure that even small drainage channels are identified and incorporated to design sufficient capacity culvert	Short term	Local	Moderate - negative	Highly probable	Minor - negative

5.5 Cumulative Impacts

Negative water quality impacts can result in the deterioration of surface water resources. All runoff draining from the project area via the unnamed water courses will eventually report into the Apies River and then eventually into the Crocodile River. The baseline water quality samples were collected and were analysed.

6 LIMITATIONS AND FURTHER WORK

The study water quality analyses is based on a single sample run which was collected during the dry season, which gives a once off baseline thus lacking in providing long term water quality baseline. It is therefore recommended that monitoring should be continued into the project to determine a longer baseline.

It is recommended that the hydraulic gradients and channel sizes are checked during the detailed design of channels. The requirement for, and design of, in-channel velocity control measures should be confirmed during the detailed design of the channels and culverts.

7 MONITORING PROGRAMME

7.1 Monitoring Program

A monitoring programme is essential as a tool to identify any risks of potential impacts as they arise and to assist in impact management plans by assessing if mitigation measures are operating effectively. Monitoring should be implemented throughout the operation of the railway yard.

7.1.1 Monitoring

It is recommended that monthly surface water quality monitoring be undertaken as follows

- Ensure that monitoring is implemented to cover all sensitive water resources around the activity areas. And monitoring sites should be located up and downstream of the site.
- Analytical suites for water quality analysis recommended include full chemical analysis including Volatile organic carbons and heavy metals

7.1.2 Reporting

Reporting on the above monitoring should be as follows:

- Internal Reporting – Monthly
  - Drainage Inspections
  - Pollutant Inspections
- External Reporting – Annual:
  - Water Quality
  - Spillages / Emissions

Accidental spillages should be reported as when they occur to the relevant authorities.

8 CONCLUSION

The proposed railway lines expansions is unlikely to pose significant risks to local surface water resources provided that appropriate measures, as discussed in this specialist report, are implemented. The most important recommendation is to ensure that the proposed railway lines expansion is implemented and that the associated storm water management infrastructure as designed by the Engineer be implemented and maintained including silt traps so as to mitigate all potential impacts to water resources..

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Appendix A: Water Quality Results

Appendix B: Summary of Nema regulation (2017) appendix 6