HIGH LEVEL SURFACE - AND GROUNDWATER IMPACT ASSESSMENT FOR THE TWIN HILLS GOLD PROJECT

Twin Hills, Karibib Area

Prepared for: Osino Resources Pty Ltd:

SLR Project No.: 733.15024.00002
Report No.: 2020-WG-15
Revision No.: 3
November 2020

DOCUMENT INFORMATION

Title	High Level Surface - and Groundwater Impact Assessment for the Twin Hills Gold Project
Project Manager	Winnie Kambinda
Project Manager Email	wkambinda@slrconsulting.com
Author	Winnie Kambinda
Reviewer	Arnold Bittner
Keywords	aquifer, river, risk, assessment, impact, mitigation
Status	Final Report
DEA Reference	
DMR Reference	
DWS Reference	
Report No.	2020-WG-15
SLR Company	SLR Environmental Consulting (Namibia)(Pty)Ltd

DOCUMENT REVISION RECORD

Rev No.	Issue Date	Description	Issued By
1	October2020	Client draft report	Winnie Kambinda
2	October 2020	Revise and consolidation of the surface and groundwater assessment into one report	Winnie Kambinda
3	November 2020	Revised to include a hydrological and hydrogeological appraisal with minor corrections from client.	Winnie Kambinda

BASIS OF REPORT

This document has been prepared by an SLR Group company with reasonable skill, care and diligence, and taking account of the manpower, timescales and resources devoted to it by agreement with **Osino Resources Pty Ltd** (the Client) as part or all of the services it has been appointed by the Client to carry out. It is subject to the terms and conditions of that appointment.

SLR shall not be liable for the use of or reliance on any information, advice, recommendations and opinions in this document for any purpose by any person other than the Client. Reliance may be granted to a third party only in the event that SLR and the third party have executed a reliance agreement or collateral warranty. Information reported herein may be based on the interpretation of public domain data collected by SLR, and/or information supplied by the Client and/or its other advisors and associates. These data have been accepted in good faith as being accurate and valid.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work. The copyright and intellectual property in all drawings, reports, specifications, bills of quantities, calculations and other information set out in this report remain vested in SLR unless the terms of appointment state otherwise.

This document may contain information of a specialised and/or highly technical nature and the Client is advised to seek clarification on any elements which may be unclear to it.

Information, advice, recommendations and opinions in this document should only be relied upon in the context of the whole document and any documents referenced explicitly herein and should then only be used within the context of the appointment.

EXECUTIVE SUMMARY

Osino Resources (Pty) Ltd, exploring the Twin Hills gold prospect, contracted SLR Environmental Consulting (Namibia) (Pty) Ltd to conduct a surface - and groundwater impact assessment to support a wider effort of specialist studies to support feasibility of mining gold north of Karibib.

- The potential impacts of the proposed activities on groundwater and surface water receptors as well as the sensitivity of the water resources were informed by the high-level water supply study with limitation in details of planned infrastructure;
- The potential impacts were assessed considering an un-mitigated case and in the mitigated case with recommended measures in place; and
- Risks identified would generally impact quality and quantity of resources on the immediate environment as well as downstream the mining operations. Assessment tables with detailed mitigation.

Summary of surface water risks

The following were assessed in terms of impact on surface water:

- Contaminant sources resulting from proposed exploration programme;
- Targets (economic water resources) present within the project area;
- Surface water resources Contamination due to various mine activities;
- Deterioration of water quality or volumes for downstream users may be as a result of the following;
  - Poor management of waste during the construction phase;
  - Alteration of drainage and Flow due to Mine Infrastructure;
  - River diversion; and
  - Flooding of Surface Infrastructure.

Summary of groundwater risks

The following were assessed in terms of impact on groundwater:

- Groundwater contamination due to recharge from contaminated surface runoff or contaminated seepage.
- Groundwater contamination due to hydrocarbon spillages during exploration drilling or seepage from improperly stored fuel on site during mine operations; and
- Impact of abstraction from production boreholes for mining operations and pit dewatering on environment and another groundwater users.

The following general recommendations are given:

- All measures recommended for mitigation, should be reviewed, and updated once the site layout has been developed to accurately assess the impacts the activities will have on the environment.
- Overall maintenance of a monitoring plan that includes all water related monitoring within the mining area, upstream and downstream of mining infrastructure will be required. Monitoring of surface – and ground water should be established for baseline and long-term data and should focus on the following:
  - Establish a surface water quality baseline;
  - Establish weather stations that will monitor rainfall and other ambient parameters;
  - Surface water monitoring should include water quality and flow volumes;
  - Groundwater monitoring should include abstraction, water levels and quality; and
  - All monitoring data will be used for regular update of water models simulating impact of mining operations on water sources.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
AMD	Acid Mine Drainage
Osino	Osino Resources (Pty) Ltd
SLR	SLR Environmental Consulting (Namibia) (Pty) Ltd
TSF	Tailings Storage Facility
ECC	Environmental Clearance Certificate
EMP	Environmental Management Plan
WRD	Waste Rock Dump

1. INTRODUCTION

1.1 BACKGROUND

Osino Resources (Pty) Ltd, exploring the Twin Hills gold prospect, contracted SLR Environmental Consulting (Namibia) (Pty) Ltd to conduct a groundwater and surface water impact assessment to support a wider effort of specialist studies to support feasibility of mining gold north of Karibib (Figure 1-1).

The footprint of the gold project covers three farms namely, Twinhill, Okawayo and Klein Okawayo where, aside from gold exploration, livestock farming, game farming and dimension stone mining are the main economic activities.

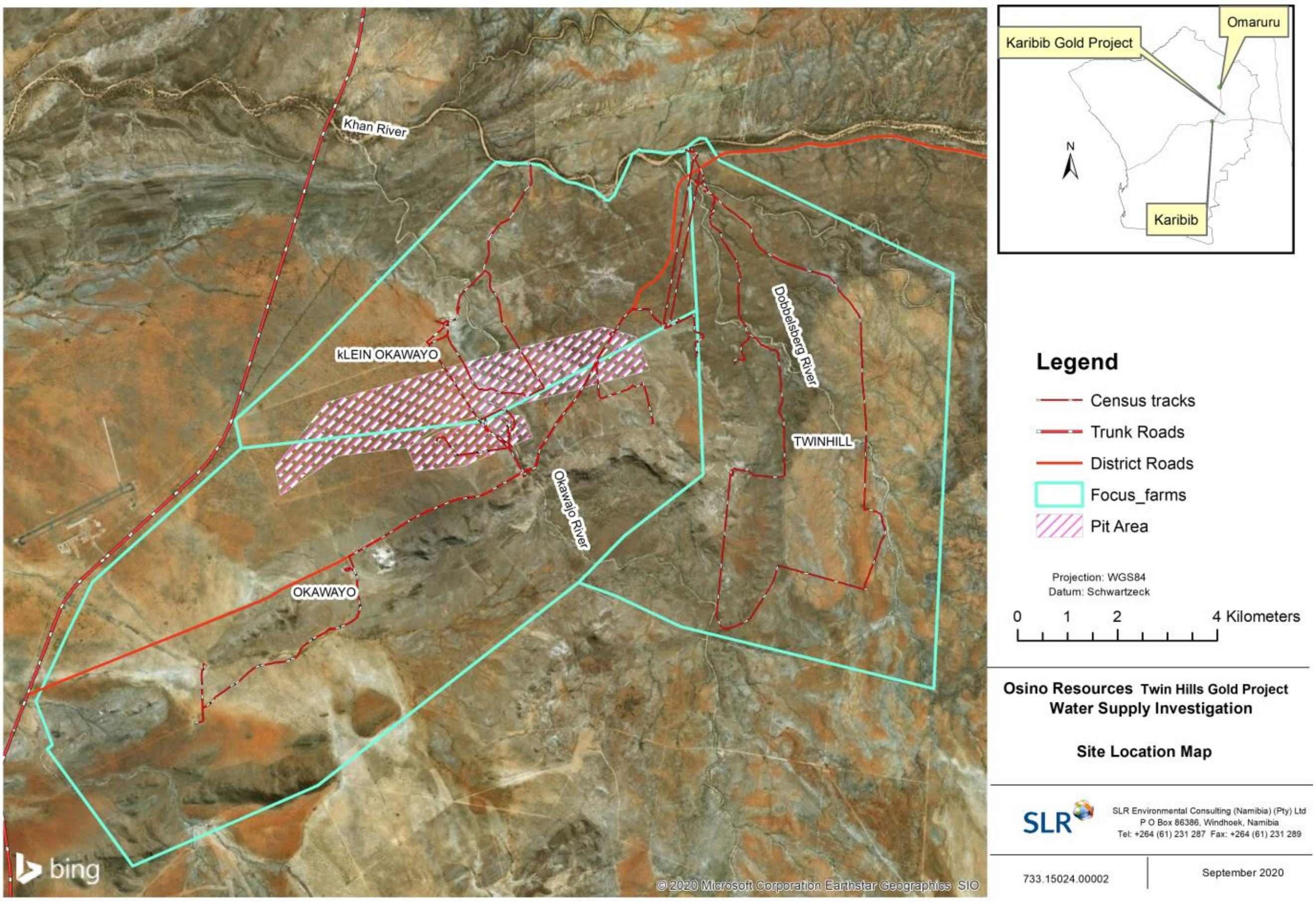

Figure 1-1:Site location map

Current and planned operation by Osino Resources will have impact on the environment. By extension, these impacts may affect surface – and groundwater. Therefore, this report identifies potential risks associated with operations and assess their potential impact before and after recommended mitigation measures are put in place.

2. SURFACE – AND GROUNDWATER APPRAISAL

Surface and groundwater appraisals are summarised from the high-level water supply study competed by SLR (2019) in 2019 below.

- **Climate**: The EPL 6953 is located in the Karibib District with generally hot daytime temperatures throughout the year, while the nights are mild to cool in winter. The mean annual rainfall is highly variable ranging between 200 - 300 mm in some parts of the EPL Area. As is the general case for most of Namibia, there is a water deficit as especially during the months from April to November, when there is little to no rainfall while becoming near neutral in January and February, where rainfall nearly matches evaporation and as a result streamflow in the rivers may occur.
- **Surface water systems:** The project area falls within the Khan River catchment (Figure 2-1); a sub-catchment within the Swakop River Catchment in the Namibian watersheds. Surface drainages in the Okawayo Minor (crossing the EPL6953) and Slang Minor rivers emerges from the surrounding hills flowing towards the Khan River whose main flow originates from the north-eastern mountain range through the project area.

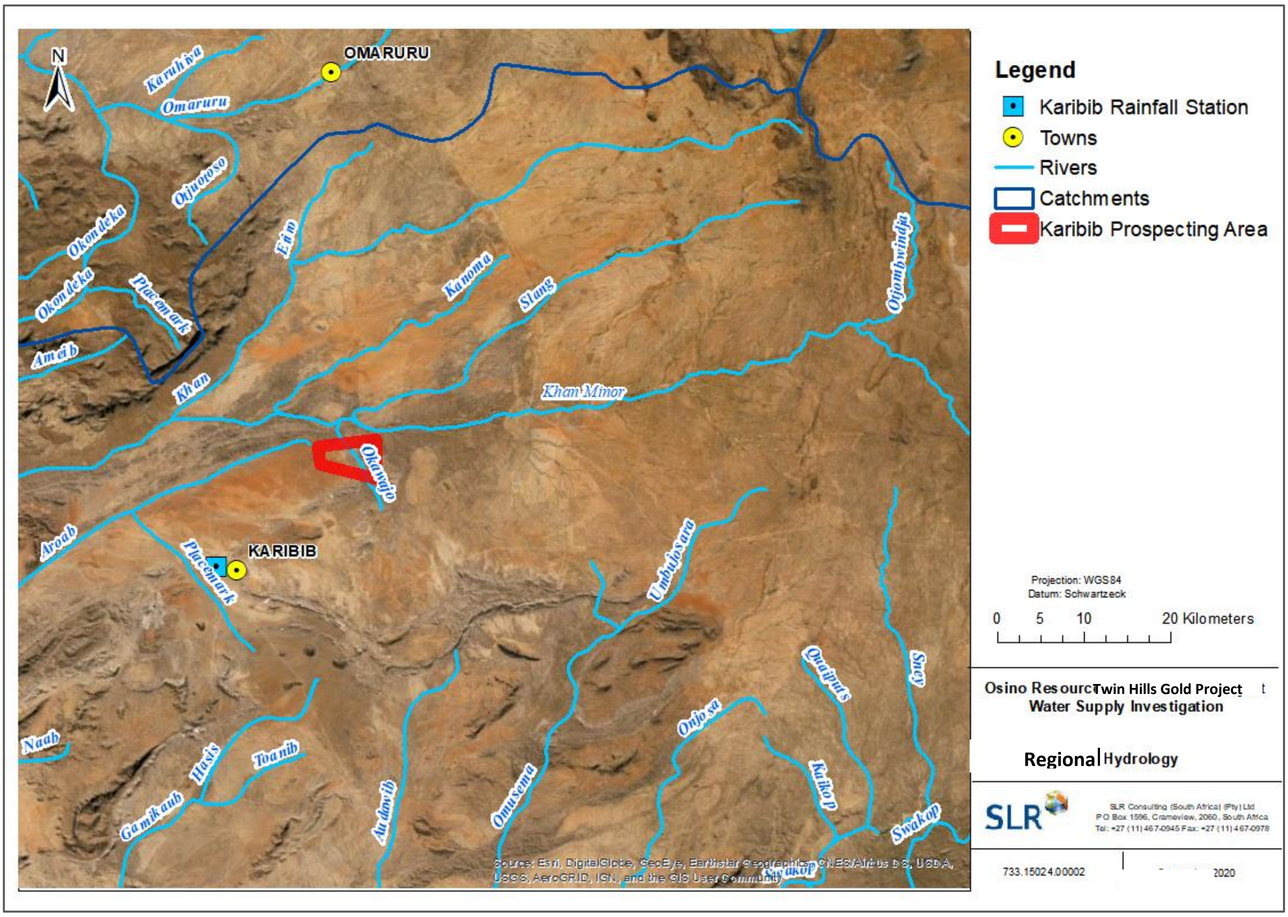

Figure 2-1: Regional hydrology

- **Aquifer potential:** Three aquifers are classified in the area according to the hydrogeological map of Namibia by aquifer type and perceived groundwater potential (Christelis & Struckmeier, 2011) Figure 2-2. First, is a porous aquifer of moderate groundwater potential, yellow in the map, confined to the Khan River; second is a fractured aquifer constituted by Kuiseb formation greywacke and shale generally low to locally moderate in groundwater potential and third is a fractured aquifer confined to the southwestern part of the project in the marbles. Porous aquifers have primary porosity while fractured aquifers have secondary porosity where groundwater is stored in faults and fractures as opposed to pore spaces in the aquifer matrix. Groundwater is the main source of water supply to the farmers and mining operations in the area. The consumption is supplied from local boreholes. During the hydrocensus conducted in 2020, 24 boreholes, yellow dots in Figure 2-2, were verified with the assistance of farm managers. Other boreholes thought to exist were confirmed to be dry and no longer in use.

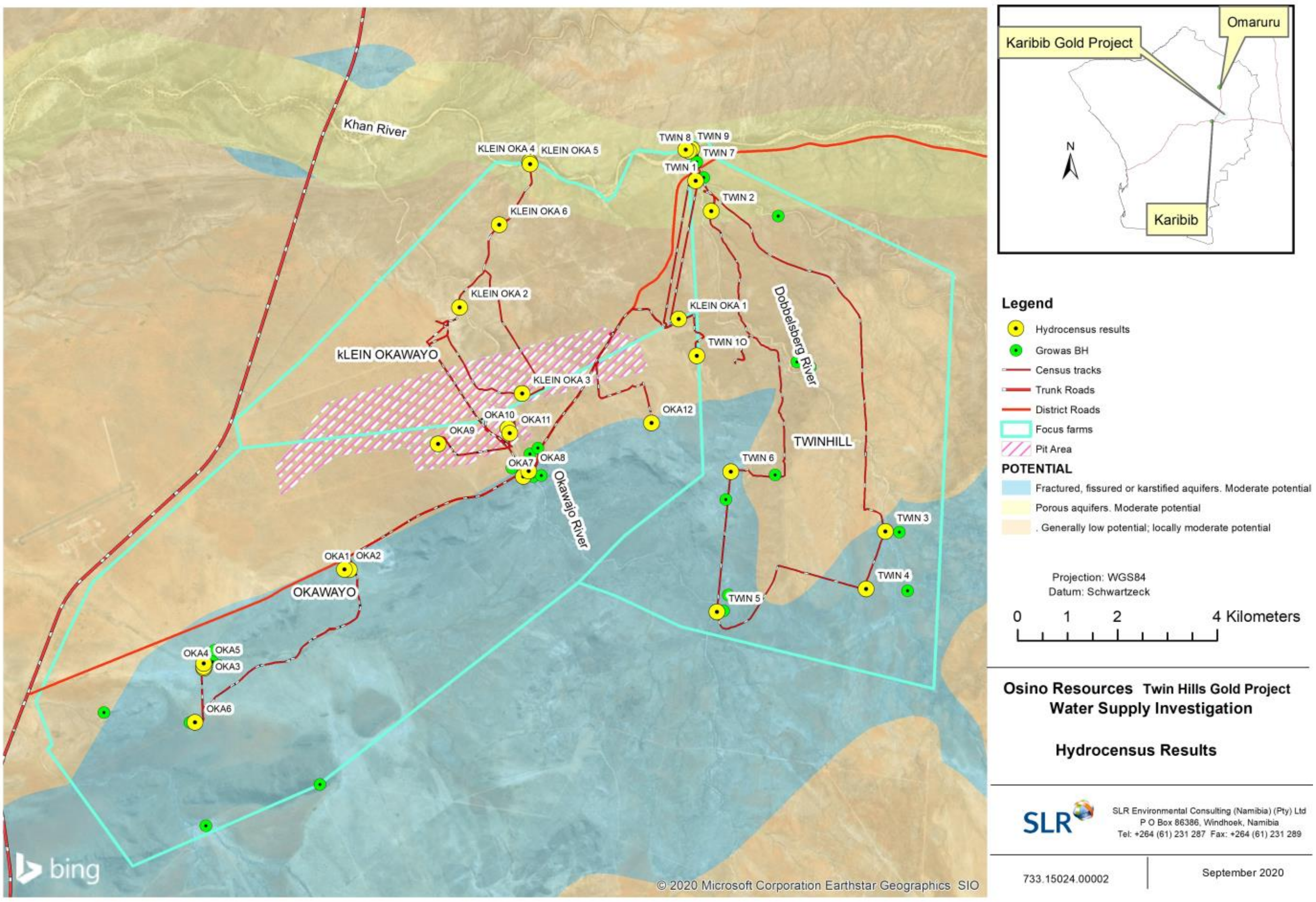

Figure 2-2: Classification of aquifers and hydrocensus results

Local groundwater has relatively shallow water levels ranging from 6 to 57 m below ground level (m bgl) with varying borehole yield influenced by aquifer potential. Figure 2-3 shows that general groundwater flow, interpolated from the GROWAS database, is from elevated highs in the south east passing through the proposed mine pit zone towards the Khan River. On a regional level, a groundwater divide in the south of the gold project marked by a white dashed line in Figure 3-3 shows that elevation highs have a significant impact on flow direction. It is noted that there is wider spacing between the contour lines in the marble area; an indication of higher permeability as opposed to the narrow spacing in the mining area; an indication of lower permeability.

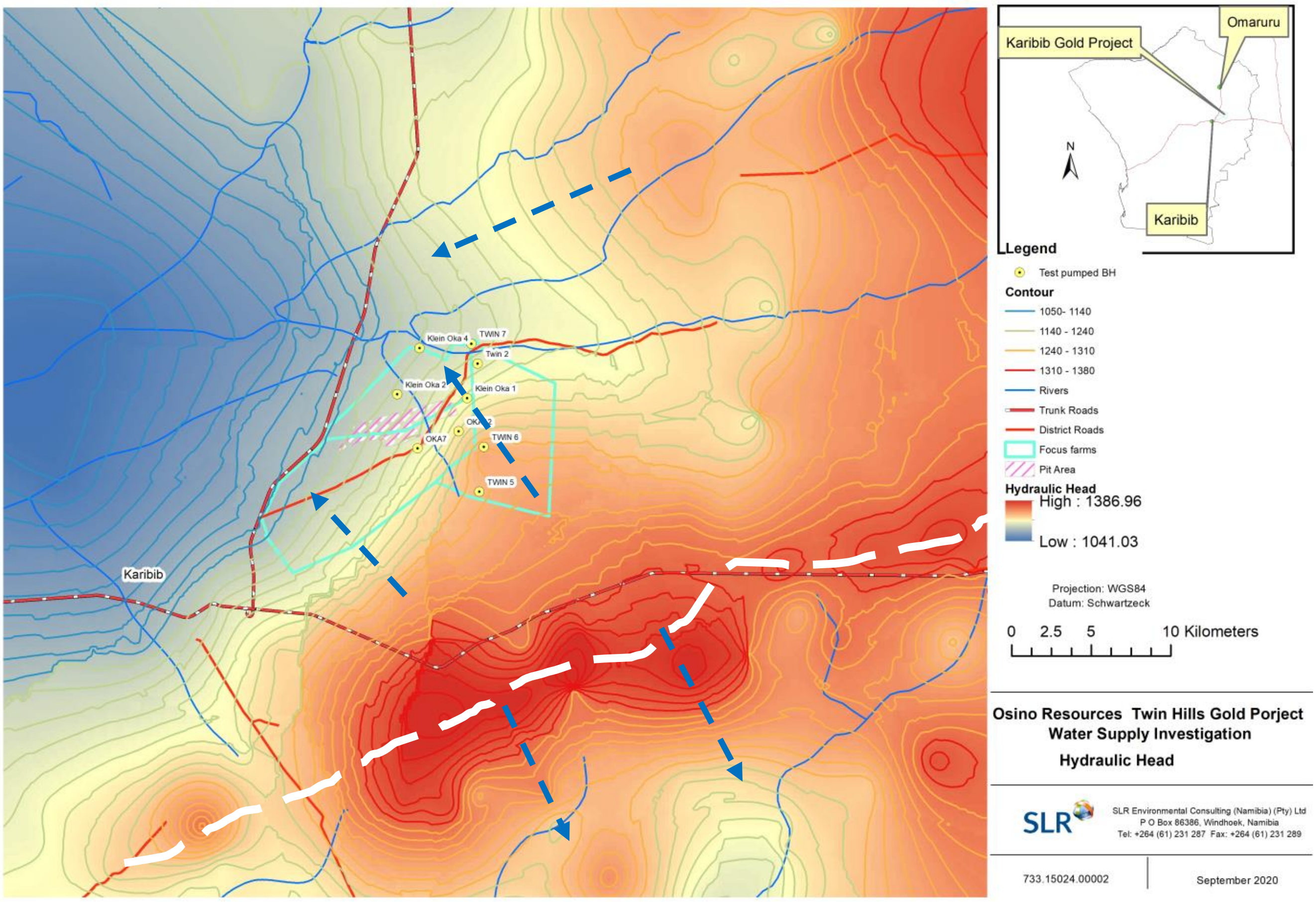

Figure 2-3: Hydraulic head and groundwater flow

3. IMPACT ASSESSMENT METHODOLOGY

The SLR standard impact assessment methodology was used to determine the significance of impacts, before and after mitigation. The impacts assessment methodology is presented in Table 3-1.

Table 3-1: Criteria for Assessing Impacts

PART A: DEFINITION AND CRITERIA		
Definition of SIGNIFICANCE		**Significance = consequence x probability**
Definition of CONSEQUENCE		**Consequence is a function of severity, spatial Scale and duration**
Criteria for ranking of the SEVERITY/NATURE of environmental impacts	**H**	Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action. Irreplaceable loss of resources.
	M	Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints. Noticeable loss of resources.
	L	Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints. Limited loss of resources.
	L+	Minor improvement. Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	M+	Moderate improvement. Will be within or better than the recommended level. No observed reaction.
	H+	Substantial improvement. Will be within or better than the recommended level. Favourable publicity.
Criteria for ranking the DURATION of impacts	**L**	Quickly reversible. Less than the project life. Short term
	M	Reversible over time. Life of the project. Medium term.
	H	Permanent. Beyond closure. Long term.
Criteria for ranking the SPATIAL SCALE of impacts	**L**	Localized – Within the site boundary.
	M	Fairly widespread – Beyond the site boundary. Local
	H	Widespread – Far beyond site boundary. Regional/ national.

PART B: DETERMINING CONSEQUENCE					
SEVERITY = L					
DURATION	Long term	**H**	Medium	Medium	Medium
	Medium term	**M**	Low	Low	Medium
	Short term	**L**	Low	Low	Medium
SEVERITY = M					
DURATION	Long term	**H**	Medium	High	High
	Medium term	**M**	Medium	Medium	High
	Short term	**L**	Low	Medium	Medium
SEVERITY = H					
DURATION	Long term	**H**	High	High	High
	Medium term	**M**	Medium	Medium	High
	Short term	**L**	Medium	Medium	High
			L	**M**	**H**
			Localised, Within site boundary.	Fairly widespread, Beyond site boundary,	Widespread, Far beyond site boundary,

PART B: DETERMINING CONSEQUENCE					
			Site	Local	Regional/National
				SPATIAL SCALE	
PART C: DETERMINING SIGNIFICANCE					
PROBABILITY (of exposure to impacts)	Definite/Continuous	**H**	Medium	Medium	High
	Possible/Frequent	**M**	Medium	Medium	High
	Unlikely/Seldom	**L**	Low	Low	Medium
			L	**M**	**H**
				CONSEQUENCE	
PART D: INTERPRETATION OF SIGNIFICANCE					
Significance		**Decision guideline**			
High		It would influence the decision regardless of any possible mitigation.			
Medium		It should have an influence on the decision unless it is mitigated.			
Low		It will not have an influence on the decision.			
***H = high, M= medium and L= low and + denotes a positive impact.**					

4. SURFACE WATER IMPACT ASSESSMENT

The surface water impact assessment undertaken here was informed by the high-level water supply study conducted for Osino Resources. The assessment provides potential impacts on the current environment by current and planned operations. Impacts of the proposed project are assessed on a high level since there is no infrastructure layout available at the start of the project.

The local surface water resources are of low sensitivity because the project site is in the low-lying areas of the Khan River Catchment which is not disturbed by urbanisation and major industries. The probability of the catchment to self-rehabilitate are high. The catchment is mostly taken up by rural areas where natural flows are through preferential flow and natural drainage. Vulnerability assessment of surface water covered possible runoff, the presence of source factors and major flow routes such as major high order discontinuities, ephemeral river channels, valleys and gullies as pathways and the presence of a surface water body as a target. Surface water will only be sensitive to contamination if the following components are all present within the project area:

- **Contaminant sources resulting from proposed exploration programme;** potential pathways for contaminant migration such as major high order discontinuities, ephemeral river channels, valleys, and gullies.
- **Targets (economic water resources) present within the project area;** during the rainy season, surface water bodies can be found along the local ephemeral river system. This surface water often recharges the local groundwater resources along the faults, solutions holes, and other discontinuities along the ephemeral rivers in the general surrounding EPL area. Therefore, surface water in the local EPL area is more vulnerable to pollution sources associated with some of the proposed local field-based detailed prospecting and or exploration activities such as drilling and trenching as well as supporting activities such as campsite and discharge of liquid and solid waste. It is important that all polluting activities must not be placed or undertaken in areas with high order discontinuities, valleys, or gullies systems in the area. Discharge of solid or liquid waste into a public stream is prohibited.
- **Surface water resources contamination due to various mine activities;** there are several pollution sources in various project phases that have the potential to pollute surface water, particularly in the unmitigated scenario. In the construction, decommissioning and closure phases these potential pollution sources are temporary and diffuse in nature. Although these sources may be temporary, the potential pollution may be long term. The operational phase will present more long-term potential sources.

- **Deterioration of water quality may be as a result of the following;** clearing the surface and site preparations, for the new infrastructure, result in exposure of soil surfaces and soil stockpiles to erosion factors. When a large area of vegetation is cleared and topsoil disturbed, it exposes a large area of loose material which is susceptible to erosion. During rainfall events, runoff from the exposed site will transport the soil material into the non-perennial streams in the project area. The baseline suspended solids in the streams are already elevated.
- **Poor management of waste during the construction phase**; typically, the following pollution sources exist at the mine: fuel and lubricants, sewage, residue from the dirty water circuit, chemicals, non-mineralised waste (hazardous, general, radioactive), and erosion of particles from exposed soils in the form of suspended solids. Discharge of dirty water into the catchment around the Refinery when extreme events do occur, some of the structures may overtop and overflow, washing dirty material into nearby streams. Potential spillages from the water storage facilities, in the event of extreme events. Although this impact will be less likely, the deterioration of water quality immediately downstream could be experienced. Removal and handling of hazardous waste offsite and waste storage facilities may result in water quality deterioration
- **Alteration of drainage and Flow due to Mine Infrastructure;** natural drainage across the project area is via preferential flow paths (natural drainage line). Development of the mine can alter the hydrologic response of an area and, potentially, an entire watershed. Development of the mine implies that beneficial vegetation will occur and replace it with turf grass lawns and impervious roofs, driveways, parking lots, and roads, thereby reducing the site's pre-developed evapotranspiration and infiltration rates. The location of surface infrastructure in relation to surface water bodies is imperative to understanding the impacts of alteration of drainage and natural flow. Construction of the mine infrastructure and the roads will reduce runoff reporting downstream due to stormwater management measures. During the construction, operation, decommissioning, and to a lesser Spatial Scale, the closure phases, rainfall, and surface water run-off will be collected in all areas that have been designed with water containment infrastructure. The collected run-off will therefore be lost to the catchment and can result in the alteration of drainage patterns.

  Although the region is generally dry, significant rainfall events do occur and these events cause temporary flow of surface water. Informed by the water balance outcomes, the discharge of water into the environment will be required. The outcome of the discharge will be a change in the flow regime. This could either increase the flood line during extreme events or have beneficial downstream effects; this excluded the evaluation of groundwater impacts. With adequate rehabilitation and closure some of the catchment is returned to a self-sustaining system and therefore will contribute to the catchment runoff. Return of natural drainage patterns because of freely draining topography.

- **River diversion;** diversion of the Okawayo River will be required, altering its course away from mining infrastructure. diversion may result in chances of downstream riverbed becoming dry. Which may cause the river to change its course over a period. The irregular release of water on the main course riverbed increases soil erosion in the downstream. Which causes saltwater invasion in the downstream. While alteration of flow consequently decreases the groundwater table in the downstream areas
- **Flooding of surface infrastructure**: Pre-mining natural drainage across the proposed project area is via preferential flow paths (natural drainage lines). The open pit will be located within a 1:100-year flood line as such it is susceptible to flooding. During the construction, operational and decommissioning phase, this activity will continue until such time as project infrastructure can be removed and/or the project areas are rehabilitated. However, the development of a flood protection berm that aims to protect against flooding and reduced flow velocity may minimise the impact. During the closure phase rehabilitation will allow for the restoration of drainage patterns.

Table 3-2: Summary of project activities, interaction and potential impacts to surface water resources

<table>
<tr><th>Project Activities</th><th>POTENTIAL SURFACE WATER IMPACT IN THE UNMANAGED SCENARIO</th><th>POTENTIAL SURFACE WATER IMPACT IN THE MANAGED SCENARIO</th></tr>
<tr><td>Surface water resources contamination due to various Infrastructure</td><td><u>Severity</u>
In the unmitigated scenario, surface water may collect contaminants (hydrocarbons, salts, and metals) from numerous sources. Potential construction and decommissioning phase pollution sources

At elevated concentrations contaminants can exceed the relevant surface water quality limits imposed by local guidelines and can be harmful to humans and livestock if ingested directly and possibly even indirectly through contaminated vegetation, vertebrates and invertebrates. The related unmitigated severity is high.

<u>Spatial / scale Spatial Scale</u>
In the unmitigated scenarios, the spatial scale is likely to extend beyond the proposed project area because contamination is mobile once it reaches flowing water courses. This will be more of an issue in the rainy season because most of the watercourses are non-perennial and the area receives relatively high rainfall. Therefore, this is rated as Medium.

<u>Duration</u>
In the unmitigated scenario, the contamination of surface water resources will occur for periods longer than the life of the proposed project and such the impact duration is rated as high.

<u>Consequence</u>
In the unmitigated scenario the consequence is high.

<u>Probability</u>
Considering the nature and location of the proposed infrastructure in proximity to local drainage channels, the unmitigated probability is Medium, reducing to low with mitigation.

<u>Significance</u>
In the unmitigated scenario, the significance of this potential impact is high.</td><td>The following measure are recommended to mitigate water quality impacts:

Vehicles and plant equipment servicing must be undertaken within suitably equipped facilities, either within workshops, or within bunded areas, from which any stormwater is conveyed to a pollution control dam, after passing through an oil and silt interceptor.

Pollutant storage – any substances which may potentially pollute surface water must be stored within a suitably sized bunded area and where practicable covered by a roof to prevent contact with rainfall and/or runoff.

Good housekeeping practices must be implemented and maintained by clean-up of accidental spillages, as well as ensuring all dislodged material like run-of-mine stockpile are kept within the confined storage footprints. In addition, clean-up material and materials safety data sheets for chemical and hazardous substances should be kept on site for immediate clean-up of accidental spillages of pollutants.

The storm water infrastructure must be designed and the following the stormwater principles must be adhered to:
• Clean water systems will be separated from dirty water systems.
• Clean run-off and rainfall water should be diverted around dirty areas and back into the environment.
• The size of contaminated water generating areas should be minimized, and contaminated water contained in systems that allow for the reuse and/or recycling of this contaminated water.
• Sizing of dirty and clean water catchments, channels and storage containment facilities must be undertaken during a detailed design.

All hazardous chemicals (new and used), mineralized waste and non-mineralised waste must be handled in such a manner that they do not pollute surface water. This will be implemented by means of the following:
• Pollution prevention through basic infrastructure design such as waste storage containment, hardstanding, and bunds.
• Pollution prevention through maintenance of equipment.
• Pollution prevention through education and training of workers (permanent and temporary).
• A Spill clean-up plan to enable containment and remediation of pollution incidents.</td></tr>
</table>

Project Activities	POTENTIAL SURFACE WATER IMPACT IN THE UNMANAGED SCENARIO	POTENTIAL SURFACE WATER IMPACT IN THE MANAGED SCENARIO
	Unmitigated Assessment: **Severity: High** **Spatial Scale: Medium** **Duration: High** **Consequence: High** **Probability: Medium** **Significance: High**	Mitigated Assessments: **Severity: Medium** **Spatial Scale: Medium** **Duration: High** **Consequence: Medium** **Probability: Medium** **Significance: Medium**
Flooding - during heavy rainfall events the open pit may be flooded by the Okawayo River.	Severity During the construction, operation, decommissioning, and to a lesser Spatial Scale, the closure phases, during heavy rainfall events the proposed open pit may be flooded by the stream located in the east direction. The overall high severity rating applies in the unmitigated scenario. Duration In the unmitigated scenario, the alteration of drainage patterns as well as the risk of flooding will extend beyond closure. Spatial scale / Spatial Scale In the unmitigated scenario, the alteration of drainage patterns as well as the risk of flooding will extend beyond closure. Consequence In the unmitigated scenario the consequence is high. Probability The probability of the flooding is definite. Significance The significance is high in all phases without mitigation. Unmitigated Assessment: **Severity: High** **Spatial Scale: Medium** **Duration: High** **Consequence: High**	In the mitigated scenario, the duration of the alterations will mostly be restricted to the phases before closure. In order to understand the impact of flooding in the study area flood lines assessment should be undertaken. Thereafter recommendations whether a flood protection berm or river diversion is needed can be made. As a preliminary measure for the current undertaking it is proposed that consequence flooding may be minimized by a flood protection berm or a river diversion and thus the consequences will be rated as is low during all phases. Mitigated Assessments **Severity: Medium** **Spatial Scale: Low** **Duration: Medium** **Consequence: Low** **Probability: Low** **Significance: Low**

Project Activities	POTENTIAL SURFACE WATER IMPACT IN THE UNMANAGED SCENARIO	POTENTIAL SURFACE WATER IMPACT IN THE MANAGED SCENARIO
	Probability: High **Significance: High**	
Deterioration in the water reserve downstream due to potential river diversion or a flood protection berm	Severity Considering the nature of the river this is considered to be a Medium Severity because the river is ephemeral and will not result in a substantial deterioration in the water reserve and downstream water uses. Spatial scale / Spatial Scale In the unmitigated scenario, the impacts of river diversion will extend beyond the site boundary as flow reduction impacts could extend further downstream. Duration In the unmitigated scenario, the impacts of river diversion will extend beyond closure. Consequence In the unmitigated scenario the consequence is Medium. Probability The probability of the alteration of drainage patterns is definite, but the magnitude of the reduced flows is unlikely to result in substantial deterioration and related flow impacts downstream therefore probability is Medium. Significance The significance is Medium in all phases without mitigation. Unmitigated Assessment: **Severity: Medium** **Spatial Scale: Medium** **Duration: Medium** **Consequence: Medium** **Probability: Medium** **Significance: Medium**	Considering the nature of the river this is considered to be a Medium Severity because the river is ephemeral and will not result in a substantial deterioration in the water reserve and downstream water uses. The probability of the alteration of drainage patterns is definite, but the magnitude of the reduced flows is unlikely to result in substantial deterioration and related flow impacts downstream therefore probability is Medium. Mitigated Assessments **Severity: Medium** **Spatial Scale: Medium** **Duration: Low** **Consequence: Low** **Probability: Low** **Significance: Low**

5. HIGH LEVEL GROUNDWATER IMPACT ASSESSMENT

Planned mining operations within the mine area may potentially impact aquifers whose groundwater levels are relatively shallow and that has a major fault and its splays as conduits through which contaminant can be transported and percolate into aquifer. When looking at the vulnerability of aquifers, it was considered that the pit zone and production boreholes may change local groundwater dynamics and seepage from other mining infrastructures such as processing plant, ore stockpiles, Waste Rock Dumps (WRD), Tailings Storage Facility (TSF) can be potential pollution sources if not constructed and managed properly while surface water recharging aquifers can also mobilise contaminants. With the above potential risks identified, a high-level groundwater impact assessment for the current exploration and planned mining activities the following risks were identified and assessed:

- **Groundwater contamination due to recharge from contaminated surface runoff or seepage:** Twin Hills gold deposit is a hydrothermal gold system with coincident structure, geochemical and magnetics in classic orogenic setting associated with arsenopyrite hosted in sediments. Although current operations have mainly focused exploration, mining the ore will require exposure of subsurface to the elements. If not constructed and managed properly mining infrastructure will be a risk to contamination of groundwater and its local users.
- **Groundwater contamination due to hydrocarbon spillages during exploration drilling and mining or seepage from improperly stored fuel on site during mine operations:** Currently potential risk to groundwater is from exploration in the form of hydrocarbon spillages and effluents from sanitary facilities that can contaminate local groundwater. As the project progresses, potential impact due to hydrocarbon spills will be more significant due to high levels of traffic and need for hydro-fuels in the project area.
- **Impact of abstraction from production boreholes for mining operations and pit dewatering on environment another and users:** Use of groundwater by Osino will escalate from minimum 60 m^3/day that is used for exploration purposes, to a much higher water demand. This will increase groundwater utilisation in the area. The mine pit may also have influence due to mine dewatering. Overall, if not managed and monitored, abstraction of groundwater for Osino’s activities may result in lowering of the groundwater levels in the aquifer.

The assessment results are presented in Table 5-1.

Table 5-1: High level groundwater impact assessment for the Twin Hills Gold project

ISSUE	POTENTIAL GROUNDWATER IMPACT IN THE UNMANAGED SCENARIO	POTENTIAL GROUNDWATER IMPACT IN THE MANAGED SCENARIO
Groundwater contamination due to recharge from contaminated surface runoff or AMD leachates from mining infrastructure and mining activities through major faults and fractures.	**Severity:** The Severity is considered **High** in the un-mitigated case taking into account that the underlying geology that is fractured and a river courses through the pit zone area. Seepage from potential pollution sources such as the stockpiles, TSF, WRD could result in elevated concentrations of major ions and metals above the national guidelines and standards for drinking water. Once contaminated recharge water percolates into the aquifer, the potential pollution plume can be transported downstream and may affect local users outside the mining area. In the unmitigated case potential impact beyond mining will also be high. **Spatial Scale:** In the unmitigated case, spatial exposure of pollutants will be **Medium** with likelihood to go beyond site boundaries as it is expected to follow groundwater flow patterns **Duration:** The duration of potential pollution will remain beyond life of project and the risk of transport of contaminants would continue after completion of the project. Hence, it will have H**igh** impact on groundwater resources. **Unmitigated Assessment:** **Severity: High** **Spatial Scale: Medium** **Duration: High** **Consequence: High** **Probability: Medium** **Significance: High**	**Recommended mitigation measures and processes:** The risk Severity may be minimized to **Medium** through ensuring that the design of mining infrastructure minimizes potential impact on groundwater by containing pollutants and ensuring that there are no seepages or overspills onto the ground that may percolate into the groundwater. This also includes proper management of storm water that may mobilize and contain pollutants which may percolate into the groundwater. Putting an early warning system in place to monitor infrastructure breaches as well as early detection of changes in groundwater quality and potential pollution proximal to mining infrastructure through a monitoring network of boreholes will ensure that the potential pollution is identified within the mining area and action is taken before it migrates out of the boundary affecting other parties. This will lower the Spatial Scale to **Low**. Develop a groundwater model that include contaminate transport scenarios to guide implementation of measures to mitigate potential pollution. This will also give an indication of how the potential pollution plume can be have initially within the boundary of the site boundary and how its migration within and downstream will be dependent on permeability of the aquifer and subsequent dispersion factors. In terms of impact after mining, considerations should be made in terms of measures that should be in place to minimizing impact on groundwater from infrastructure, potential pollution of surface water in the long term. Any pollution of groundwater on downgradient farms is unlikely if measures in place confine the potential plume. Therefore, the significance is considered **Low** in the mitigated case. **Mitigated Assessment:** **Severity: Medium** **Spatial Scale: Low** **Duration: Medium** **Consequence: Medium** **Probability: Low** **Significance: Low**

<table>
<tr><th>ISSUE</th><th>POTENTIAL GROUNDWATER IMPACT IN THE UNMANAGED SCENARIO</th><th>POTENTIAL GROUNDWATER IMPACT IN THE MANAGED SCENARIO</th></tr>
<tr>
<td>Groundwater contamination due to hydrocarbon spillages during exploration drilling or seepage from improperly stored fuel on site during mine operations</td>
<td><u>Severity:</u>
Hydrocarbons from equipment and vehicles and storage facilities used during mining operations from exploration drilling, onsite vehicles, wash area and fuel storage can be mobilized by surface water. Once contaminated water percolates into the aquifer the pollution plume can be transported downgradient affecting other users if not mitigated.
The Severity is considered Medium in the unmitigated case taking into account that fuel will be stored in a standard storage facility and fuelling areas will be designated special areas within the site boundaries initially. Further, equipment used on site are well maintained during the operations will be maintained and fit for the purpose.
<u>Duration:</u>
The duration of potential pollution will be High and the risk of transport of contaminants from fuel spills would continue after completion of the project in the unmitigated case
<u>Spatial Scale:</u>
In the unmitigated case, spatial exposure of pollutants will be Medium with likelihood to go beyond site boundaries as it is expected to follow groundwater flow patterns if unmitigated.
Unmitigated Assessment:
Severity: Medium
Spatial Scale: Medium
Duration: High
Consequence: Medium
Probability: Medium
Significance: Medium</td>
<td><u>Recommended mitigation measures and processes:</u>
Managing operations at potential pollution at fuel storage facilities, maintenance areas and wash areas will be key in minimizing impacts due to hydrocarbons. This will include adopting measures that track fuel operations and facilities to ensure that there are no seepages or overspills on to the ground that can be mobilized by surface water into the groundwater. The measures will minimize the Severity of impact to Low level.
Construction of concrete lined and bunds in refueling areas should be done while proposer storm water management should be in place to ensure that water from these areas is channeled into ponds. Drip pans should be placed under trucks and excavators, checklists should include assessing leaks from vehicles and storage facilities. Quick response to clean up after oil or hydrocarbon spills should be instituted. Waste materials should be dumped off site at a suitable landfill site.
With measures in place the Spatial Scale is considered Low as any pollution will be confined to the project area.
Exploration boreholes should be capped or alternatively backfilled with local rock material to prevent long-term pollution of the groundwater after exploration.
Storm water management and groundwater monitoring plan in place should be maintained.
Any potential pollution plume is expected to be initially contained within site boundary and its migration downstream will be dependent on permeability of the aquifer and subsequent dispersion factors. Any pollution of groundwater on downgradient farms is unlikely in the mitigated case. Therefore, the significance is considered Low in the mitigated case
Mitigated Assessment:
Severity: Low
Spatial Scale: Low
Duration: Low
Consequence: Low
Probability: Low
Significance: Low</td>
</tr>
</table>

ISSUE	POTENTIAL GROUNDWATER IMPACT IN THE UNMANAGED SCENARIO	POTENTIAL GROUNDWATER IMPACT IN THE MANAGED SCENARIO
Impact of abstraction from production boreholes for mining operations and pit dewatering on the environment and other groundwater users	**Severity:** The current water requirement for exploration activities at this phase have had little impact on local groundwater, however there is potential that water intensive operations with drilling of more production as well as other mining infrastructure such as the pit may affect groundwater use from aquifers. The impact on groundwater aquifers in terms of lowering the water table is expected to be limited to the closer area around the production borehole(s) which at this stage have not been identified as well as to the pit zone which may lower water levels due to dewatering. At this stage of mining influence on groundwater levels has not be modelled though expected to have impact. That stated, it is expected that at least in any area of influence groundwater processes would carry on in a modified way. Therefore, the severity is Medium in the unmitigated case. **Duration:** The risk of lowering the water table will be for the life of the of the project. The duration will be Medium in the unmitigated. **Spatial Scale:** The impact will be localised to the mining project and nearby surroundings therefore considering the current volumes it will be L**ow** in the unmitigated case **Probability** Groundwater abstraction should adhere to recommendations for use of groundwater through detailed studies and modelling of such abstraction. In that regard, impact on the groundwater table is expected to be localised unless abstraction volumes are too high. **Unmitigated Assessment:** **Severity: Medium** **Spatial Scale: Medium** **Duration: Medium** **Consequence: Medium** **Probability: Medium** **Significance: Medium**	**Recommended mitigation measures and processes:** Additional production boreholes should be drilled in order to supplement the water supply from borehole OKA12 these will be drilled at varying locations and utilised as recommended to reduce overall impact on groundwater due to abstraction. Abstraction volumes must be metered and water levels in production boreholes measured on a regular basis as a monitoring measure. Further, the groundwater resource management plan forming should be done to cover water efficiency and re-use from mining processes to be utilised for various purposes. Process water must be recycled where possible and alternative dust suppressants should be explored to be used instead of water. A groundwater model simulating impact of groundwater due to abstraction from production as well as pit dewatering should be in place and updated regularly with monitoring data. Although these measures will be in place the severity of potential impact on groundwater by mining related activities will remain **Low** in the mitigated case whilst minimising the Spatial Scale of such impact there is possibility that areas outside the immediate project area will be impacted. In the event that groundwater abstraction for mining activities affect other users, impact on other groundwater user's boreholes must be proven to be caused by mining operations through continuous groundwater level monitoring of production borehole(s) and farm monitoring borehole(s). Contingency water supply should be in place such as trucking water from a reliable source or deepening of boreholes to maintain supply to affected users; In light of that of those measures in place, the overall impact is **Low** under the mitigated case. **Mitigated Assessment:** **Severity: Medium** **Spatial Scale: Medium** **Duration: Medium** **Consequence: Medium** **Probability: Low** **Significance: Low**

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Osino Resources (Pty) Ltd, exploring the Twin Hills gold prospect, contracted SLR Environmental Consulting (Namibia) (Pty) Ltd to conduct a surface - and groundwater impact assessment to support a wider effort of specialist studies to support feasibility of mining gold north of Karibib. The following is concluded:

- The potential impacts of the proposed activities on groundwater and surface water receptors as well as the sensitivity of the water resources were informed by the high-level water supply study with limitation in details of planned infrastructure;
- The potential impacts were assessed considering an un-mitigated case and in the mitigated case with recommended measures in place; and
- Risks identified would generally impact quality and quantity of resources on the immediate environment as well as downstream the mining operations. Assessment tables with detailed mitigation.

6.2 RECOMMENDATIONS

The following general recommendations are given:

- All measures recommended for mitigation, should be reviewed, and updated once the site layout has been developed to accurately assess the impacts the activities will have on the environment.
- Overall maintenance of a monitoring plan that includes all water related monitoring within the mining area, upstream and downstream of mining infrastructure will be required. Monitoring of surface – and ground - water should be established for baseline and long-term data and should focus on the following:
  - Establish a surface water quality baseline;
  - Establish weather stations that will monitor rainfall and other ambient parameters;
  - Surface water monitoring should include water quality and flow volumes;
  - Groundwater monitoring should include abstraction, water levels and quality; and
  - All monitoring data will be used for regular update of water models simulating impact of mining operations on water sources.

7. PROPOSED PRELIMINARY SURFACE- AND GROUNDWATER MONITORING SCHEDULE

A preliminary surface- and groundwater monitoring schedules are recommended in Table 7-1 and Table 7-2 should be followed while the minimum water quality parameters are given in Table 7-3 should be analysed for.

Table 7-1 : Recommended Surface Water Monitoring Programme

Monitoring Element	Description	Frequency
Water quality	A monitoring programme should be developed, and this should cover upstream and downstream receptors.	Wet and dry season monitoring frequency. Monitoring needs to carry on after the project has ceased and the results reach a steady state to detect residual impacts.
Flow Volumes	Flow monitoring should be carried out in channels and pipelines and at abstraction and discharge facilities on site including pit dewatering.	On a monthly basis to update and calibrate the water balance for the mine.
Water Levels	Monitoring water levels in pollution control dams and channels to ensure the freeboard is maintained.	Monthly through the dry season and weekly through the wet season or after storm events.
Water management structures and facilities	Inspection of channels, silt traps, culverts, pipeline, dam walls and dams for signs of erosion, cracking, silting and blockages of inflows, to ensure the performance of the stormwater remains acceptable.	Weekly to monthly during wet season and after storm events or as per site management schedule. Monthly in dry season.
Meteorological data	Measurement of rainfall where possible onsite should be undertaken.	Daily

Table 7-2: Recommended groundwater monitoring programme

Borehole ID	Comment	Groundwater level monitoring		Groundwater quality	Production volumes/Water meter
		Quarterly	Weekly	Quarterly	Daily
TWIN 5		x		x	
TWIN 6		x		x	
Twin 2		x		x	
Klein Oka 1		x		x	
OKA7	Farm production BH		x	x	
Klein Oka 4	Farm production BH	x	x	x	
Klein Oka 2	Farm production BH	x	x	x	
OKA12	Osino production BH		x	x	x
TWIN 5				x	
New monitoring boreholes		x		x	
New production boreholes			x	x	x

Table 7-3: Recommended parameters for groundwater quality monitoring

Metals	Units	Metals	Units	Major Ions	Units
Lithium as Li*	µg/l	Iron as Fe	µg/l	p H	mS/m
Beryllium as Be*	µg/l	Manganese as Mn	µg/l	Electrical Conductivity	NTU
Boron as B*	µg/l	Arsenic as As	µg/l	Turbidity	mg/l
Strontium as Sr*	µg/l	Cadmium as Cd	µg/l	Total Dissolved Solids (calc.)	mg/l
Zirconium as Zr*	µg/l	Cobalt as Co	µg/l	P-Alkalinity as $CaCO_3$	mg/l
Molybdenum as Mo*	µg/l			Total Alkalinity as $CaCO_3$	mg/l
Cadmium as Cd*	µg/l			Total Hardness as $CaCO_3$	mg/l
Tin as Sn*	µg/l			Ca-Hardness as $CaCO_3$	mg/l
Antimony as Sb*	µg/l			Mg-Hardness as $CaCO_3$	mg/l
Tellurium as Te*	µg/l			Chloride as Cl^-	mg/l
Barium as Ba*	µg/l			Fluoride as F^-	mg/l
Lanthanum as La*	µg/l			Sulphate as SO_4^{2-}	mg/l
Tungsten as W*	µg/l			Nitrate as N	mg/l
Iridium as Ir*	µg/l			Nitrite as N	mg/l
Platinum as Pt*	µg/l			Sodium as Na	mg/l
Gold as Au*	µg/l			Potassium as K	mg/l
Thallium as Tl*	µg/l			Magnesium as Mg	mg/l
Lead as Pb*	µg/l			Calcium as Ca	
Bismuth as Bi*	µg/l			Stability pH, at 25°C	
Thorium as Th*	µg/l			Langelier Index	
Sodium as Na*	µg/l			Ryznar Index	
Magnesium as Mg*	µg/l			Corrosivity ratio	
Aluminium as Al*	µg/l			E.coli	
Silica as Si*	µg/l				
Phosphorous as P*	µg/l				
Sulphur as S*	µg/l				
Calcium as Ca*	µg/l				
Titanium as Ti*	µg/l				
Vanadium as V*	µg/l				
Zinc as Zn	µg/l				
Mercury as Hg	µg/l				

UNSIGNED COPY

-- --

Winnie Kambinda
(Report Author)

Arnold Bittner
(Reviewer)

8. REFERENCES

1. SLR. (2020). High Level Groundwater Supply Study for the Twin Hills Gold Project. Report No 2020-WG-15

AFRICAN OFFICES

South Africa

CAPE TOWN
T: +27 21 461 1118

JOHANNESBURG
T: +27 11 467 0945

Namibia

WINDHOEK
T: + 264 61 231 287