Hagler Bailly Pakistan

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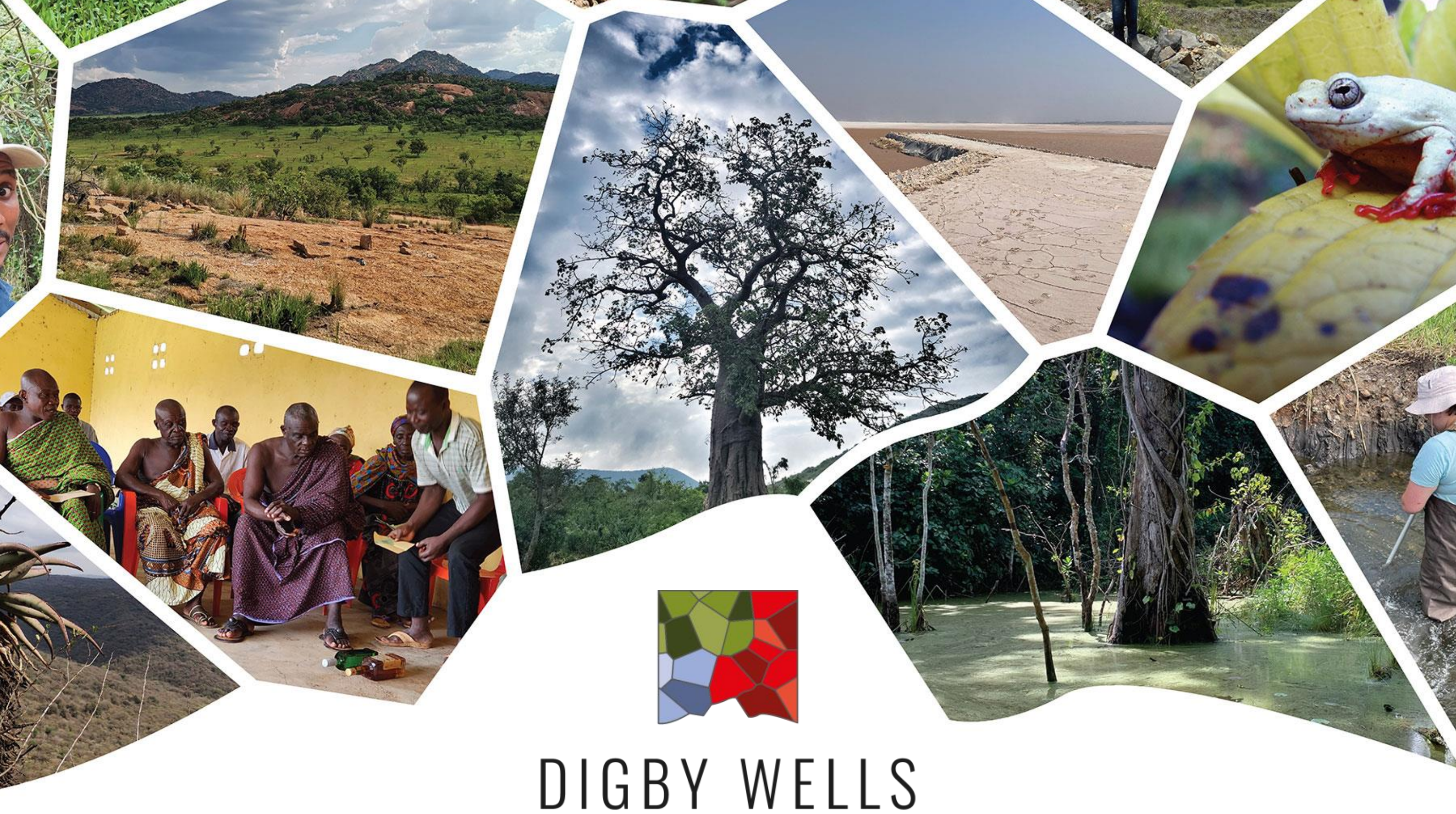
Appendix K: Surface Water Assessment



DIGBY WELLS ENVIRONMENTAL

Reko Diq Mining Project, Pakistan

Surface Water Impact Assessment

Prepared for:

Reko Diq Mining Company

Project Number:

BAR7212

August 2024

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EXECUTIVE SUMMARY

Digby Wells Environmental (hereinafter Digby Wells) has been appointed by Barrick Gold Corporation, Reko Diq Mining Company (RDMC) to assist in the compilation of environmental and social management plans for the Reko Diq Project in Pakistan (hereinafter the Project). The services would include the compilation of various management plans to feed into the Environmental and Social Management System (ESMS), in compliance with the International Finance Corporation's Performance Standards (IFC PSs) on Environmental and Social Sustainability.

This report is the Surface Water Impact Assessment in support of the ESMS process being undertaken for the proposed Project and the report aims to assess the baseline hydrology of the Project area. The overall objectives of the study are to:

- Determine and establish the baseline hydrological setting of the Project area prior to the commencement of construction activities;
- Develop a conceptual stormwater management plan for the proposed project area; and
- Develop a Water Balance which contribute to the Project's Water Management Plan.

This report should be read in conjunction with other specialist studies such as Groundwater Geochemistry and Soils.

Key Findings

The Reko Diq Mine Site (RDMS) is located on a catchment divide between the Hamun-i-Mashkel Basin to the south and the Sistan Basin to the north. The Hamun-i-Mashkel Basin is the largest hydrological unit in Balochistan (catchment area of about 126,500 km^2) and is fed by the Baddo Rud, Tahlab, Rakhshan and Mashkel rivers (SRK, 2010). The RDMS climate is an arid hot desert climate according to the Köppen climate classification system characterised by very low rainfall (MAP, 32.7 mm) and very high evaporation (MAE, 2055 mm). Following high intensity storm events surface water may flow for a short distance and time before either evaporating or infiltrating to the ground. Sometimes the RDMS is prone to rare flooding that occurs due to extreme rainfall events occasionally occurring during the pre-monsoon and/or the monsoon season.

The Storm Water Management Plan (SWMP) for the RDMS comprises a system of infrastructure including diversion drains, berms and storage facilities which help to separate clean water from the natural environment and contact water from mine processes as per the IFC storm water guidelines. In the event of flooding occurring, the diversion drains and berms help to control the high velocity flows away from the mining infrastructure.

The water balance indicates a raw water requirement of 2.53 Mm^3/month at the RDMS. The volume of raw water sent directly to the process plant to be used without treatment is 1.72 Mm^3/month for process make-up water requirements. An additional 697 596 m^3/month will be sent to the Reverse Osmosis (RO) plant for treatment and then distributed to various processes at the RDMS. A dedicated raw water dam will be constructed with a capacity of 400

000 m^3. Process water, 2.71 Mm^3/month, from the process plant is conveyed to the process water dam for storage, and all of this water will be re-used at the plant.

Groundwater contribution into the open pit (Western Porphyry only for the first 10 years of operation) will peak at 14 427 m^3/month, while the rainfall contribution will fluctuate over the years, ranging between 0 and 22 389 m^3/month in the 10th year. Rainfall contribution to the dewatering volume will increase as the size and footprint of the pit increases.

The potential environmental risks associated with the Project are summarised below:

- Flow path patterns and channel geometry of already silted watercourses are bound to be altered, especially during the high intensity extreme rainfall events
- Contamination of soil and water resources due to accidental spills and releases of fuels, solvents, oils, and chemicals, and disposal of waste, will likely occur, especially following extreme storm events; and
- An increase in the rate of erosion of disturbed soils will likely occur during construction of infrastructure, mining related activities during the operation phase and at decommissioning associated with the demolition and removal of infrastructure.

This study highlighted the activities and associated impacts the Project could have on water recourses in the immediate and surrounding environment. The environmental impacts on water resources before mitigation are classified to have moderate to minor negative significance. However, rating the impacts after mitigation measures, the impacts were reduced to a negligible impact significance. Overall, if the mitigations provided in this report are implemented, the project activities will not result in significant impacts on the receiving soil and water resources.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACRONYMS, ABBREVIATIONS AND DEFINITION

ARD	Acid Rock Drainage
BEPA	The Balochistan Environmental Protection Act
B-EPA	Balochistan Environmental Protection Agency
BESS	Battery Energy Storage System
CCTV	Closed-Circuit Television
COS	Coarse Ore Stockpile
ESIA	Environmental and Social Impact Assessment
ESMS	Environmental and Social Management System
EXP PFS	Expansion Pre-feasibility Study
g/t	grams per tonnes
IMD FS	Initial Mine Development Feasibility Study
HDPE	High-Density Polyethene
HFO	Heavy Fuel Oil
HPGR	High-pressure Grinding Roll
Km	Kilometres
KL	Kilolitre
kt	Kilo tonnes
LOM	Life of Mine
m	Metres
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
m.a.m.s.l	Meters above mean sea level
mm	millimetres
MW	megawatts
Mt	million tonnes
Mtpa	million tonnes per annum
NHA	National Highway Authorities
NAG	Non-Acid Generating
PAG	Potentially Acid Generating
RDMC	Reko Diq Mining Company

RDMS	Reko Diq Mine Site
RO	Reverse Osmosis
RBC	Rotational Biological Contactor
RoM	Run of Mine
STP	Sewage Treatment Plants
SWMP	Stormwater Management Plan
TDS	Total Dissolved Solids
TSF	Tailings Storage Facility
TSS	Total Suspended Solids
WCS	Water Conservation Strategy
WMP	Waste Management Plan
WRD	Waste Rock Dump
WSF	Waste Storage Facility
WTP	Waste Treatment Plant
WUE	Water Use Efficiency

1. Introduction

Digby Wells Environmental (hereinafter Digby Wells) has been appointed by Barrick Gold Corporation, Reko Diq Mining Company (RDMC) to assist in the compilation of environmental and social management plans for the Reko Diq Project in Pakistan (hereinafter the Project). The services would include the compilation of various management plans to feed into the Environmental and Social Management System (ESMS), in compliance with the International Finance Corporation's Performance Standards (IFC PSs) on Environmental and Social Sustainability.

This report is the Surface Water Impact Assessment in support of the ESMS process being undertaken for the proposed Project and the report aims to assess the baseline hydrology of the Project area. The overall objectives of the study are to:

- Determine and establish the baseline hydrological setting of the Project area prior to the commencement of construction activities;
- Develop a conceptual stormwater management plan for the proposed project area; and
- Develop a Water Balance which contribute to the Project's Water Management Plan.

This report should be read in conjunction with other specialist studies such as Groundwater Geochemistry and Soils. The regional locality of the Project area is illustrated in Figure 1-1.

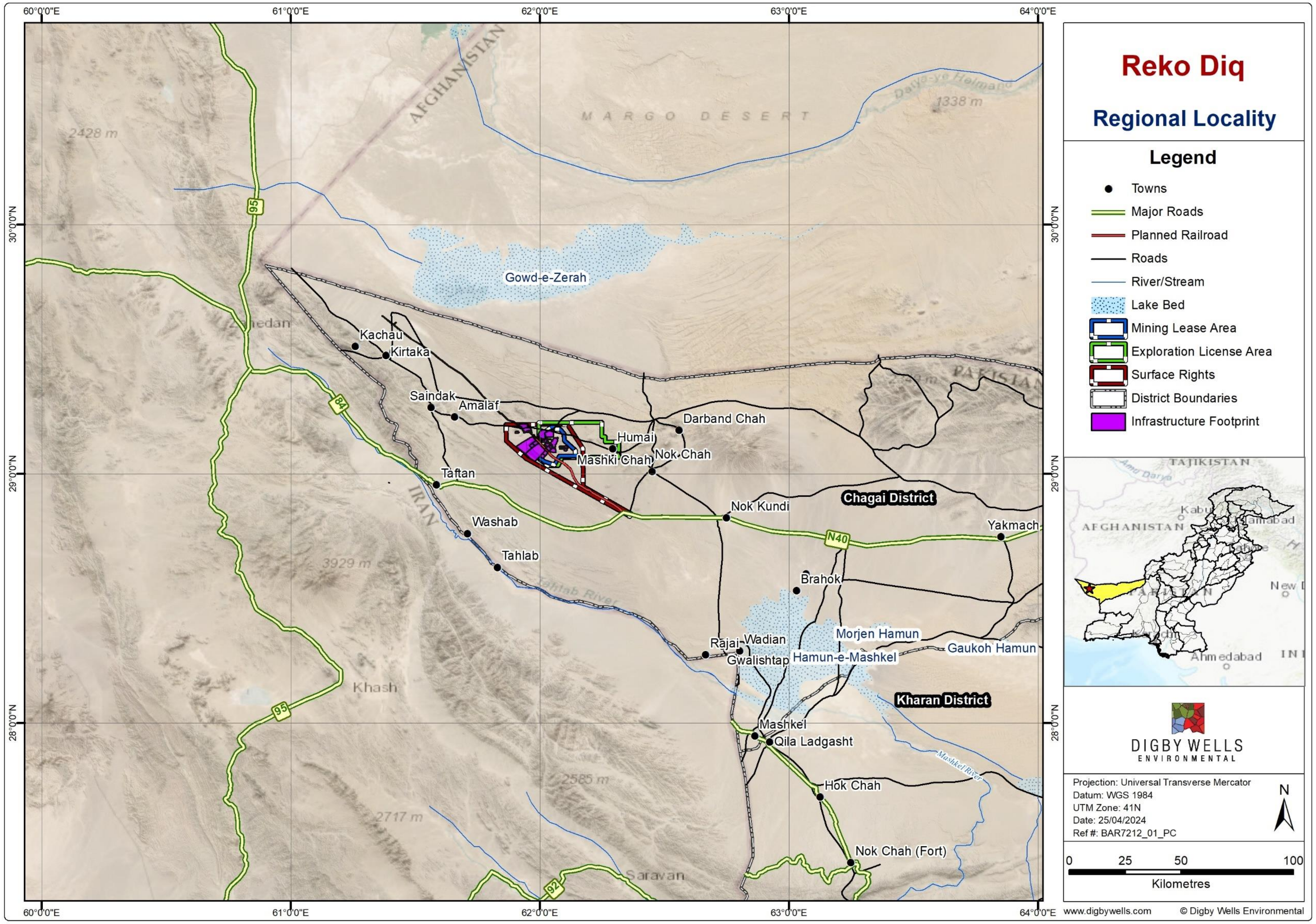


Figure 1-1: Regional Locality

2. Project Description

The Project is a Copper-Gold mining operation with an onsite processing plant to produce a high-quality copper-gold concentrate (the Concentrate) that will be exported for final processing into various products. The current Life-of-Mine (LoM) is 38 years in terms of defined resources (resources that have been identified already) with significant exploration upside.

The construction phase is anticipated to take approximately 40 months, including pre-stripping. The mine will be a truck-and-shovel open pit mining operation with processing facilities that include crushing, grinding, and flotation. The final Concentrate will be railed to Port Qasim for final export by ship.

The mine will be developed in two phases, Phase 1 is expected to have a capacity of 45 Mt per annum (Mtpa) and Phase 2 is expected to have a combined processing capacity of 90 Mtpa. Phase 1 operations are anticipated to commence in 2028 and Phase 2 operations in 2030.

2.1. Reko Diq Mine Site and Associated Facilities

Figure 2-1 provides an overview of the RDMS and the major proposed infrastructure.

The core infrastructure that will be established at the RDMS includes:

- Two main pits, Western Porphyry and Tanjeel (Figure 2-1). The mining method of these pits will be a 24-hour open-pit shovel and truck operation;
- Two designated Waste Rock Dumps (WRD) for the waste rock from the Western Porphyries pit. The Tajeel Pit will have a separate WRD in its proximity.
- Tailings storage facility (TSF).
- A processing plant.

2.1.1. Supporting Infrastructure

The proposed supporting infrastructure at the RDMS includes:

- Several sources for power supply will be utilised for the Project. The Project's estimated peak power requirements will be 183 megawatts (MW) in Phase 1 and 348 MW in Phase 2:
  - Diesel generators during the early works and construction phases until the establishment of the Heavy Fuel Oil (HFO) power station;
  - A Solar Photovoltaic (PV) system with an installed capacity of 183 MW in Phase 1 and 384 MW in Phase 2;
  - It is anticipated that the Project's energy requirements will be met through a grid connection from Year 15 (operational phase).

- Diesel, HFO and other sources of fuel will be railed to the site from Port Qasim and stored in bunded contained atmospheric tanks at the designated storage areas.
- Accommodation Facility to provide on-site accommodation for all employees and contractors;
- Security infrastructure;
- Waste management facilities.

2.1.2. Water Supply and Management

Water for the Construction Phase, Phase 1 and Phase 2 of the Project will be sourced from a sedimentary groundwater system located approximately 70 km to the northwest of the mining area referred to as the Northern Groundwater System (Figure 1-1). The system represents a small and isolated part of a much larger basin and there are no communities or community water sources located within the proposed borefield and its area of influence.

Water in the system is saline and challenging to access, and as such is not suitable for human consumption or most agricultural or industrial uses without significant treatment and abstraction infrastructure. There are currently no planned developments or users of the target groundwater system, and the scope of the Project would not preclude future use of the broader basin by others. Independent international best practice environmental and social impact assessment and hydrogeological studies, using physical surveying and remote sensing techniques, have demonstrated that there are no surface expressions of the groundwater system and no known dependent biodiversity.

This groundwater system is considered capable of enabling development and sustaining operation of the Project, which is expected to add significantly to the socio-economic advancement within the region and country through employment, infrastructure, and services.

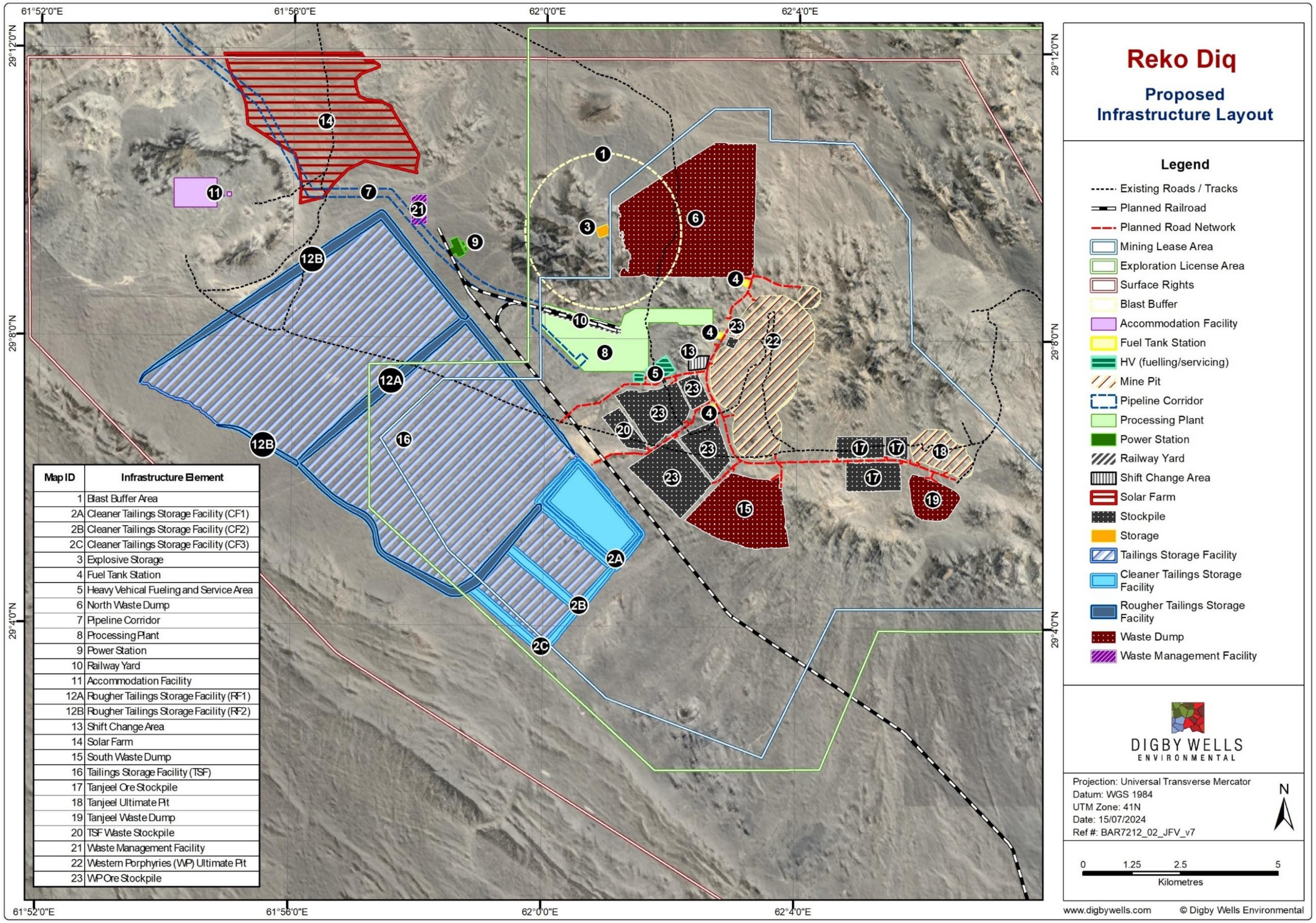


Figure 2-1: Proposed Reko Diq Mine Site Layout

2.2. Transport and Marine Port

The Project will use the existing road and rail networks to transport materials during construction and operational phases and utilise the air transportation option for personnel. The main Project transport routes (Road Transport Route and Rail Transport Route) are shown in Figure 2-2.

2.2.1. Transport of Concentrate to Port Qasim

The Concentrate will be transported from the RDMS processing plant to Port Qasim via an existing railway line, passing through the Balochistan and Sindh provinces. The existing rail route is approximately 1,350 km in length as outlined in Figure 2-2.

The Project will make use of the existing PIBT Terminal where all facilities are owned and operated by PIBT. An area will be leased to RDMC for the construction of a Concentrate storage shed.

An extract of the onshore and offshore layout is shown in Figure 2-4.

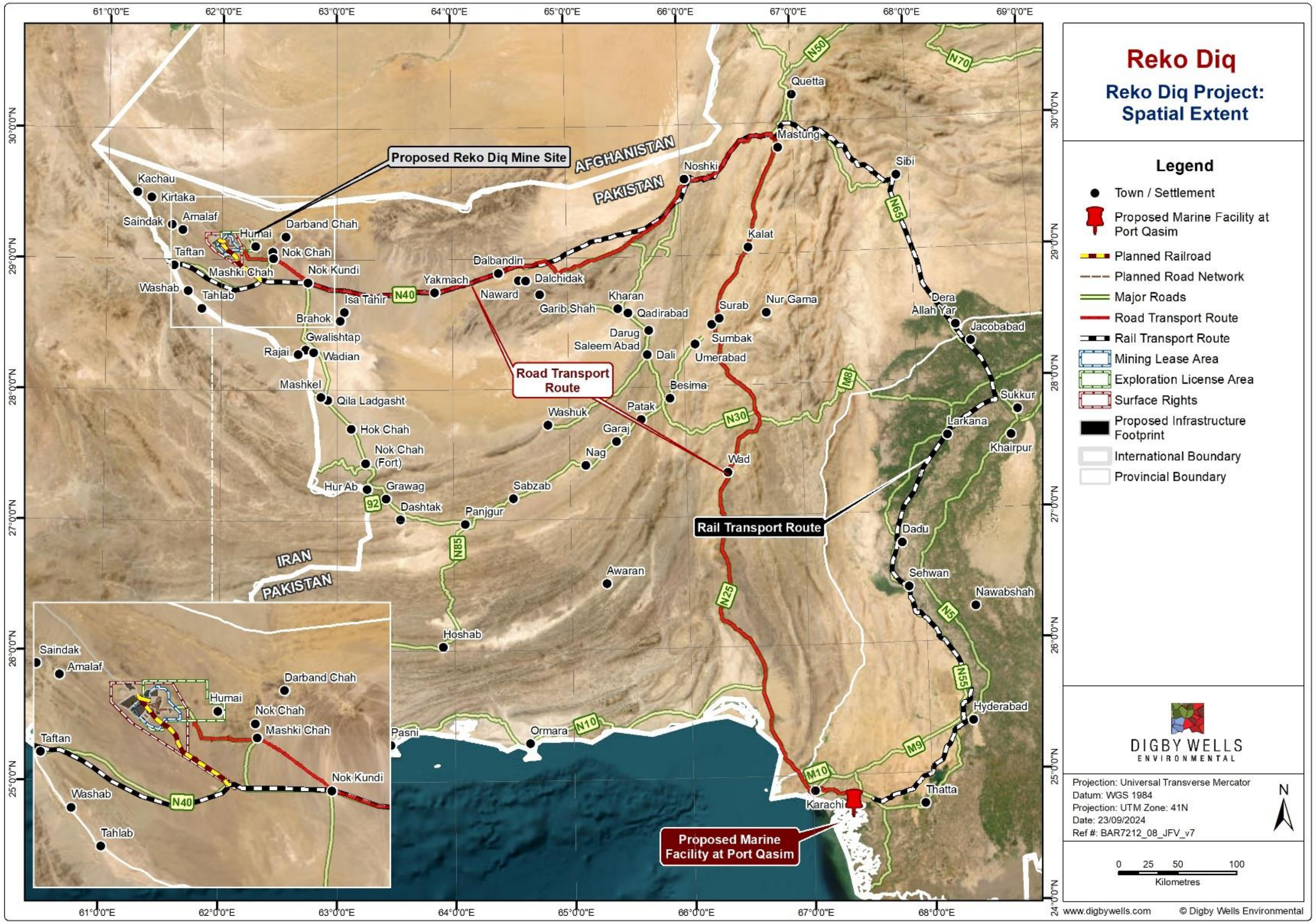


Figure 2-2: Reko Diq Spatial Extent and Transport Routes (Rail Transport Route and Road Transport Route)

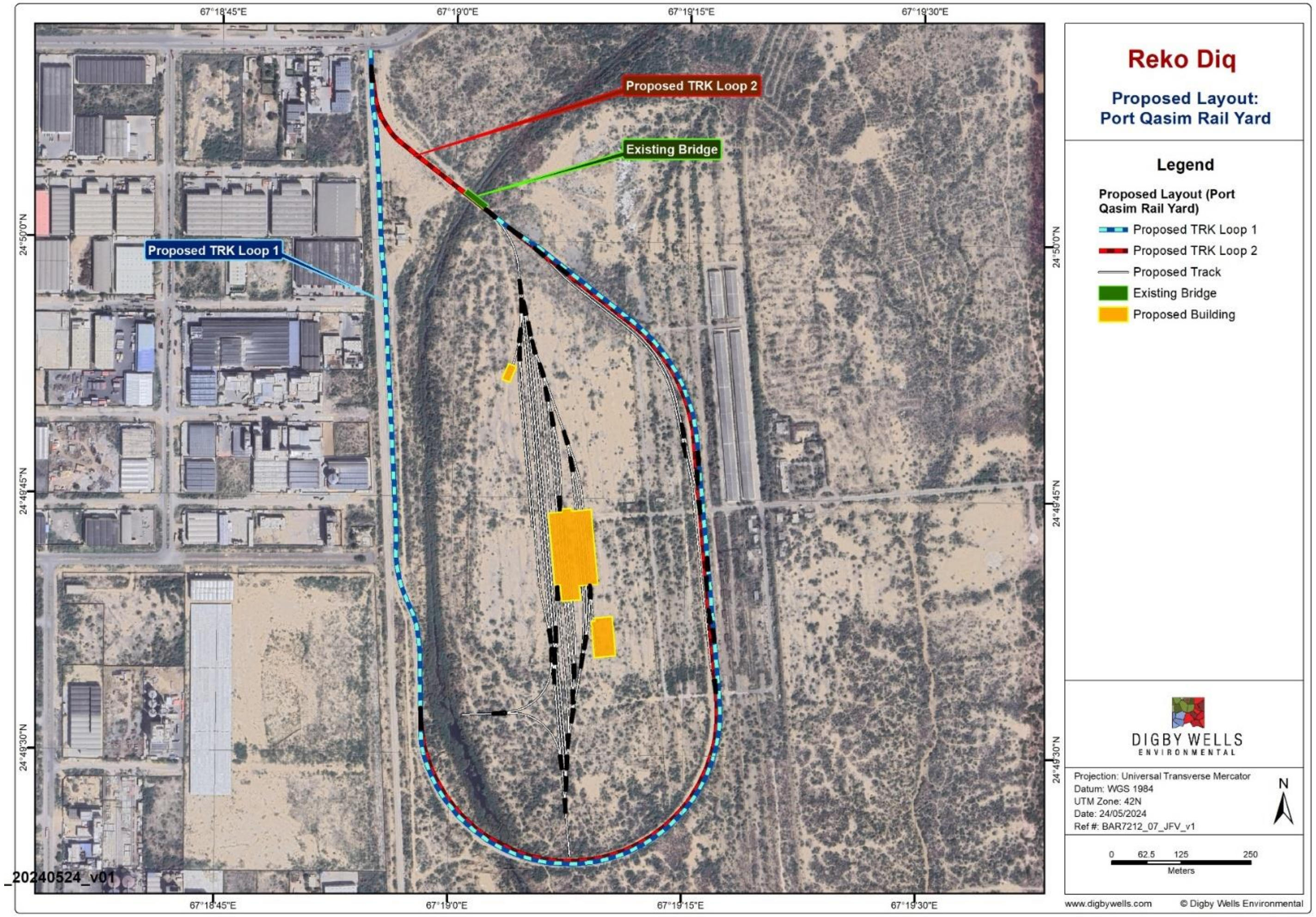


Figure 2-3: Proposed Rail Yard Layout at Port Qasim

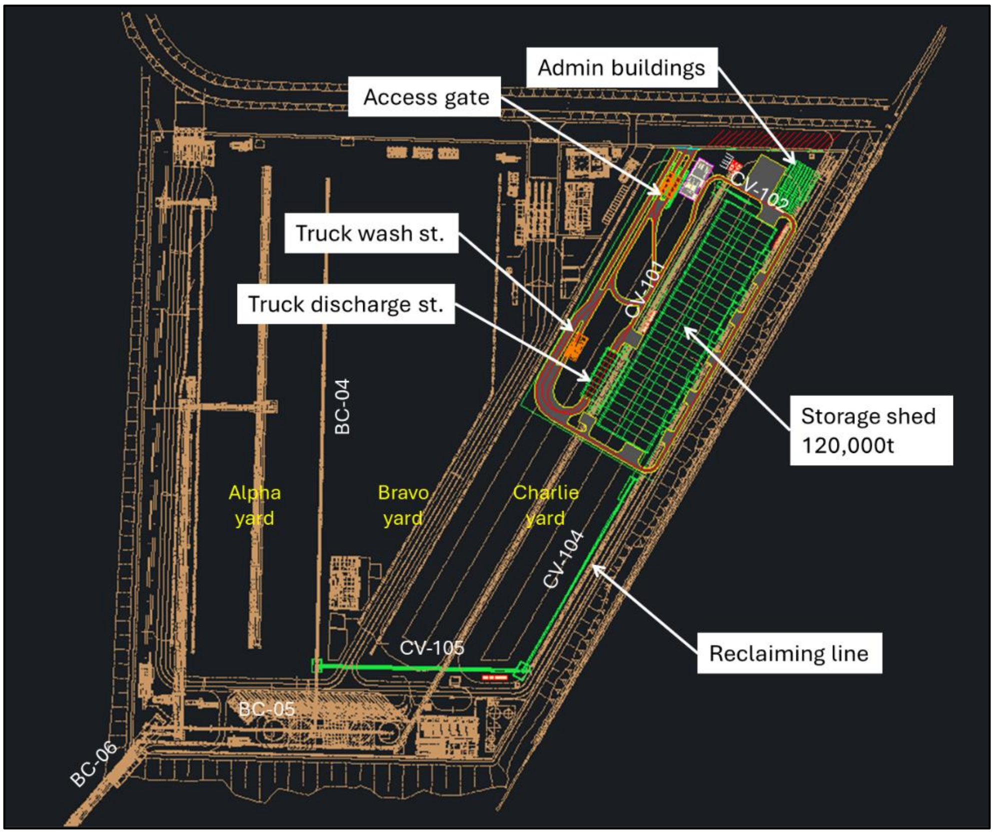


Figure 2-4: Layout of Concentrate Facilities at PIBT at Port Qasim

2.2.2. Land Requirement

No private land acquisition or resettlement will be required for the Project. All the land required for the Reko Diq Mining Project is Government owned land which will be either leased or purchased from the Government. The key project facilities will be fenced and access to the land will not be restricted for local communities.

2.2.3. Employment

Preference will be given to locals for employment and appropriately qualified individuals from the surrounding communities. Table 2-1 presents the estimated average staffing during different stages of the Project.

Table 2-1: Estimated Average Employment at Reko Diq Mine Site in various stages of the Project

Project Phase	Early Works, Feasibility Study & Detailed Engineering	Phase 1 Construction	Phase 1 Operations and Phase 2 Construction	Phase 2 Operations

	2024	2025-2027	2028-2033	2034-2040
A. Contractors				
A.1. Contractors - Construction	2,353	8,255	6,803	-
A.2. Contractors - Operations & Services	200	200	331	614
Total Contractors	2,553	8,455	7,133	614
B. RDMC Employees				
B.1. RDMC Local	460	1,761	2,465	4,814
B.2. RDMC Expat	86	120	449	404
RDMC Total Employees	546	1,881	2,914	5,218
Total Engaged Workforce (A+B)	**3,099**	**10,336**	**10,047**	**5,832**

The type of employment required includes skilled and management, semi-skilled (such as drivers, fitters and carpenters) and unskilled (labourers and guards).

2.2.4. Project Schedule

The Project will be developed in stages as per each area with the initial production of concentrate in late 2027. Table 2-2 presents the anticipated Project schedule.

Table 2-2: Project Schedule

Phase	Aspect	Scheduled
Construction Phase	Early Works	Q3 2024 – Q2 2025
	Phase 1 construction	2025 – 2027
	Phase 2 construction	2028 – 2030
Operational Phase	Early Works commissioning	Q1 2025
	Phase 1 commissioning	Q1-Q3 2027
	Phase 2 commissioning	Q1-Q3 2031
Decommissioning	Rehabilitation and post-closure management	After mine operations have ceased.

Q refers to one-fourth quarter of a year i.e., Q2 is second quarter of the year 2025.

3. Relevant Legislation, Standards and Guidelines

The relevant legislation, regulations and guidelines for this study are described in Table 3-1 below.

Table 3-1: Applicable Legislation, Regulations, Guidelines and By-Laws

Legislation, Regulation, Guideline or By-Law	Applicability
Pakistan Environmental Protection Agency Review of Initial Environmental Examination and Environmental Impact Assessment Regulations, 2000 This set of Regulations provides lists of projects that require an initial environmental examination (IEE) and of projects that require an environmental impact assessment (EIA).	According to Section 4, activities such as mining and mineral processing fall within Schedule II projects, which requires an EIA.
Balochistan Environmental Protection Act, 2012 The Balochistan Environmental Protection Act 2012 (BEPA 2012) is to provide for the protection, conservation, rehabilitation and improvement of the environment, for the prevention and control of pollution, and promotion of sustainable development.	Section 20 of the BEPA Act guides the protection, conservation, development, use, control and management of water resources
IFC Environmental, Health, and Safety (EHS) Guidelines, 2007	Provides recommended practices for water management, including water use, water quality and stormwater management.
World Bank Group, IFC Performance Standards on Environmental and Social Sustainability, 2012	Performance Standard 3: Resource Efficiency and Pollution Prevention: This outlines a project-level approach to resource efficiency and pollution prevention and control in line with internationally disseminated technologies and practices. In addition, this promotes the ability for private sector to adopt such technologies and practices as far as their use is feasible in the context of a project that relies on commercially available skills and resources.

4. Assumptions, Limitations and Exclusions

Assumptions, limitations and exclusions considered in this report are discussed in Table 4-1.

Table 4-1: Limitations and Assumptions with Resultant Consequences

Assumptions and Limitations	Consequences
The study was based on the approved infrastructure layout as presented by the client team.	Any changes to the layout plan may necessitate the update of the study as it may also influence the current impact assessment ratings.
Water management plans used in this report for the TSF and Process Plant were developed by Knight Piésold (Knight Piesold Consulting, 2024b) and Lycopodium (Lycopodium, 2024) respectively.	This study developed and recommended stormwater management around the mine pits, ore stockpiles and waste rock dumps which constitute dirty areas.
The proposed water management infrastructure as reflected on the final layout has been adopted and assessed as part of this study.	Water management infrastructure designed by Knight Piésold (Knight Piesold Consulting, 2024b) and Lycopodium (Lycopodium, 2024) would cater for the relevant 24-hour design storm events to allow for extreme rainfall/runoff volumes.
The water balance presented in this study is to the required standard for an ESIA. Further refinement will occur over the next few months during the continued feasibility work that is ongoing.	The water balance focusses on the clean water flows into the various storage facilities, dirty water flow from the WRDs, water supply to the various tasks and consumption points as well as the TSF balance incorporated from the Knight Piésold (Knight Piesold, 2024) studies. The water balance will be updated during feasibility to increase confidence and operationalise the water balance for decision making and operational support functions.

5. Methodology

This section describes the methods undertaken to complete the surface water study.

5.1. Baseline Hydrology

A review of existing literature, reports and data for the Project area was conducted to get an understanding of the hydrological setting of the site in terms of the surface water features (the Rivers, Pans and Dams) and other hydrological characteristics such as topography, drainage patterns, surrounding surface water uses, catchment characteristics and climatic conditions.

5.1.1. Climate

Rainfall data from 1983 – 2023 was obtained from the Nok Kundi weather station that is located approximately 80 km southeast of the Project area. Rainfall from the Nok Kundi weather station was used because of its relatively long record length and correlation to observed rainfall at Reko Diq. Historic site-specific temperature data (2004 -2007) (SMEC, 2010) and evaporation data was obtained from the Design Climatology Report (Knight Piesold , 2024a) (see Appendix B). The mean annual precipitation (MAP) and mean annual evaporation (MAE) were determined using the above-mentioned climate data.

5.2. Stormwater Management Plan

The conceptual stormwater management plan (SWMP) described in this study is based on inputs from Knight Piésold (Knight Piesold Consulting, 2024b) and Lycopodium (Lycopodium, 2024), for the TSF and the Process Plant, respectively. Management of water around mine pits, ore stockpiles and heavy vehicle washing areas was addressed as part of this study to augment the engineering inputs, as mentioned above. Overall, the conceptual SWMP is in line with the relevant country specific and international IFC guidelines which recommend the following principles:

- Collect all stormwater of poor quality and contain it within the storage facilities;
- Route or divert all clean stormwater directly to natural watercourses without increasing the risk of a negative impact on safety and infrastructure, for example, loss of life or damage to property due to an increase in peak runoff flows;
- Minimise, as much as possible, the footprint or catchment of the dirty water area and maximise the clean water areas within the site to ensure minimal water quality impact on the generated site runoff;
- Only discharge excess dirty water where it cannot be reused, this must be authorised and comply with the discharge standards set by the relevant authorities;
- The SWMP must be appropriate over the life cycle of the mine, over different hydrological cycles and must incorporate principles of risk management; and
- The statutory requirements of various regulatory agencies and the interests of stakeholders must be considered and incorporated.

5.3. Water Balance

The water balance was developed based on the inflows, outflows, transfers and potential losses within the mine system. All input data including climatic (rainfall and evaporation), dam capacities, groundwater ingress rates were collated and utilised in developing the water balance. Reasonable assumptions were made where no measured data was available.

5.4. Impact Assessment

The impact assessment methodology used for the Project involves two phases, namely impact identification and impact assessment. Impact identification was performed through the use of an input-output model, whereby Project activities (see Section 8, Table 8-1) are superimposed onto the environmental and social baseline characteristics of the project area to generate assessment outputs in the form of instances of potential positive or negative biophysical and socio-economic changes in the environment.

A quantitative assessment of the significance of potential Project-induced impacts was done as follows:

Significance = Consequence x Probability

Whereby

Consequence = Type of Impact x (Intensity + Spatial Scale + Duration)

And

Probability = Likelihood of an Impact Occurring

In addition, the formula for calculating consequence:

Type of Impact *(Nature) =* ***+1*** *(Positive Impact) or* ***-1*** *(Negative Impact)*

Details of the impact assessment methodology are provided in Appendix A.

6. Findings and Discussion

The following sections discuss the findings of the desktop assessment, SWMP and the WCS.

6.1. Baseline Hydrology

The following sections describes the hydrological setting of the site in terms of the surface water features (the Rivers, Pans and Dams) and other hydrological characteristics such as topography, drainage patterns, surrounding surface water uses, catchment characteristics and climatic conditions.

The Reko Diq Project area is characterised as having an arid hot desert climate (Bwh) in the Köppen climate classification. The BWh is charactered by hot dry summers and cold wet winters (Mindat, n.d). The climate can be further characterised into four seasons which is winter (December to March), pre-monsoon (April to May), monsoon (June to September) and post-monsoon (October to November) (Hagler Bailly Pakistan and SRK Consulting , 2010).

Based on the analysed data, rainfall is mostly received during the months of January to March (30 to 50%). The average highest rainfall occurs in February and the average lowest in September (see Figure 6-1). The MAP for the Project site is 32.7 mm. Following extreme rainfall events that occasionally occur during the pre-monsoon and/or the monsoon season, the Project area is prone to flooding.

The MAE calculated from pan evaporation data was determined to be 5026 mm, while the adjusted lake evaporation MAE was determined to be 2505 mm. Both values are extremely high compared to the observed MAP which confirm the very dry and extremely hot conditions for the area. As indicated in Figure 6-1 evaporation is higher during the months of April to October, a period when there is little to no rainfall.

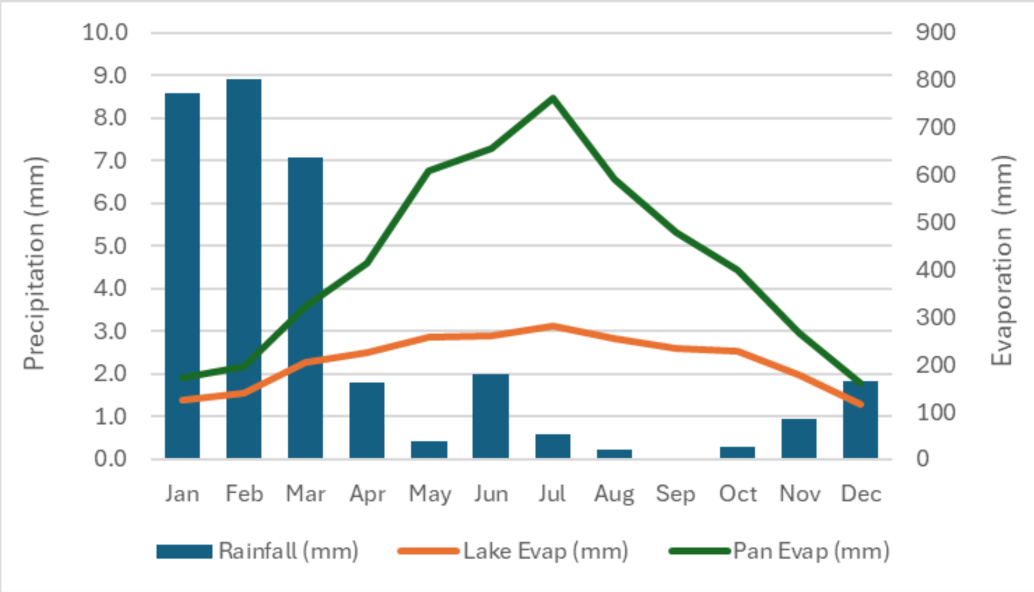
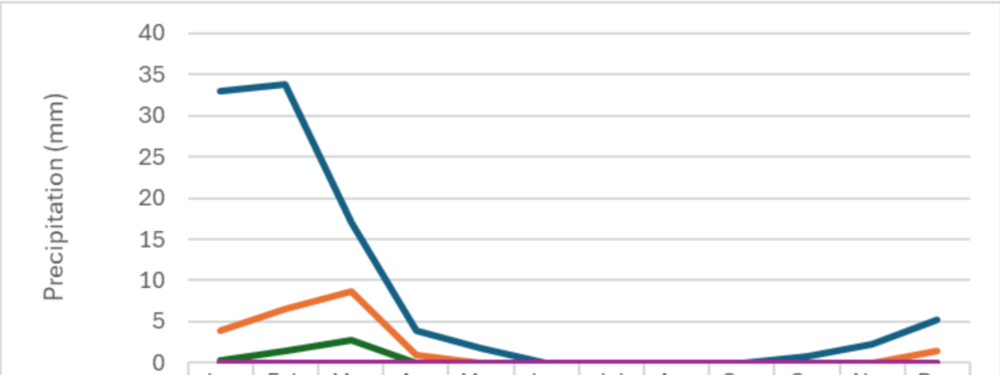


Figure 6-1: Monthly Average Precipitation and Evaporation

As illustrated in Figure 6-2, 90% of rainfall events in February are not expected to exceed 33.9 mm, while 90% of rainfall events during the driest month of September will be 0 mm.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
90%le	33.06	33.9	17.04	3.9	1.8	0	0	0	0	0.7	2.2	5.2
70%le	3.91	6.55	8.62	0.88	0	0	0	0	0	0	0	1.4
50%le	0.35	1.4	2.7	0	0	0	0	0	0	0	0	0
30%le	0	0	0	0	0	0	0	0	0	0	0	0
10%le	0	0	0	0	0	0	0	0	0	0	0	0

Figure 6-2: Rainfall Distribution

The maximum temperature that was recorded was in July with temperatures reaching a high of 39 ºC, while in January temperatures reached a low of 5 ºC. Figure 6-3 illustrates the monthly minimum and maximum temperatures that were observed at Reko Diq.

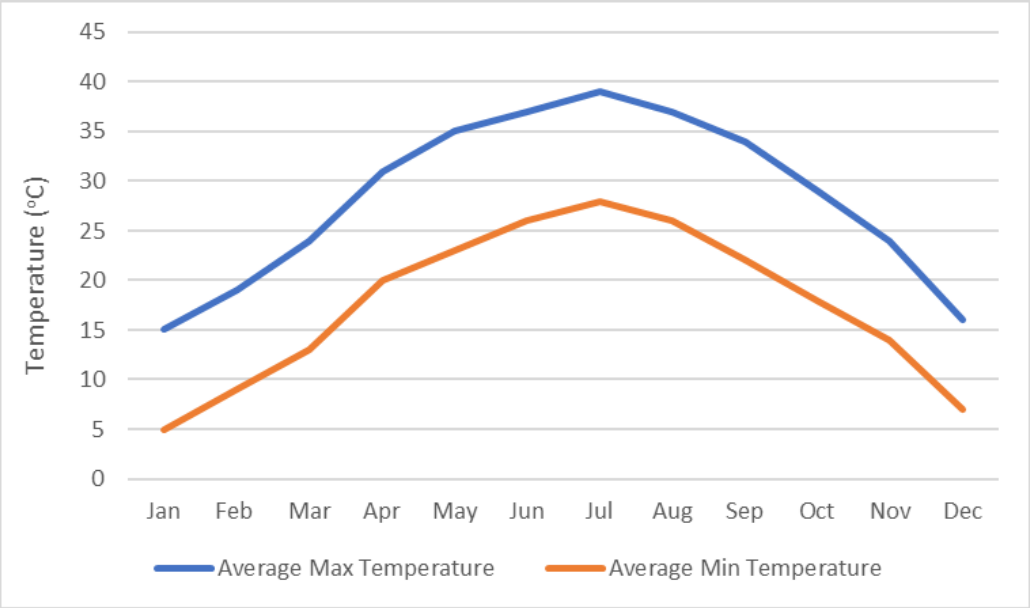


Figure 6-3: Monthly Minimum and Maximum Temperature

6.1.1. Drainage

Surface drainage lines at the RDMS are typically dry due to the very low rainfall (average annual precipitation is 32.7 mm based on climate records for the period 1983-2023 at Nok Kundi). Following high intensity storm events surface water may flow for a short distance and time before either evaporating or infiltrating to the ground.

The RDMS is located on a catchment divide between the Hamun-i-Mashkel Basin to the south and the Sistan Basin to the north. The Hamun-i-Mashkel Basin is the largest hydrological unit in Balochistan (catchment area of about 126,500 km^2) and is fed by the Baddo Rud, Tahlab, Rakhshan and Mashkel rivers (SRK, 2010).

Occasionally, following high intensity storm events characterised by heavy downpours, flooding occurs which carries with it massive sediment loads to downgradient areas. The hydrological setting of the Project area is presented in Figure 6-4.

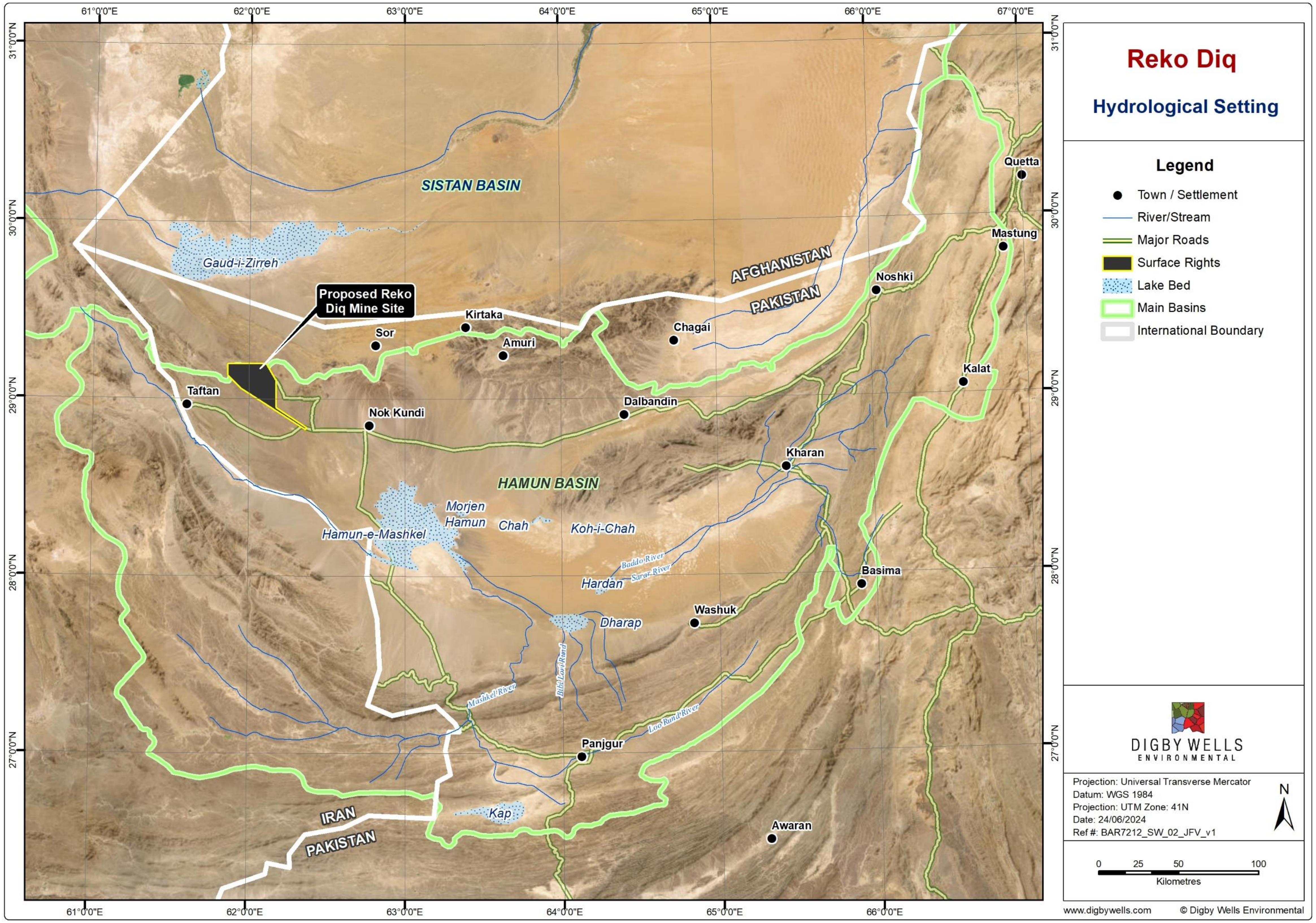
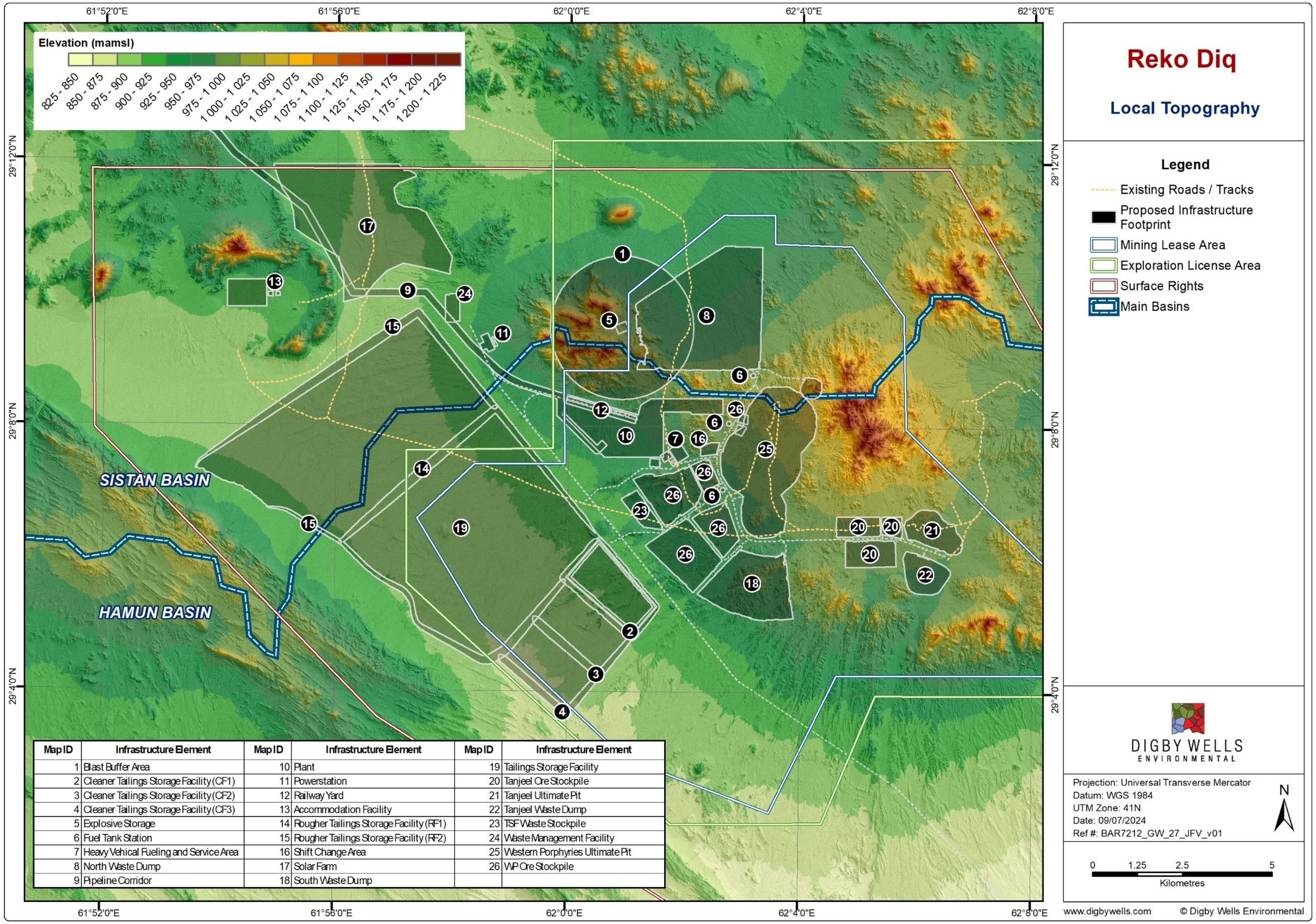


Figure 6-4: Hydrological Setting of the Reko Diq Project Site

6.1.2. Topography

The Project is located on the Balochistan Plateau, which is part of the western highlands of Pakistan, the RDMS is located within the caldera which forms part of the Chagai Hills (Hagler Bailly Pakistan and SRK Consulting , 2010). The Reko Diq region is one of the many eroded remnants of volcanic centres in the Chagai volcanic mountain chain. The topography of the area can be classified as having steep hilly slopes with an elevation ranging from approximately 850 to 1180 m.a.m.s.l. (Figure 6-5). The dominant topographic features consist of gravel plains, sandy plains and shifting sand dunes (Hagler Baily Pakistan, 2024).



Map ID	Infrastructure Element	Map ID	Infrastructure Element	Map ID	Infrastructure Element
1	Blast Buffer Area	10	Plant	19	Tailings Storage Facility
2	Cleaner Tailings Storage Facility (CF1)	11	Powerstation	20	Tanjeel Ore Stockpile
3	Cleaner Tailings Storage Facility (CF2)	12	Railway Yard	21	Tanjeel Ultimate Pit
4	Cleaner Tailings Storage Facility (CF3)	13	Accommodation Facility	22	Tanjeel Waste Dump
5	Explosive Storage	14	Rougher Tailings Storage Facility (RF1)	23	TSF Waste Stockpile
6	Fuel Tank Station	15	Rougher Tailings Storage Facility (RF2)	24	Waste Management Facility
7	Heavy Vehical Fueling and Service Area	16	Shift Change Area	25	Western Porphyries Ultimate Pit
8	North Waste Dump	17	Solar Farm	26	WP Ore Stockpile
9	Pipeline Corridor	18	South Waste Dump		

Figure 6-5: Local Topography

6.1.3. Water Quality

A hydrocensus survey was carried out within and around the RDMS which confirmed the absence of surface flows in the area. People in local settlements use water from different sources including dug wells, boreholes, and springs. No surface water quality was assessed as the drainage lines were dry during the hydrocensus surveys.

6.2. Stormwater Management Plan

This section describes the conceptual SWMP for the RDMS which ensures the separation of clean and dirty areas as shown in Figure 6-6.

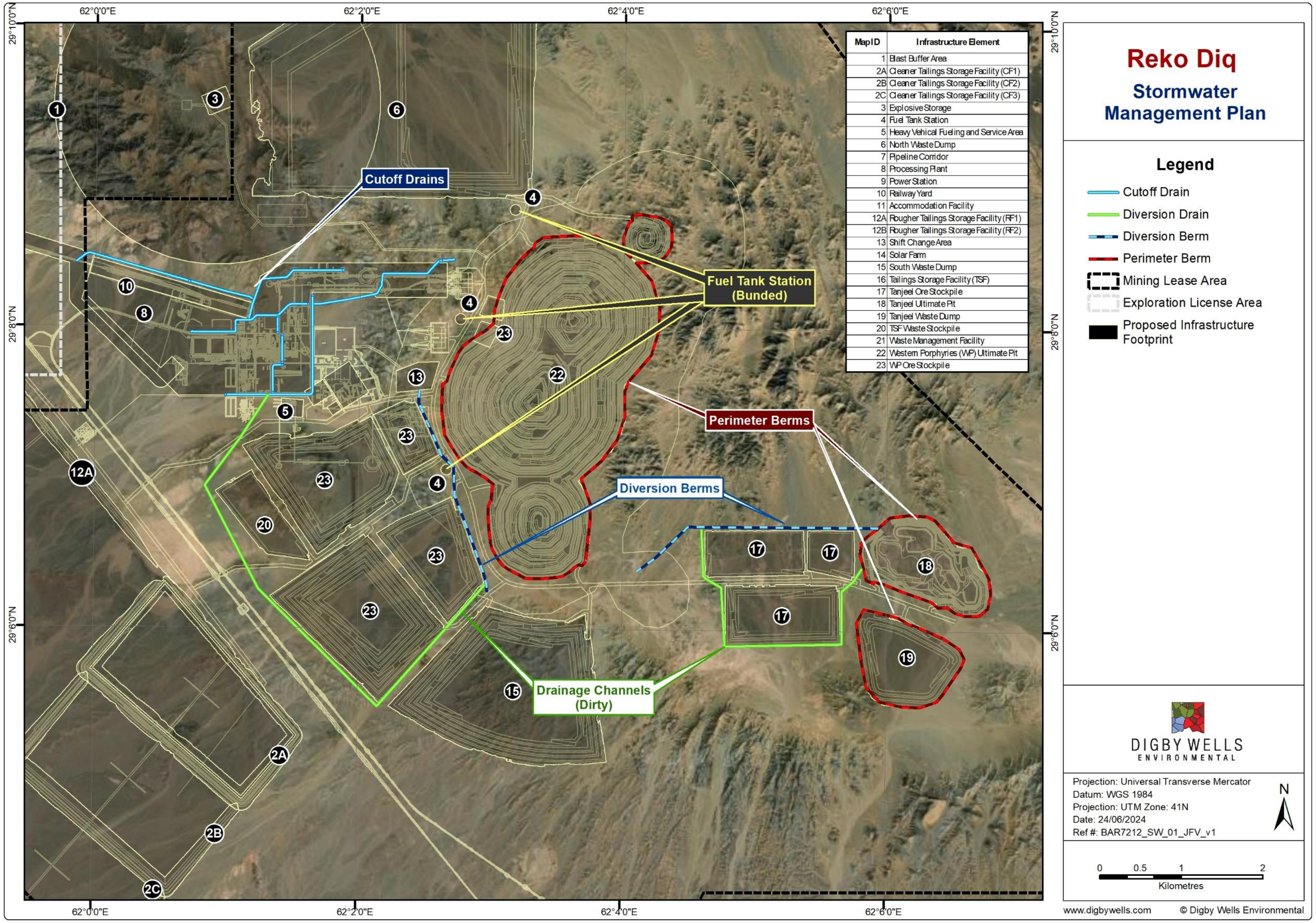


Figure 6-6: Reko Diq Mine Conceptual Stormwater Management Plan

6.2.1. Process Plant Storm Water Management

The SWMP for the process plant area is designed for a 1:100- year 24-hour event (Lycopodium, 2024). Simulated storm depths are presented in Table 6-1 (Knight Piesold , 2024a). Stormwater infrastructure will be designed for the 1:100-year return period event. However, as the mining area develops, infrastructure such as waste dumps and ammonium nitrate fuel oil (ANFO) facility will be constructed within upgradient areas thereby reducing the storm flow velocity. The Process Plant SWMP includes the following:

- Stormwater runoff from catchments upstream of the processing plant will be diverted around the plant area by earth drains;
- Stormwater runoff from both the upstream catchments and the plant area will be discharged into the environment from the south-west side of the plant area; and
- The stormwater runoff that will be discharged into the environment will flow under the road and rail into existing cut-off drains that are located between the rail and TSF.

Table 6-1: Storm Depths (100-year ARI) (Knight Piesold , 2024a)

Storm Duration (h)	Storm Depth (mm)
0.5	36.9
1.0	51.2
2.0	66.1
3.0	74.9
4.0	81.2
5.0	86.2
6.0	90.4
7.0	93.9
9.0	99.9
12.0	106.9
24.0	125.0

6.2.2. Tailings Storage Facility Water Management

The water management around the Rougher and Cleaner TSFs is outlined below (Knight Piesold Consulting, 2024c):

- Water in the slurry will be captured by the underdrainage of the Rougher TSFs and the pond area will be locally lined to minimise seepage to groundwater aquifers.
- Similarly, the Cleaner TSFs will have HDPE lining which is expected to prevent seepage to the groundwater domain.
- The final tailings beach surface of the Rougher TSFs is based on essentially a single point deposition located in the corner of each facility. The tailings will naturally deposit as an alluvial fan at approximately 1V:200H slope to the diagonally opposite corner where a low spot will form.

The TSFs closure Water Management Plan is described below (Knight Piesold Consulting, 2024c):

- The final tailings beach surface of each Cleaner Cell is based on full perimeter deposition occurring during operation. Each cell is divided in half (A and B) by the construction of a central wall where the final pond will be located.
- The closure hydrology design includes the spillway design, surface water runoff on the closure surface and downstream toe surface water management.
- The Rougher TSF closure spillways will be located at the centre of the south embankment for RF1 and the west corner at natural ground for RF2. A small ephemeral pool will be located immediately upstream of each closure spillway to collect sediment from the tailings surface and to attenuate flows before discharge. Some vegetation may begin to form in this area as a result of rainfall collection, but they will generally mimic the local dry lake beds. A rock lined channel will then convey runoff past the downstream toe of the embankment to the environment. The underdrainage system will continue to flow passively by gravity.
- A Cleaner TSF closure spillway will be located at the west corner of each cell to cascade excess flows from CF1 to CF2 to CF3. A final closure spillway from the CF3 facility to natural ground will consist of a rock lined drop chute structure with benches to suit the embankment downstream profile. The underdrainage system will be decommissioned by sealing the outlet pipe.
- The perimeter toe of the Rougher and Cleaner TSF embankments will consist of a small rock bund. This will prevent surface erosion of the toe, especially from upstream catchments to the northeast and provide some sediment control from the embankment runoff.

6.2.3. Mine Pits, Waste Rock Dumps, Ore Stockpiles and Heavy machinery Washbays Water Management

- Stormwater diversion drains will be installed to divert any clean water before it enters the Ore Stockpile areas.
- The mine pits will all have perimeter berms around them to prevent natural runoff entering the pits. Water collecting in the pits will be pumped to a central storage pond, from where it can be used within mine processes such as dust suppression; and

6.3. Water Balance

The site water balance is a combined balance incorporating all the environmental flows and planned water reticulation and infrastructure on site. Digby Wells was tasked with the development of a site wide water balance that incorporates the following inputs:

- Digby Wells - Environmental flows (runoff, direct rainfall, evaporation) for all the operational areas as well as the waste rock dumps (WRDs), stockpiles, open pit inflows (groundwater and rainfall) and tailings storage facility (TSF) footprints;
- Knight Piésold (KP) – The TSF water balance (Sawyer, 2024) was developed by KP for the first 10 years of operation. The outputs of the TSF model were provided to Digby Wells as the input into the larger water balance for the Environmental and Social Impact Assessment (ESIA); and
- Lycopodium (Lyco) – Lyco is responsible for the development of the detailed operational water balance focusing on the raw water requirements and the process water circuit. This also includes the potable water circuit for supply to the mine staff and the accommodation facility. Lyco provided the outputs from their water balance (Lycopodium, 2024) to Digby Wells to incorporate into the larger ESIA water balance.

It should be noted that the current water balance looks at the average conditions (rainfall and evaporation) for the site. In addition, a wet scenario has been simulated to provide an overview of what can be expected over a 12-month period at above average rainfall in line with what climate change predictions provided. Stormwater considerations and design of water infrastructure considering extreme events are detailed in the above-mentioned reports developed by KP and Lyco.

7. Water Balance Setup

The water balance was developed in Microsoft Excel and was developed for the first 11 years of operation from July 2028 to June 2038 to align with the TSF balance developed by KP. The balance was developed with monthly timesteps, and all volumes and flows are reported in m^3, m^3/month and m^3/annum.

Figure 7-1 shows the basic flow diagram developed for the setup of the water balance. The flow diagram shows the water lines and connections between facilities with only major flows considered. A more detailed flow diagram is outlined in the Lycopodium water balance (Lycopodium, 2024).

7.1. Assumptions and Constants

Table7-1 outlines some of the abbreviations used in the balance with Table7-2 and Table7-3 summarising the main assumptions, constants and data sources.

Table7-1: Abbreviations

Abbreviations	
Waste Rock Dump	WRD
Tailings Storage Facility	TSF
Raw Water Dam	RWD
Process Water Dam	PrWD
Waste Management Facility	WMF
Western Porphyry	WP

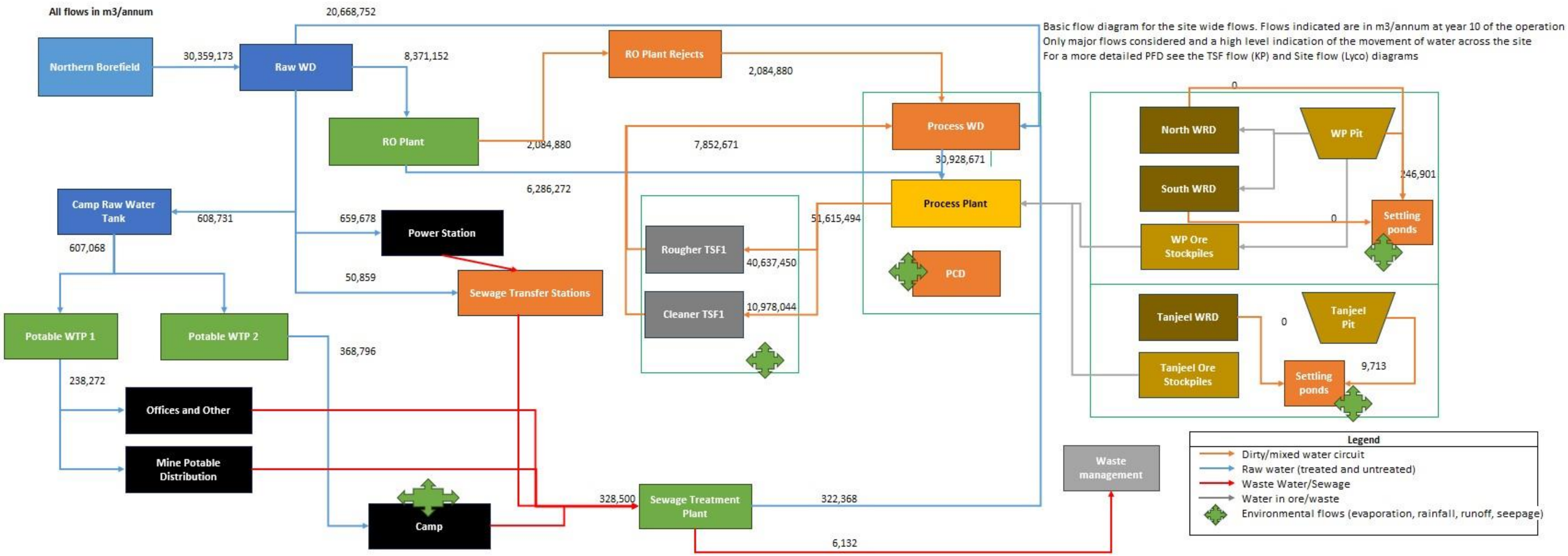


Figure 7-1: Basic flow diagram outlining the main flows and planned water infrastructure

Table7-2: Main assumptions and constants applied to the water balance

Facility/Flow	Unit	Value	Comment
Solar farm footprint	m^2	10,792,479	Obtained from site layout plan
North WRD footprint	m^2	9,898,981	Obtained from site layout plan
South WRD footprint	m^2	3,586,149	Obtained from site layout plan
Tanjeel WRD footprint	m^2	1,113,369	Obtained from site layout plan
Tanjeel stockpile footprint (combined)	m^2	2,015,900	Obtained from site layout plan
WP stockpile footprint	m^2	6,197,100	Obtained from site layout plan
Waste management facility footprint	m^2	313,825	Obtained from site layout plan
Process plant footprint	m^2	4,165,583	Obtained from site layout plan
Rough TSF Beach Area	m^2	13,884,053	Obtained from KP TSF Water Balance
Rough TSF Pond Area	m^2	200,146	Obtained from KP TSF Water Balance
Cleaner TSF Beach Area	m^2	1,997,416	Obtained from KP TSF Water Balance
Cleaner TSF Pond Area	m^2	89,268	Obtained from KP TSF Water Balance
Fuel Tank Station footprint	m^2	40,953	Obtained from site layout plan
Heavy Vehicle Fuelling & Service footprint	m^2	298,995	Obtained from site layout plan
Accommodation/Camp footprint	m^2	825,000	Obtained from site layout plan
RWD Capacity	m^3	400,000	Obtained from Lycopodium process water balance
RWD Surface Area	m^2	88,000	Obtained from Lycopodium process water balance
PrWD Capacity	m^3	70,000	Obtained from Lycopodium process water balance
PrWD Surface Area	m^2	24,200	Obtained from Lycopodium process water balance
Raw Water to Potable Water Treatment Plant (PWTP)	m^3/month	50,728	Obtained from Lycopodium process water balance - based on workforce and camp plan

Facility/Flow	Unit	Value	Comment
Raw Water to Power Station	m^3/month	4,238	Obtained from Lycopodium process water balance
Other Raw Water Demand	m^3/month	54,973	Obtained from Lycopodium process water balance
Raw Water to RO Plant	m^3/month	697,596	Obtained from Lycopodium process water balance
Raw Water to Process Water Make-up	m^3/month	1,722,396	Obtained from Lycopodium process water balance
Total Raw Water Demand	m^3/month	2,529,931	Calculation based on total personnel and process water demand
Dust suppression area	m^2	4,065,766	Conservative calculation - 25% of Plant area, haul roads (mine site only at 10km total), 25% of pit area, 25% solar farm area, 25% of camp area
Mine Water Dust Suppression	m^3/month	372,018	Assumption calculation based on 1L/m^2 (water only no additives) 3 times per day - Assumed to be from other sources (rejects/dewatering/treated sewage water)
Process Dust Suppression using process water (reused/recycled)	m^3/month	228,457	Crusher, dump pockets, conveyors, stockpile discharge and scrubbers - Lycopodium water balance
Process plant workforce	people	528	Obtained from Lycopodium process water balance
Mining/Mine Services Workforce	people	2,688	Obtained from Lycopodium process water balance
Power station	people	70	Obtained from Lycopodium process water balance
Total workforce	people	3,286	Calculation based on number of permanent personnel and estimated contract workers
Camp Residents - Operational period	people	3,275	Obtained from Lycopodium process water balance
Camp Residents - Construction period	people	9,300	Obtained from Lycopodium process water balance
Potable consumption - Operation Allowance	L/person/day	70	Obtained from Lycopodium process water balance
Potable consumption - Camp Allowance	L/person/day	300	Obtained from Lycopodium process water balance

Facility/Flow	Unit	Value	Comment
Open area runoff coefficient (average and below average rainfall)	factor	0.4	Average runoff coefficient - needs to be refined/calibrated once operational
Open area runoff coefficient (above average rainfall)	factor	0.6	Average runoff coefficient - needs to be refined/calibrated once operational
WRD runoff coefficient	factor	0.3	Average runoff coefficient - based on other Barrick mine site water balances
Solar plant runoff A	factor	0.4	Average runoff coefficient for open area assumed to be 40% of total footprint
Solar plant runoff B	factor	0.9	90% runoff coefficient on 60% of footprint to capture water falling on solar panels
Open Pit Runoff/Rainfall factor	factor	0.9	Direct rainfall and wall runoff for open pits

Table7-3: Other assumptions and data sources

Other Assumptions
It is assumed that all water storage facilities (dams/ponds) will be in place and operating from day 1 of operation
TSF water balance was completed by Knight Piésold (Knight Piesold, 2024) and that data was transferred into the site wide balance directly
The Knight Piésold TSF balance was conducted with 0 rainfall input. This has however been calculated separately in the balance as a separate flow line
Assumed all ponds/dams are lined with no seepage
Dewatering rates from the two pits was based on the provided mine plans
Process and potable water balance was completed by Lycopodium (Lycopodium, 2024) and the output was provided as input into the site wide balance
The water balance runs from July 2027 to June 2028. First 11 years of operation from the first processing month
Evaporation and rainfall data was sourced from Knight Piésold (Knight Piesold , 2024a) to align the site wide balance with the same climate data as the TSF design
WRD and stockpile footprints - entire footprint used from day 1 of operation as no current data on footprint sequence is available
Starting volume for the raw water dam and the process water dam was set at 0% of capacity
Raw water pumped into the raw water dam was set at 2% more than the required raw water volumes as a contingency. This will cause some overflow but will allow a full capacity dam to be maintained. Overflow can be directed to the PCD
Wet Rainfall Scenario – An above average rainfall scenario was simulated for a 12-month period. The climate change assessment indicated that at the end of LoM a 30% increase in annual rainfall can be expected. This equates to an increase from 32.7 mm/a to 42.5 mm/a. Further increases are expected beyond the LoM. As a result, the conservative approach was taken to simulate a wet rainfall year equivalent to a 1 in 10-year flood rainfall event based on the available rainfall data. This is equivalent to 81 mm/annum.

7.2. Rainfall Scenarios, Evaporation and Surface Runoff

Rainfall and evaporation data used by KP (Knight Piesold , 2024a) in the TSF model was applied to the water balance calculations. Daily rainfall records from 1983 to 2023 were used to calculate the average monthly rainfall for the site. The mean annual precipitation (MAP) applied to the water balance was 32.7 mm/annum and the mean annual evaporation (MAE) was 2 505 mm/annum. Monthly rainfall and evaporation over a 12-month period is shown in Figure 7-2.

An above average rainfall scenario (wet scenario) was simulated for a 12-month period. The climate change assessment indicated that at the end of LoM a 30% increase in annual rainfall can be expected. This equates to an increase from 32.7 mm/a to 42.5 mm/a. Further increases are expected beyond the LoM. As a result, the conservative approach was taken to simulate a wet rainfall year equivalent to a 1 in 10-year flood rainfall event based on the available rainfall data. This is equal to 81 mm/annum (Figure 7-2).

A dry scenario has not been simulated. The water supply security is based on current estimates of aquifer availability and conservatively assume negligible recharge from rainfall. As a result, the impact of a dry period on the operation is not expected to be significant.

Runoff coefficients for surface runoff from open areas as well as dumps and ponds were applied to the model to evaluate the expected stormwater volumes. For open surface areas, for example the process plant area, a 0.4 runoff coefficient was applied. For waste rock dumps and stockpiles a 0.3 runoff coefficient was applied. However, for waste dumps a study completed by Geosystems (Milczarek, 2009) showed that due to the high evaporation it is likely that little to no surface flow will report from the waste dumps thus the water balance model can be considered conservative.

For lined facilities a factor of 1 was applied (direct rainfall) and for the open pit areas a factor of 0.9.

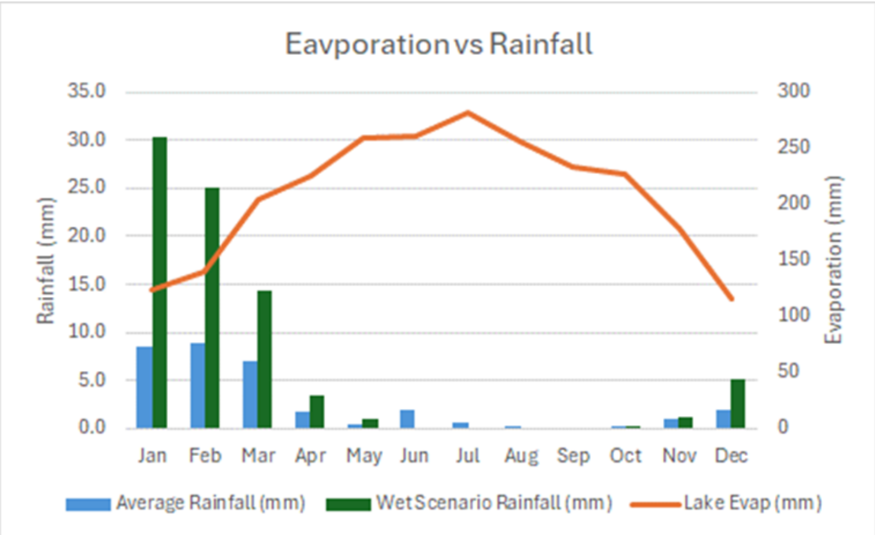


Figure 7-2: Climate Data

7.2.1. Water Balance Results

The following summary of the water balance calculations and results:

- Raw Water
  - A total raw water demand of 2.53 Mm^3/month is required for the operation;
  - The raw water will be supplied from the well field being developed for the project and will be primarily groundwater.
  - The total raw water demand includes potable water, power station, process plant make-up water and mine services;
  - Dust suppression is excluded as it is assumed that other water sources (treated sewage water, dewatering) will be used;
  - A portion of the raw water will be treated through the potable water treatment plant for human consumption and another portion will be treated through a dedicated RO plant for the volume of water required by the process at better quality than what it is received at;
  - Raw water sent directly to the process plant to be used without treatment is 1.72 Mm^3/month for process make-up water requirements. An additional 697 596 m^3/month will be sent to the RO plant for treatment and then distributed to the various processes; and
  - A dedicated raw water dam will be constructed with a capacity of 400 000 m^3.
- Process Water
  - A process water dam with a capacity of 70 000 m^3 will be constructed and will received worked water (water that has already been used in a task) from the process circuit;
  - The process water dam will be a mixed water facility that receives both raw water and process water (worked water);
  - The process water dam will receive RO plant reject water, treated sewage water, raw water directly from the raw water dam (untreated) as well as decant return water from both the rougher and cleaner TSF facilities;
  - Water from the process plant will be sent directly to the process plant for use in the various processes;
  - The total inflow into the process water dam is 2.71 Mm^3/month and all of this water will be used and this includes recycled return water from the TSF; and

- WRD
  - Calculated runoff from the WRDs is:
    - South WRD = 35 185 m^3/annum;
    - North WRD = 97 123 m^3/annum; and
    - Tanjeel WRD = 10 924 m^3/annum.
  - Calculated runoff from the WRDs under the wet rainfall scenario are:
    - South WRD = 86 885 m^3/annum
    - North WRD = 239 833 m^3/annum
    - Tanjeel WRD = 24 830 m^3/annum
  - A comparison of the above-mentioned volumes over a 12-month period is shown in Table 7-4
  - Due to the nature of the material that will be placed on the dumps, the study completed by Geosystems indicated that minimal infiltration into the dumps will occur due to the high evaporation rates and that any flow (seepage) through the dumps will be minimal and slow to daylight (100 years or more after closure). The lateral flow or runoff along the surface of the dumps will be in the ranges shown above, however, all the water will likely evaporate and only a small volume will report to the stormwater infrastructure during high intensity, above average rainfall events.
- TSF
  - The TSF balance is discussed in detail in the KP report (Sawyer, 2024) and as such is only summarised in this report;
  - The Rougher TSF (1 and 2) pools will be kept at a constant volume of 200 000 m^3. The decant return rate from the Rougher TSF will on average be 2.8 Mm^3/annum.
  - The Rougher TSF will be unlined and seepage from the facilities is expected to range between 9 595 m^3/month and 33 865 m^3/month as the depositional area and the area of the pool increases over time;
  - The Cleaner TSFs will be lined and no seepage is expected. The pool volumes on the Cleaner TSFs will be kept at a constant 50 000 m^3 over each facilities life with a decant return water volume of approximately 1.18 Mm^3/annum; and
  - Rainfall and runoff contributions onto the TSF footprints under average rainfall will be 70 894 m^3/annum. This water will contribute to the process circuit and be used in the process through the decant return lines in addition to the super natant portion.

- A comparison against the rainfall and runoff contribution under average vs wet conditions are shown in Table 7-5. The current TSF design does cater for a probable maximum precipitation (PMP) event and as a result the volume under an annual wet scenario will not impact the operation of the TSFs.

- Dust Suppression
  - In total approximately 600 475 m^3/month water will be required for dust suppression (conservatively assuming no additives or dust suppressing chemicals);
  - Dust suppression on hall roads and other operation areas will require 372 018 m^3/month; and
  - Process water from the process water dam will be used for conveyor belts, crushers, scrubbers, stockpile discharge areas and dump pockets and will require 228 457 m^3/month.
- Dewatering
  - Dewatering rates were sourced from the dewatering model that is in the process of being developed.
  - Groundwater contribution into the open pit (Western Porphyry only for the first 10 years of operation) will peak at 14 427 m^3/month with the rainfall contribution fluctuating over the year and will range between 0 and 22 389 m^3/month in year 10. Rainfall contribution to the dewatering volume will increase as the size and footprint of the pit increases; and
  - Please refer to the groundwater specialist report for more detailed analysis of the dewatering rates.

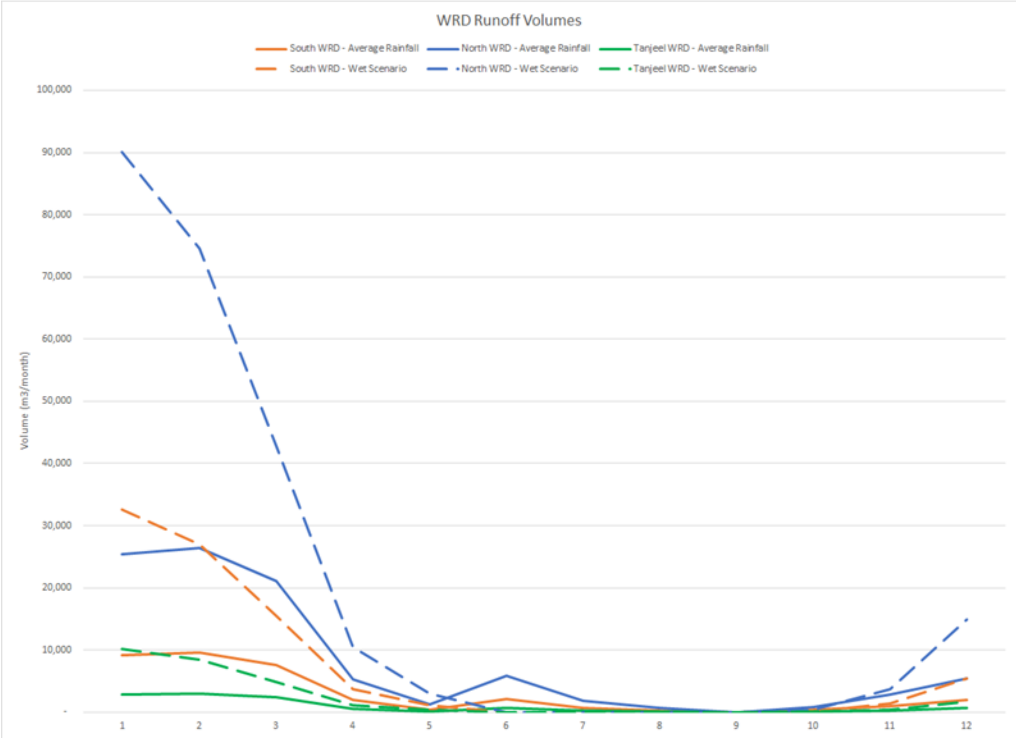


Table 7-4: WRD Runoff

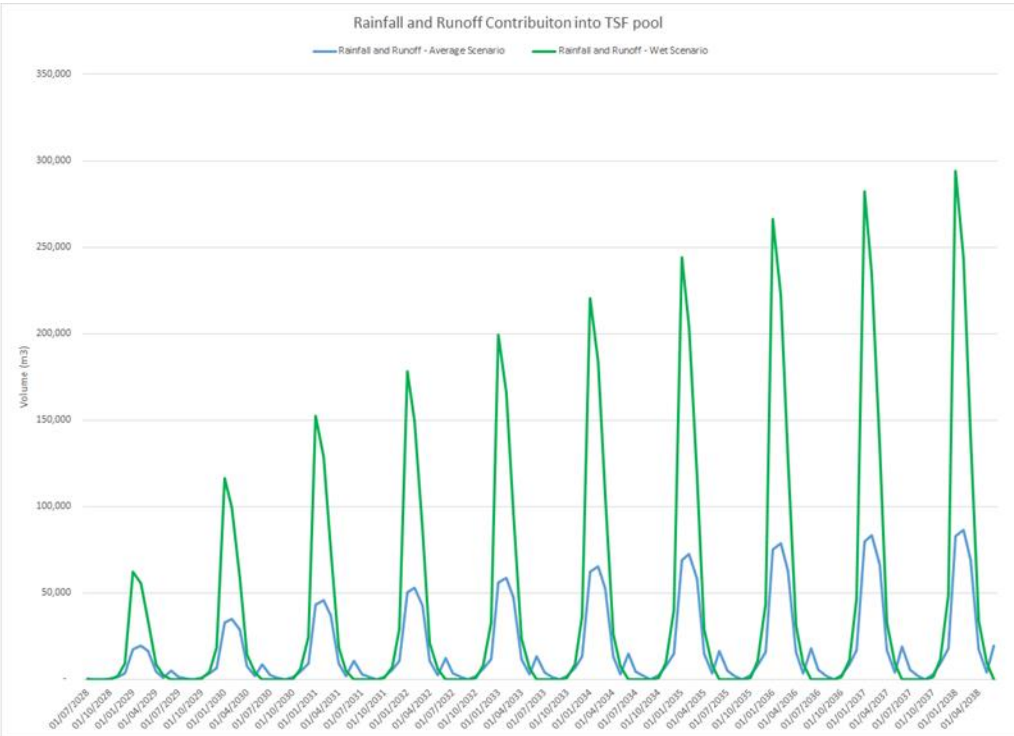


Table 7-5: TSF rainfall and Runoff Volumes

7.2.2. Water Management Plan

Raw water from the raw water storage pond will be pumped to the centralised potable water treatment plant, the process water make-up pond and the camp raw water storage tank. Raw water will be supplied to the accommodation village, plant site, workshops, buildings, and site water treatment plant (Lycopodium, 2024).

Raw water will be transferred to a lined process water pond where it will be contained for 24 hours for storage. Raw water will then be transferred to the storage tank at the process plant. Recycled water from the process plant, the sewage treatment plants, storm water run-off collection ponds, reject water, the mill freshwater tank and the rougher tailings dewatering plant will also be transferred to the process water pond.

Oily water that will be generated from plant workshops, lubricant store, fuel storage facility and washdown facility will be collected and treated at an oily water treatment facility where both waste oil concentrate and treated oily water will be produced. The treated oily water will then be used for dust suppression.

8. Impact Assessment

This section rates the significance of the potential impacts of pre-mitigation and post-mitigation. The following activities listed in Table 8-1 are the activities that will potentially affect surface water resources.

Table 8-1: Summary of Project Activities

Phase	Activity
Construction	• Vegetation clearance and topsoil removal (stockpiled for rehabilitation use) land preparation for construction of infrastructure including the accommodation camp, road and powerline; • Excavation and backfilling of substrate during construction of a water supply pipeline from the Fan Sediments to RDMC, road and supporting infrastructure; • Construction of surface infrastructure which include the WTP, access roads, storage facilities, and accommodation camps; and • Use of vehicles and machinery during construction.
Operational	• Mining and extraction of gold and copper ore; • Transportation of mine material to the processing facilities for production high-quality copper-gold concentrate; • Operation and maintenance of the processing plant;

	• Transporting of tailings through a pipeline to the TSF southwest of pit; • Transportation of ore and waste rock from the open pit to the crushers, ore stockpile processing plant and WRD; and • Operation and management of open storage facilities such as the stormwater holding ponds, wastewater sump, settling bays and clean water sumps.
Decommissioning, Rehabilitation and Post Closure	• During decommissioning of the cells and the TSF, NAG coarse waste rock will be placed on the tailing surfaces; • Construction of a spillway on the southern embankment of the TSF to allow for discharge; and • Decant systems will be decommissioned and closed.

8.1. Construction Phase

Activities during the Construction Phase may have potential impact on surface water resources Table 8-2.

Table 8-2: Interactions and Impacts of Activities During the Construction Phase

<table>
<tr><th>Interaction</th><th>Impact</th></tr>
<tr><td>Vegetation clearance and topsoil removal (stockpiled for rehabilitation use) land preparation for construction of infrastructure including the accommodation camps, roads powerline.</td><td rowspan="3">Alteration of flow paths patterns and channel geometry leading to increased sedimentation and siltation of nearby watercourses or drainage lines</td></tr>
<tr><td>Excavation and backfilling of substrate during construction of pipeline, road and supporting infrastructure.</td></tr>
<tr><td>Construction of surface infrastructure which includes the WTP, access roads, storage facilities, and accommodation camp.</td></tr>
<tr><td>The use of vehicles and machinery during construction.</td><td></td></tr>
</table>

8.1.1. Impact Description: Alteration of flow path patterns and channel geometry leading to increased sedimentation and Siltation of Nearby Watercourses or Drainage Lines

Site clearance and excavation for surface infrastructure construction and pipeline installation will disturb soils will alter the natural topography and drainage patterns within the project area, and likely influencing increased chances of erosion and sediment mobilisation into nearby watercourses or drainage lines. Temporary stockpiling of stripped soils excavated along the pipeline route and from other infrastructure footprint areas will create sources of sediment which can be mobilised by wind and water to nearby watercourses.

8.1.1.1. Management Objectives

Management objectives for the construction phase are the following:

- To limit clearance of vegetation cover and removal of topsoil to the immediate Project footprint;
- To limit disturbance of soils to construction footprint areas where applicable, as much as practically possible; and

8.1.1.2. Management Actions

- Minimise the footprint of disturbance, as far as practical;
- Restore/ reprofile disturbed areas where the pipeline will be buried;

8.1.1.3. Impact Ratings

The tables below (see Table 8-3) indicate the impact ratings and the significance of the activities during the construction phase.

Table 8-3: Impact Ratings (Before and After Mitigation Measures) of Vegetation Clearance and Topsoil Removal

Dimension	Rating	Motivation	Significance
Activity and Interaction: Vegetation clearance, topsoil removal, excavation and land preparation for construction of infrastructure.			
Impact Description: Alteration of flow paths patterns and channel geometry leading to increased sedimentation and siltation of nearby watercourses or drainage lines.			
Prior to Mitigation/Management			
Duration	3	Medium term: 2 to 5 years	Moderate (negative) - 45
Extent	2	Local: Extending across the site and to nearby settlements. Sub-division of a district.	
Intensity	4	Serious long term environmental effects. Environmental damage can be reversed in less than a year.	
Probability	5	Certain / Definite: There are sound evidence-based reasons to expect that the impact will definitely occur (90-100%)	
Nature	Negative		
Mitigation/Management Actions			

Dimension	Rating	Motivation	Significance
Activity and Interaction: Vegetation clearance, topsoil removal, excavation and land preparation for construction of infrastructure.			
• Minimise the footprint of disturbance, as far as practicable. Demarcate the proposed areas for land clearance and earthworks to minimise the unnecessary expansion of the footprint of disturbance; • Where practical, land clearance and earthwork activities must be undertaken during the dry period when proximal watercourses are dry; • Keep the topsoil stockpile with a vertical slope of 1:3 to minimise chances of erosion; • Provide suitable sanitary facilities and remove waste to an appropriate waste facility; • Install effective sediment and erosion control measures before starting work to minimise mobilisation of sediment into watercourse; • Clearing of vegetation and excavations must be limited to the development footprint, and the use of any existing access roads must be prioritised to minimise creation of new ones. This will minimise chances of soil disturbance and subsequent soil erosion. • Disturbed areas remaining after construction activities should be rehabilitated in a timely manner as much as practically possible; and • Due to the dry nature of the Project area monitoring of total suspended solids (TSS), TDS and turbidity in surface water resources in close proximity to the project site may not be practically possible. However, when conditions permit such monitoring is recommended upstream and downstream of construction areas to facilitate the prompt implementation of remedial actions, if necessary			
Post-Mitigation			
Duration	2	Short term: Up to 2 years.	Minor (negative) -25
Extent	1	Site Specific: Limited to the site and its immediate surroundings.	
Intensity	2	Moderate, short-term effects but not affecting ecosystem function. Rehabilitation requires intervention of external specialists and can be done in less than a month.	
Probability	5	Certain / Definite: There are sound evidence-based reasons to expect that the impact will definitely occur (90-100%)	
Nature	Negative		

8.2. Decommissioning, Rehabilitation and Post Closure Phase

Activities during the decommissioning phase that may have potential impact on surface water resources (Table 8-4).

Table 8-4: Interactions and Activities During the Decommissioning Phase

Interaction	Activity
• During decommissioning of the cells and the TSF, NAG coarse waste rock will be placed on the tailing surfaces; • Movement of vehicles and machinery during demolition and removal of infrastructure; • Construction of a spillway on the southern embankment of the TSF to allow for discharge post closure; • Rehabilitation of disturbed areas; and • Possible Acid Mine Drainage (AMD)	• Increased sedimentation and siltation of surface watercourses or drainage lines resulting from erosion of disturbed soils during demolition and removal of infrastructure; •

8.2.1. Impact Description: Increased sedimentation and siltation of surface watercourses resulting from erosion of disturbed soils during demolition and removal of infrastructure

Disturbance of soils through demolition and removal of surface infrastructure may increase the rate of soil erosion.

8.2.1.1. Management Objectives

- To control soil erosion and sedimentation during rehabilitation processes;

8.2.1.2. Management Actions

The following management actions are recommended:

- Minimise disturbance of soils to the infrastructure demolition footprint, as much as practically possible;
- Maintain the sediment and erosion control measures in place until the completion of demolition and rehabilitation activities;
- Reprofile the rehabilitated areas to achieve the desired post-mining land use;

8.2.1.3. Impact Ratings

The tables below (Table 8-5) indicate the impact ratings and the significance of the activities during the decommissioning, rehabilitation and closure phase.

Table 8-5: Impact Ratings (Before and After Mitigation Measures) for the Decommissioning of Surface Infrastructure

Dimension	Rating	Motivation	Significance
Activity and Interaction: Decommissioning of surface infrastructure.			
Impact Description: Increased sedimentation and siltation of surface watercourses resulting from erosion of disturbed soils during demolition and removal of infrastructure.			
Prior to Mitigation/Management			
Duration	3	Medium term: 2 to 5 years	Minor (negative) -32
Extent	2	Local: Extending across the site and to nearby settlements. Sub-division of a district.	
Intensity	3	Moderate, short-term effects but not affecting ecosystem function.	
Probability	4	Likely: The impact may occur (50-90%)	
Nature	Negative		
Mitigation/Management Actions			
• Minimise the disturbance of soils to the footprint where demolition of infrastructure will be taking place; • Movement of demolition machinery and vehicles should be restricted to designated access roads to minimise the extent of soil disturbance and subsequent erosion; • Maintain the sediment and erosion control measures in place until the completion of demolition and rehabilitation activities to minimise entry of sediment into watercourses; and • Landscape re-profiling to be undertaken to rehabilitate disturbed sites and to allow free drainage that promotes the desired post mining land use.			
Post-Mitigation			
Duration	2	Short term: Up to 2 years.	Negligible (negative) -12
Extent	1	Site Specific: Limited to the site and its immediate surroundings.	
Intensity	1	Minor effects on biological or physical environment.	

Dimension	Rating	Motivation	Significance
Activity and Interaction: Decommissioning of surface infrastructure.			
Probability	3	Probable: Has occurred here or elsewhere and could therefore occur (20-50%)	
Nature	Negative		

9. Unplanned and Low Risk Events

The unplanned and low risk events are described in Table 9-1.

Table 9-1: Unplanned and Low Risk Events

Unplanned Risk	Mitigation Measures
• Accidental spills (Hydrocarbons / Chemicals)	• Develop and implement suitable spill response procedures; • Construction workers should be trained on standard procedures for the transport, handling, use and disposal of hydrocarbons; • Spill kits should be maintained in all locations where hydrocarbons are used or stored; • All vehicles should be properly maintained and inspected regularly to avoid leakages of grease, oil and fuel; • Washing and servicing of vehicles and machinery should be undertaken at designated, appropriately designed areas; • Vehicles and machinery must be used on demarcated roads and kept at designated parking areas. • Drip trays or plastic sheeting must be used when vehicles break down outside of designated workshop or service areas; • Waste must be discarded in designated waste storage areas; • All storage areas for fuels and oils used during the construction phase should be appropriately bunded and spill kits should be in place. Onsite personnel should be trained to use spill kits, for containing and cleaning up any leakages or spills of fuels, oils and grease; • Administer effective and timely clean-ups in the event of spillages occurring; • Oil and grease collection traps need to be cleaned and emptied to prevent overflow and need to be maintained in good working order. The condition of the oil and grease collection traps must be included in the annual audit checks; • Ensure that the infrastructure (e.g., pipelines, fuel storage areas) are first emptied of all residual material before decommissioning; and

Unplanned Risk	Mitigation Measures
	• Train mine personal and contractors to use the proper site methodology in reporting, handling and disposing of hydrocarbon and chemical waste according to the safety data sheets (SDS) guidelines.

10. Climate Change Projections and Considerations

To assess projected trends in climate and adequately assess future climate risk, it is necessary to look at global climate models such as the Coupled Model Intercomparison Project Phase 6 (CMIP6). The CMIP6 dataset considers five Shared Socio-economic Pathways (SSPs), each representing different potential emissions scenarios in relation to different global climate change responses (Digby Wells, 2024).

This section of the report presents the projected design rainfall depths as a result of climate change impact, these climate analyses were determined using SSP2-4.5 and SSP5-8.5. Table10-1 below compares temperature variables for the Project area across two emissions scenarios, SSP2-4.5 and SSP5-8.5. When compared to a historic baseline, all temperature variables are projected to increase across each future time-period under both scenarios.

Table10-1: Temperature Projections*
(SMHI, 2023; The World Bank, 2024)

Climate Variable	Scenario	Reko Diq Mine				
		Baseline (1981-2010)	**2011-2040**	**2041-2070**	**2071-2100**	**Trend**
Mean Temperature	SSP2-4.5	22.98°C	+ 1.09°C	+ 2.11°C	+ 2.94°C	↗
	SSP5-8.5		+ 1.25°C	+ 2.86°C	+ 5.11°C	↗

The Clausius-Clapeyron equation was used to estimating the increase in design rainfall depth using the above temperature changes, and the rainfall scaling factor (R) as proposed by Wasko et al. (2023). The Clausius-Clapeyron equation is presented as follows:

$$Future\ Design\ Rainfall = Present\ Design\ Rainfall \times \left(\frac{100+R}{100}\right)^{\wedge Temperature\ Change}$$

The values of R that correspond to various storm durations are shown in Table 10-2.

Table 10-2: Rainfall Scaling Factors

Storm Duration	≤1 hr	2 hr	3 hr	6 hr	9 hr	12 hr	18 hr	≥24 hr
R (%)	15.0	14.7	14.4	13.5	12.6	11.7	9.8	8.0

There is a notable increase in design rainfall depth for the 1:50 year and 1:100-year recurrences on various time intervals, regardless overall values remain relatively low. This could exacerbate some of the identified impacts for the proposed mine, particularly on surface water and stormwater management. The occurrence of high intensity extreme storm events are confirmed by the 2022 floods that happened in Balochistan causing damages accounting for 15 percent of the recovery and reconstruction needs (UNDP, 2024). According to the UNDP, Balochistan experienced unprecedented levels of rainfall, surpassing typical monthly averages by sevenfold and this has been attributed to climate warming of estimated 1.2°C, resulting in approximately 75 percent more intense five-day rainfall (UNDP, 2024). It is important to note the following impacts this could have on the RDMS:

- An increase in design rainfall depth indicates that storm events are expected to become more intense, leading to greater volumes of water being generated as surface runoff. Consequently, this results in larger and high velocity flows, altering natural flow paths.
- The planned stormwater infrastructure, such as channels, dams or ponds, may be undersized for these more intense rainfall events. This could lead to overflows and flooding, especially during extreme weather events.
- While intense flash flooding could lead to potential contamination of downstream water bodies with mobilised chemicals and other pollutants, flash floods could also result in a damage to the mine infrastructure.

It is important to carefully consider possible and practical adaptive management measures to mitigate the risks on both the mining operation and the surrounding environment through an adaptive water management approach.

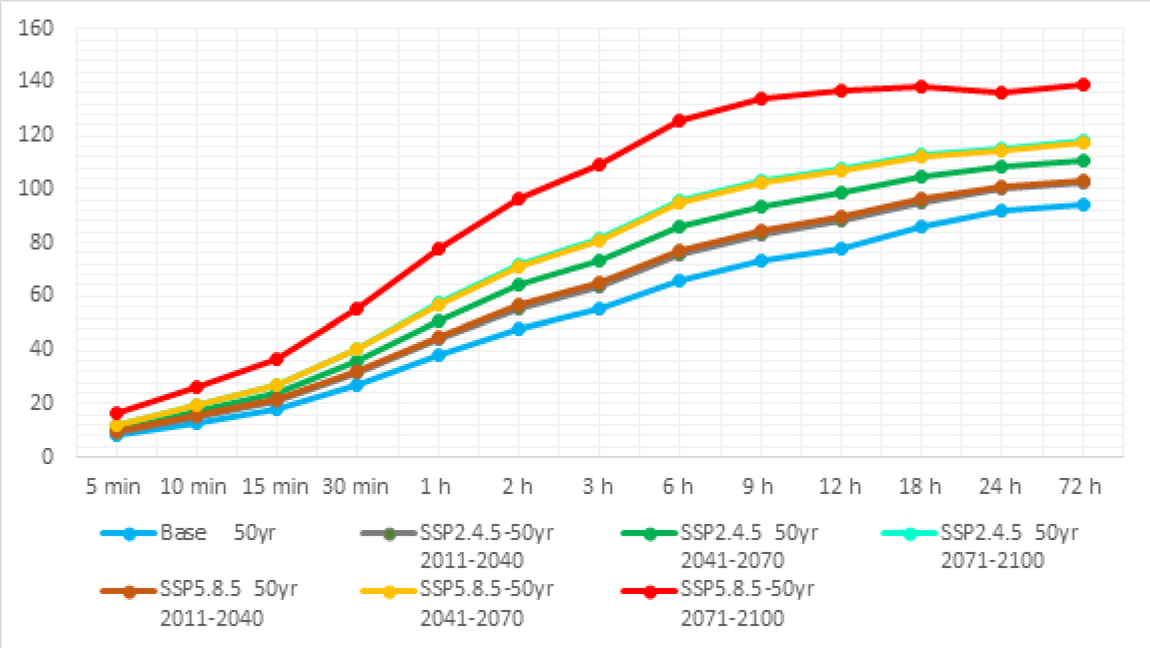


Figure 10-1: Adjusted Rainfall Event - 1:50yr Recurrence Interval

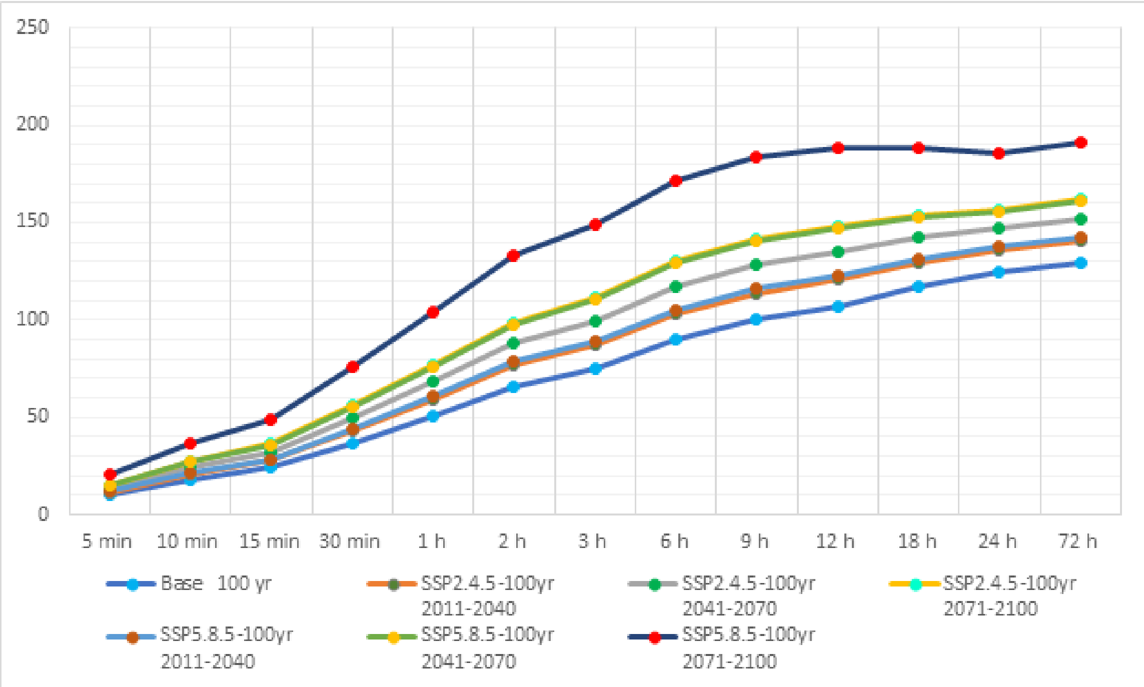


Figure 10-2: Adjusted Rainfall Event - 1:100yr Recurrence Interval

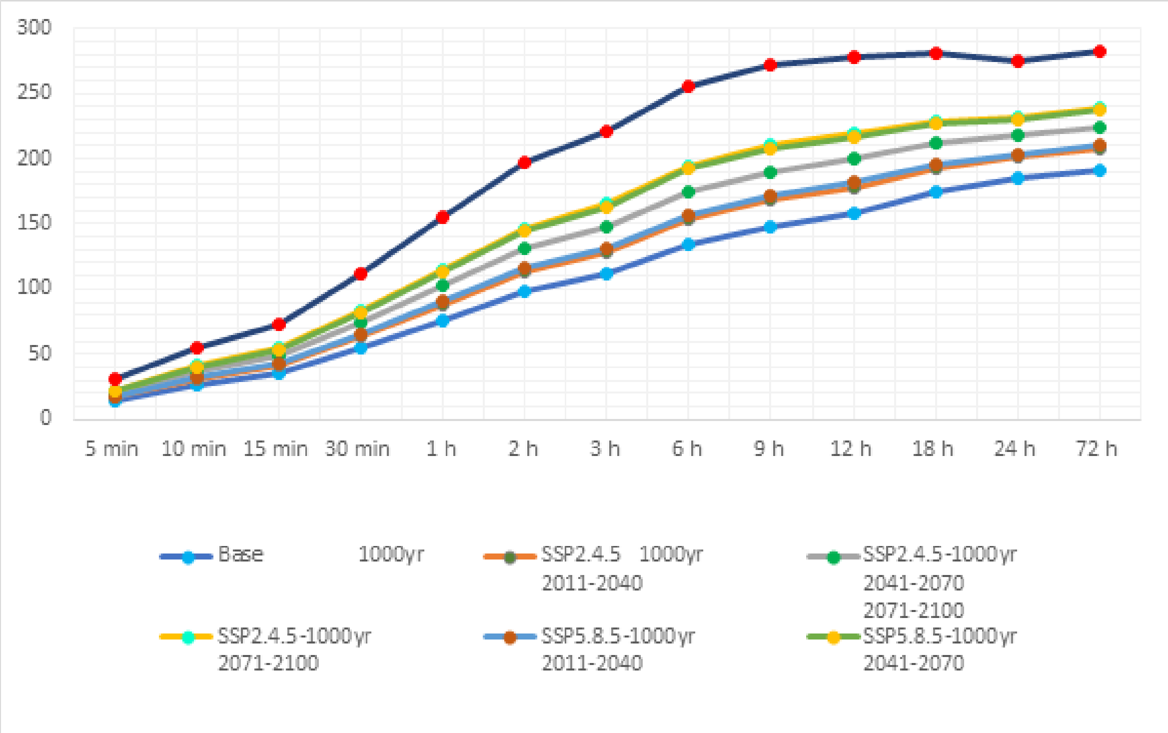


Figure 10-3: Adjusted Rainfall Event - 1:100yr Recurrence Interval

11. Environmental Management Plan

The Environmental Management Plan (EMP) for the Construction, Operational and Maintenance, Decommissioning, Rehabilitation and Closure Phase is tabulated below in Table 11-1.

Table 11-1: Environmental Management Plan

Activity/ies	Aspects Affected	Impacts/Risks	Mitigation Measure	Mitigation Type	Time period for implementation
Construction Phase					
• Vegetation clearance and topsoil removal (stockpiled for rehabilitation use) land preparation for construction of infrastructure including water line, road powerline installation • Excavation and backfilling of substrate during construction of pipeline, road and supporting infrastructure; • Construction of surface infrastructure which include the WTP, access roads, storage facilities, accommodation camps; • Use of vehicles and machinery.	• Surface watercours es	• Alteration of flow path patterns and channel geometry; and Contamination of soil and water resources due to accidental spills and releases of fuels, solvents, oils, and chemicals, and disposal of waste.	• Where practical, land clearance and earthwork activities must be undertaken during the dry season; • Reprofile disturbed areas where the subsurface pipeline will be installed; • Install erosion control measures before construction of any infrastructure; • Construction workers should be trained on standard operating procedures for the transport, storage, handling, use and disposal of hydrocarbons, chemicals and general waste; • All storage areas for fuels and oils used during the construction phase should be appropriately bunded and spill kits should be in place; • Inspection, washing and servicing of vehicles and machinery should be undertaken at designated areas to avoid leakages and spills elsewhere within the mine site; • Provide suitable sanitary facilities and remove waste to an appropriate waste facility; • Install effective sediment and erosion control measures before starting construction work to minimise mobilisation of sediment into watercourse; • Clearing of vegetation and excavations must be limited to the development footprint, and the use of any existing access roads must be prioritised to minimise creation of new ones. This will minimise chances of soil disturbance which accelerates soil erosion and subsequent sedimentation and siltation of watercourses; • Disturbed areas remaining after construction activities should be rehabilitated in a timely manner as much as practically possible; and • Due to the dry nature of the Project area surface water monitoring of near the project site may not be practically possible. However, when conditions permit such monitoring is recommended upstream and downstream of the Project site to facilitate the prompt implementation of remedial actions, if necessary.	• Control by adhering to construction design plan; and • Control through water quality monitoring, where feasible.	• Construction Phase
Operational Phase					
• Mining and extraction of gold and copper ore • Transportation of mine material to the processing facilities for production of	• Surface water quality and quantity	• Mobilisation of contaminants in stormwater runoff which may lead to contamination	• Limit movement of vehicles and people only to designated routes; • Inspection and maintenance of operational vehicles should be conducted regularly; • Construction workers should be trained on standard procedures for the transport, handling, use and disposal of hydrocarbons;	• Control through management and monitoring; • Control through soil erosion management measures;	• Operational and Maintenance phase

Activity/ies	Aspects Affected	Impacts/Risks	Mitigation Measure	Mitigation Type	Time period for implementation
high-quality copper-gold concentrate; • Transporting of tailings through a pipeline to the TSF southwest of pit; • Operation and maintenance of the processing plant; • Transportation of ore and waste rock from the open pit to the crushers, ore stockpile processing plant and WRD; and • Operation and management of open storage facilities such as the stormwater holding pond, wastewater sump, settling bays and clean water sumps.		of water resources	• Dispose of all general and hazardous waste into proper onsite waste bins; • Monitoring of the quality of water resources, where feasible, should continue within and around the Project area; • Regularly maintain sediment control structures and wastewater sumps to ensure they have adequate capacity to capture runoff and sediments and prevent overflow; • Ensure that stockpiles are placed in suitable locations and are appropriately protected to minimise erosion and evacuation of unconsolidated materials into watercourses; • Regular inspection for occurrence of erosion should be conducted, especially after rainfall events, and maintenance should be implemented once incidences of erosion, berm breaches or damages to stormwater drains are noticed; • Movement of vehicles and machinery should be confined to designated haul and access roads; and • Monitoring the quality of water resources, where feasible, should continue to detect any potential sources of pollution; • Runoff from dirty areas should be directed to the stormwater management infrastructure and should not be allowed to flow into the natural environment; • Overall housekeeping and maintenance of stormwater infrastructure (including berms, de-silting of dams and clean-up of leaks) must be adhered to throughout the life of mine; • Fuel and hazardous material storage areas must be located on hard standing and bunded facilities. This will prevent mobilisation of leaked hazardous substances. • Implement an adaptive water management approach.	• Control through Water quality monitoring; and • Control through SWMP	
Decommissioning and Rehabilitation Phase					
• During decommissioning of the cells and the TSF, NAG coarse waste rock will be placed on the tailing surfaces; • Movement of vehicles and machinery during	• Surface water quality and quantity	• Increased Sedimentation and siltation of surface watercourses resulting from erosion of disturbed soils during demolition and	• Minimise disturbance of soils to the infrastructure demolition footprint, as much as practically possible; • Ensure that the infrastructure (e.g., pipelines, fuel storage areas) are first emptied of all residual material before decommissioning; • Monitoring of seepage from waste rock dumps where there is potentially acid generating material; • Maintain the sediment and erosion control measures in place until the completion of demolition and rehabilitation activities;	• Control through maintenance and monitoring • Remedy through rehabilitation	• Decommissioning and Rehabilitation

Activity/ies	Aspects Affected	Impacts/Risks	Mitigation Measure	Mitigation Type	Time period for implementation
demolition and removal of infrastructure; • Construction of a spillway on the southern embankment of the TSF to allow for discharge; • Decant systems will be decommissioned and closed; • Rehabilitation of disturbed areas; and •		removal of infrastructure; •	• Landscape re-profiling must be undertaken to rehabilitate disturbed sites and to allow free drainage that promotes the desired post mining land use; • Ensure chemicals, reagents or hydrocarbons are stored on impermeable surfaces with appropriate containment structures; • Monitoring the quality of water resources should continue to detect any potential sources of pollution to enable implementation of appropriate remediation measures; and • Monitor seepage from waste rock dumps that contain acid generating material; • Movement of demolition machinery and vehicles should be restricted to designated access roads to minimise the extent of soil disturbance and subsequent erosion; • Maintain the sediment and erosion control measures in place until the completion of demolition and rehabilitation activities to minimise entry of sediment into watercourses; • Strategic removal of surface infrastructure should be implemented so that potentially contaminated runoff is diverted away from designated clean water areas. This may be achieved by temporarily retaining stormwater infrastructure to divert dirty water from clean areas while the potentially contaminating sources are decommissioned; • All mining personnel should be taught and trained to handle hazardous chemical waste to minimise spillages. The use of spill kits is highly recommended. All chemical storage facilities should be bunded; • Washing and servicing of vehicles and machinery should be undertaken at designated, appropriately designed areas; • Administer effective and timely clean-ups in the event of spillages occurring.		

12. Conclusion

This surface water impact assessment was undertaken to identify potential impacts of the RDMC Project on surface water resources and associated mitigation measures. Below are the conclusions made from this study:

- The RDMS climate is characterised as an arid hot desert climate in the Köppen climate classification system. with very low rainfall (MAP, 32.7 mm) and very high evaporation rates (MAE, 2055 mm);
- The Project area is prone to rare flooding that occurs following high intensity extreme rainfall events which occasionally occur during the pre-monsoon and/or the monsoon season;
- The SWMP for the RDMS comprises a system of infrastructure including diversion drains, berms and storage facilities which help to separate clean water from the natural environment and contact water from mine processes as per the IFC stormwater guidelines. In the event of flooding occurring, the diversion drains and berms will be able to control the high velocity flows away from the mining infrastructure;
- The water balance indicates a raw water requirement of 2.53 Mm^3/month at the RDMS.
- Raw water sent directly to the process plant to be used without treatment is 1.72 Mm^3/month for process make-up water requirements. An additional 697 596 m^3/month will be sent to the RO plant for treatment and then distributed to the various processes;
- A dedicated raw water dam will be constructed with a capacity of 400 000 m^3.
- The total inflow into the process water dam is 2.71 Mm^3/month and all of this water will be re-used; and
- Groundwater contribution into the open pit (Western Porphyry only for the first 10 years of operation) will peak at 14 427 m^3/month with the rainfall contribution fluctuating over the year and will range between 0 and 22 389 m^3/month in year 10. Rainfall contribution to the dewatering volume will increase as the size and footprint of the pit increases.
- The potential environmental risks associated with the Project are as follows:
  - Alteration of flow path patterns and channel geometry of already silted watercourses or drainage lines;
  - Contamination of soil and water resources due to accidental spills and releases of fuels, solvents, oils, and chemicals, and disposal of waste; and
  - An increase in the rate of erosion of disturbed soils will likely occur during construction of infrastructure, mining related activities during the operation phase

and at decommissioning associated with the demolition and removal of infrastructure.

This study highlighted the activities and associated impacts the Project could have on water recourses in the immediate and surrounding environment. The environmental impacts on water resources before mitigation are classified to have moderate to minor negative significance. However, rating the impacts after mitigation measures, the impacts were reduced to a negligible impact significance. Overall, if the mitigations provided in this report are implemented, the project activities will not result in significant impacts on the receiving soil and water resources.

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Appendix A: Impact Assessment Tables

Impact Assessment Parameter Ratings

Rating	Intensity		Spatial scale	Duration (duration of an impact without mitigation)	Probability (over the life of the project)
	Negative Impacts ***(Type of Impact = -1)***	***Positive Impacts*** ***(Type of Impact = +1)***			
5	Significant impact on the environment. Irreparable and irreplaceable damage to highly valued species, habitat or ecosystem. Persistent severe damage. Irreparable and irreplaceable damage to highly valued items of great cultural significance or complete breakdown of social order.	Significant improvement to livelihoods and living standards of a large percentage of population, as well as significant increase in the quality of the receiving environment.	<u>Global</u> Contribute to global impact	<u>Inter -Generational</u> >20 years	<u>Certain / Definite</u> There are sound evidence-based reasons to expect that the impact will definitely occur (90-100%)

Rating	Intensity		Spatial scale	Duration (duration of an impact without mitigation)	Probability (over the life of the project)
	Negative Impacts ***(Type of Impact = -1)***	***Positive Impacts*** ***(Type of Impact = +1)***			
4	Serious long term environmental effects. Environmental damage can be reversed in less than a year. On-going serious social issues. Significant damage to structures / items of significance.	On-going and widespread positive benefits to local communities which improves livelihoods, as well as a positive improvement to the receiving environment. Average to intense social benefits to some people. Average to intense environmental enhancements.	Regional Will affect the entire province or region. A broad geographical area distinguished by similar features.	Long term 5-20 years	Likely The impact may occur (50-90%)
3	Moderate, short-term effects but not affecting ecosystem function. Rehabilitation requires intervention of external specialists and can be done in less than a month. On-going social issues. Damage to items of significance.	Average, on-going positive benefits, not widespread but felt by some.	Sub-regional Will affect the sub-regional / commune area e.g. district level/ areas within the region with similar features	Medium term 2 to 5 years	Probable Has occurred here or elsewhere and could therefore occur (20-50%)

Rating	Intensity		Spatial scale	Duration (duration of an impact without mitigation)	Probability (over the life of the project)
	Negative Impacts (Type of Impact = -1)	*Positive Impacts (Type of Impact = +1)*			
2	Moderate, short-term effects but not affecting ecosystem function. Rehabilitation requires intervention of external specialists and can be done in less than a month. On-going social issues. Damage to items of significance.	Average, on-going positive benefits, not widespread but felt by some.	Local Extending across the site and to nearby settlements. Sub-division of a district.	Short term Up to 2 years	Unlikely Has not happened yet but could happen once in the lifetime of the Project, therefore there is a possibility that the impact will occur (5-20%)
1	Minor effects on biological or physical environment. Environmental damage can be rehabilitated internally with/ without help of external consultants. Minor medium-term social impacts on local population. Mostly repairable. Functions and processes not affected	Low positive impacts experience by very few of population.	Site Specific Limited to the site and its immediate surroundings.	Immediate Hours to weeks but less than 1 month	Rare / improbable Conceivable, but only in extreme circumstances and / or has not happened during lifetime of the Project but has happened elsewhere. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures (1-5%).

Probability Consequence Matrix

Probability		Significance																									
	5	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75
	4	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60
	3	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45
	2	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30
	1	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15
		-15	**-14**	**-13**	**-12**	**-11**	**-10**	**-9**	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
		Consequence																									

Significance Threshold Limits

Score	Description	Rating
57 to 75	A very beneficial impact which may be sufficient by itself to justify implementation of the Project. The impact may result in permanent positive change.	**Major (positive)**
39 to 56	A beneficial impact which may help to justify the implementation of the Project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and/or social) environment.	Moderate (positive)
20 to 38	An important positive impact. The impact is insufficient by itself to justify the implementation of the Project. These impacts will usually result in positive medium to long-term effect on the social and/or natural environment.	Minor (positive)
3 to 19	A small positive impact. The impact will result in medium to short term effects on the social and/or natural environment.	Negligible (positive)
-3 to -19	An acceptable negative impact for which mitigation is desirable but not essential. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the social and/or natural environment. The impacts are reversible and will not result in the loss of irreplaceable aspects.	Negligible (negative)
-20 to -38	An important negative impact which requires mitigation. The impact is insufficient by itself to prevent the implementation of the Project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the social and/or natural environment.	Minor (negative)
-39 to -56	A serious negative impact which may prevent the implementation of the Project. These impacts would be considered by society as constituting a major and usually a long-term change to the (natural and/or social) environment and result in severe effects. The impacts may result in the irreversible damage to irreplaceable environmental or social aspects should mitigation measures not be implemented.	Moderate (negative)
-57 to -75	A very serious negative impact which may be sufficient by itself to prevent implementation of the Project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts will be irreplaceable and irreversible should adequate mitigation and management measures not be successfully implemented.	Major (negative)

Appendix B: Design Climatology Memorandum

MEMORANDUM

To: RDMC		**Date:**	23 January 2024
Attn: Daniel Nel		**Our Ref:**	PE24-00070
		KP File Ref.:	PE701-00020/18-A djtm M24006
cc: Ruan Pretorius		**From:**	David Morgan

RE: REKO DIQ PROJECT – DESIGN CLIMATOLOGY

EXECUTIVE SUMMARY

Please find herein an assessment of the engineering design criteria for the climatology of the Reko Diq Project site in the province of Balochistan in Pakistan. The investigation and calculations discussed herein provide the hydrologic basis for surface water management and water balance modelling.

It is noted that the Reko Diq Project (Reko Diq) site is located in an area that has a Köppen climate classification of BWh (Arid, desert, hot climate). The critical design values generated in this document are summarised in tables E.1 and E.2.

Table E.1: Monthly climate parameters

Month	Annual Precipitation (mm)			Average Pan Evap. (mm)	Average Lake Evap. (mm)
	100-yr ARI Wet	Average	100-yr ARI Dry		
Jan	0	2	0	400	227
Feb	0	0	0	266	179
Mar	33	11	0	160	116
Apr	0	5	0	171	124
May	96	14	0	195	139
Jun	96	0	0	323	205
Jul	0	0	0	414	225
Aug	0	0	0	608	259
Sep	0	0	0	656	260
Oct	0	0	0	763	281
Nov	0	0	0	590	256
Dec	0	0	0	480	234
1-year Totals	225	32	0	5,026	2,505

Table E.2: Storm events (24-hour and 72-hour totals)

Duration (hours)	100-year ARI (mm)	1,000-year ARI (mm)	PMP (mm)
24	125	185	425
72	129	191	438

1. DATA SOURCE / ACQUISITION

KP was provided with a significant number of historical data files from the weather stations that were previously installed at the site. It is noted that these datasets were fairly limited, with a large amount of data missing. Also some of the data were questionable with some large rainfall events recorded with no corresponding increase in relative humidity. KP expects this is due to the gauge being cleaned with water.

RDMC sourced daily precipitation data from the nearby regional gauge at Nok Kundi from the Pakistan Meteorological Agency and provided it to KP. KP was also able to source some additional monthly precipitation data for Nok Kundi from NOAA. The climate stations in the vicinity and information regarding them are summarised in Table 1.1.

Table 1.1: Summary of nearby climate stations

Station Name	Distance to Site (km)	Precipitation Data Available	First Reading	Last Reading	Duration (years)
Reko Diq/Tanjeel	-	15 minute	10/06/2004	05/11/2007	3.4
		Daily	11/06/2004	27/02/2011	6.7
Reko Diq	-	10 minute	28/02/2008	28/02/2011	3.0
Nok Kundi	80	Daily	01/01/1983	30/09/2023	41
		Monthly	Jan 1951	Sep 2023	73

After considering both the distance to the project site and the quantity and quality of the available data, KP selected the Nok Kundi daily precipitation dataset for use in this analysis.

The Nok Kundi daily data were analysed to obtain the following required design information:

- Depth / Duration / Frequency (DDF) curves for short-duration extreme rainfall events for a range of durations, with an Average Recurrence Interval (ARI) of 2 years up to the Probable Maximum Precipitation (PMP);
- Typical variability of annual precipitation;
- Typical variability of monthly precipitation;
- Extreme monthly precipitation (1 year sequence) for 5 to 100 year ARI wet/dry precipitation; and
- Extreme monthly precipitation (5 month sequence) for 5 to 100 year ARI wet precipitation.

The Reko Diq 10 minute data were utilised to provide guidance on the development of the DDF curves as well as the magnitude of the generated design storms. It was also used to generate the typical variability of monthly evaporation and a wind rose.

The locations of climate stations and the project site are shown on Figure 1.1.

2. PRECIPITATION ANALYSIS

Precipitation data from the Nok Kundi rain gauge were reduced into a standardised format and then analysed on daily, monthly, and annual timescales. Daily precipitation data were used to derive design extreme storms for sizing water conveyance infrastructure (spillways, channels, etc.). Monthly and annual precipitation data were used for water balance modelling purposes. The following sections summarise the analyses conducted and the results attained.

It is noted that the data in this assessment were evaluated based on water years, starting in October and ending in September, due to the distinct dry and wet seasons lining up with a typical December to April.

2.1 DAILY PRECIPITATION ANALYSIS

KP performed frequency analysis on daily and 3-day annual maxima from 41 years of data from the Nok Kundi daily dataset to estimate the statistical likelihood of experiencing extreme storms at the Reko Diq site. As a result of gaps in the data, 3 years were excluded from the analysis. A large number of different probability distributions (e.g. Log-Pearson 3, Generalised Extreme Value, Generalised Logistic, Wakeby, Frechet, etc.) were fitted to the annual maxima of the daily and 3 day precipitation data using EasyFit 5.4 Professional software.

For the analyses, three of the best fits were selected for comparison, as shown in figures 2.1 and 2.2.

For the 1-day assessment the Wakeby distribution was nominated by EasyFit to provide the best fit to the entire dataset whilst Gen. Extreme Value and Log-Pearson 3 distributions are alternative standard distributions typically used to assess climate data. After reviewing the fits, KP determined that the Gen. Extreme Value distribution provided a better fit to the historical data.

For the 3-day assessment the Gen. Pareto distribution was nominated by EasyFit to provide the best fit to the entire dataset whilst Gen. Extreme Value and Log-Pearson 3 distributions are alternative standard distributions typically used to assess climate data. After reviewing the fits KP determined that the Gen. Extreme Value distribution provided a better fit to the historical data.

The results of the selected fits to historic precipitation records are presented in Table 2.1, noting that the values provided have been augmented by 14.3% and 4.4% for the daily and the 3 day results respectively to account for potential straddling errors in sampling which may occur from the usage of fixed 24 hour duration observational periods for deriving daily design storms (Ref. 1).

Upon a review of the 10 minute interval precipitation from the Reko Diq automatic weather station for 2008 to 2011, one significant storm event was identified. This event started on the 7th of December 2008 at 12:00 pm and ended on the 8th of December at 10:20 am. This event was significant, with 91.7 mm falling. Without any adjustments to the frequency analysis, the event would have an ARI of approximately 83 years. To provide additional conservatism to the design storm estimates, KP adjusted the calculated 24 hour and 72 hour design storm depths by 1.24 and 1.08 respectively. This resulted in the 2008 storm event being equivalent to approximately a 50 year ARI event.

Table 2.1: Extreme 24 hour and 72 hour design precipitations

Annual Recurrence Interval (ARI) (yr.)	24-h Duration Precipitation Depth (mm)	72-h Duration Precipitation Depth (mm)
5	26	26
10	41	41
20	59	60
50	92	94
100	125	129
Largest Recorded[1]	66	83

1. Unfactored daily values at the Nok Kundi gauge.

KP utilised the 24 hour design precipitation information in Table 2.1 to derive DDF curves for short duration storms. The Rainfall Ratio Method (Ref. 2) was employed for this purpose.

The results for Reko Diq are summarised in Table 2.2 and plotted on Figure 2.3.

Table 2.2: Reko Diq Project depth / duration / frequency data

Storm Duration	Precipitation Depth (mm) for given ARI (year) Storm						
	5	10	20	50	100	1,000[1]	PMP
5 min	2	3	5	8	10	15	36
10 min	4	6	9	13	18	27	62
15 min	5	8	11	18	24	36	83
30 min	8	12	17	27	37	55	125
1 h	11	17	24	38	51	76	174
2 h	14	22	31	48	66	98	225
3 h	16	24	35	55	75	111	255
6 h	19	30	43	66	90	134	307
9 h	21	33	47	73	100	148	340
12 h	23	35	51	78	107	158	364
18 h	25	38	55	86	117	174	399
24 h	26	41	59	92	125	185	425
72 h	26	41	60	94	129	191	438[2]

1. The 1,000 year ARI depths are based on a logarithmic interpolation between the 24 hour 100 year ARI and the 24 hour PMP, assuming the PMP is equivalent to a 10 million year ARI event.
2. 72 hour PMP was estimated based on factoring the 24 hour PMP by the ratio of the 100 year 72 hour and the 100 year 24 hour storm depths.

2.2 PROBABLE MAXIMUM PRECIPITATION

The PMP storm event was estimated using the Nok Kundi daily precipitation dataset, as above. The Hershfield Statistical Method (Refs. 3, 4, 5 and 6) was used to estimate PMP values for the site. To reduce the 24 hour PMP depth to sub-daily storm depths, the Rainfall Ratio Method was used (Ref. 2), as described in Section 2.1. The PMP storm depths estimated for Reko Diq are summarised in Table 2.2 above and shown on Figure 2.3. As per the other design storm events, KP adjusted the 24 hour PMP estimate by 1.24 to account for the storm in 2008.

2.3 MONTHLY PRECIPITATION ANALYSIS

Sampling statistics were computed on the daily precipitation data from the Nok Kundi climate station to describe the variability of monthly precipitation at Reko Diq. The computed sampling statistics for the monthly precipitation data from Nok Kundi are summarised in Table 2.3. It is noted that the averages provided in Table 2.3 are not for use in any models as they do not adequately represent the variability of monthly precipitation.

Table 2.3: Monthly precipitation statistics (Nok Kundi)

Month	Average	Median	Std. Dev.	Min.	Max.	25th Pct.	75th Pct.
Oct	0.3	0.0	1.5	0.0	9.0	0.0	0.0
Nov	1.0	0.0	3.3	0.0	17.0	0.0	0.0
Dec	1.8	0.0	5.2	0.0	31.8	0.0	2.2
Jan	8.6	0.4	17.1	0.0	75.0	0.0	7.5
Feb	8.9	1.4	18.4	0.0	94.0	0.0	7.1
Mar	7.1	2.7	15.0	0.0	93.6	0.0	8.8
Apr	1.8	0.0	5.1	0.0	30.1	0.0	1.3
May	0.4	0.0	1.5	0.0	9.0	0.0	0.0
Jun	2.0	0.0	12.5	0.0	80.0	0.0	0.0
Jul	0.6	0.0	2.5	0.0	12.4	0.0	0.0
Aug	0.5	0.0	2.2	0.0	10.5	0.0	0.0
Sep	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The sample statistics for monthly precipitation at the Nok Kundi weather station were also depicted as a "box and whisker" plot (Figure 2.4) to illustrate the variability of monthly precipitation at Reko Diq.

2.4 ANNUAL PRECIPITATION ANALYSIS

Monthly precipitation records from the Nok Kundi climate station were summed to produce annual totals for the 41 years of available record. It is noted that, due to missing data, 3 years of records were excluded from the analysis.

Sampling statistics were computed on these values to provide a broad overview of the variability of annual precipitation at Reko Diq and are summarised in Table 2.4.

Table 2.4: Annual precipitation statistics

Selected Statistic	Statistic Value (mm)
Average	32.3
Median	17.8
Std. Deviation	42.4
Minimum	0.0
Maximum	219.4
25th Percentile	6.7
75th Percentile	42.1

2.5 WATER BALANCE SCENARIO ANALYSIS

KP performed frequency analysis on annual precipitation values similar to the method described (with daily data) in Section 2.1. As well as annual values, the maxima for the Wet Season, defined by ANCOLD (Ref. 7) as the period in which 70% of the annual rainfall occurs on average, were also assessed in the same manner. Analysis of the monthly dataset indicated the Wet Season period to be 30 days.

Exceedance and non-exceedance probabilities were assigned to the annual totals (rather than the annual monthly maxima), by sorting the values in descending (for the "Wet" series) and ascending (for the "Dry" series) order. Probability distributions were fitted to the data and then plotted for comparison, as shown on figures 2.5 to 2.7 for the "Wet," "Dry," and "30-day" series respectively. KP selected the Gen. Pareto probability distribution for the annual wet series, the Gen. Extreme Value probability distribution for the annual dry series, and the Johnson SB probability distribution for the 30-day wet series as the best-fitting distributions for each of the series. The results of these calculations are summarised in Table 2.5.

Table 2.5: Extreme long duration design precipitation

Annual Recurrence Interval (ARI) (yr.)	Annual Wet Precipitation Depth (mm)	Annual Dry Precipitation Depth (mm)	30-day Wet Precipitation Depth (mm)
5	49	1	38
10	78	0	64
20	113	0	93
50	171	0	133
100	225	0	163

In order to apportion the statistically-computed annual to monthly time series for use in water balance modelling, the rainfall pattern observed in the median year (2009 - 2010) and wettest year (2004 - 2005). For the dry year, no pattern was applied as rainfall was assumed to be zero. These monthly ratios were then multiplied by the computed statistical annual values to form the required synthetic scenarios. The results of this computation are provided in Table 2.6.

Table 2.6: 1-year duration synthetic precipitation scenarios

Month	Wet Scenarios (mm)			Average	Dry Scenarios (mm)		
	100-yr ARI	10-yr ARI	5-yr ARI	(mm)	5-yr ARI	10-yr ARI	100-yr ARI
Jan	0	0	0	2	0	0	0
Feb	0	0	0	0	0	0	0
Mar	33	11	7	11	0	0	0
Apr	0	0	0	5	0	0	0
May	96	34	21	14	0	0	0
Jun	96	33	21	0	0	0	0
Jul	0	0	0	0	0	0	0
Aug	0	0	0	0	0	0	0
Sep	0	0	0	0	0	0	0
Oct	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0
Dec	0	0	0	0	0	0	0
1-year Totals	225	78	49	32	0	0	0

It is noted that the synthetic wet years may have months where the precipitation is less than the average or the synthetic dry years. Similarly, the synthetic dry year may have months where the precipitation is greater than the average or the synthetic wet years. This is due to the rainfall recorded within the specific year selected to match the required scenario.

As the wet season duration is a notional 30 day period, no pattern was developed. The 30 day total can be applied to February as that is typically the month where the most significant rainfall occurs.

3. EVAPORATION ANALYSIS

Some evaporation data were provided in the data for the Reko Diq/Tanjeel daily dataset. It is not clear whether these data were collected from a pan or were estimated from other parameters by the weather station. Given that the rate of evaporation being recorded was extremely high KP treated this data as Class A Evaporation Pan data. Due to the amount of missing data, KP estimated the average monthly pan evaporation by averaging the daily values recorded for each month and then multiplying that by the number of days in the month.

The estimated monthly average pan evaporation rates are provided in Table 3.1 along with an estimate of equivalent Lake Evaporation using the relationship described in Stanhill 1976 (Ref. 8).

4. WIND ANALYSIS

The 10 minute interval wind data recorded in the Reko Diq dataset were analysed to produce basic wind roses. The average wind speed and direction values were analysed in order to produce the wind roses shown on Figure 4.1. The prevailing wind direction based on the wind rose is South to North-northwest.

As a check, KP reviewed the airstrip at Nok Kundi which shows that the sealed air strip is aligned North to South.

KP notes that there was insufficient data to undertake statistical analysis of the wind to determine design wind speeds. However, the maximum wind speed recorded on site is 27.2 m/s.

5. CLIMATE CHANGE CONSIDERATIONS

The IPCC Sixth Assessment Report (Ref. 9) discusses the impacts of Climate Change on Asia. The report splits the continent into six regions of Central, North, East, Southeast, South and West Asia. Pakistan is in the South Asia region.

Future projections for both monthly precipitation and maximum temperature were sourced for the Nimroz region of Afghanistan from the World Bank Group Climate Change Knowledge Portal. The Nimroz region of Afghanistan was selected over the Balochistan region of Pakistan as shown on Figure 5.1. This decision was made as Balochistan is a very large province with a wider range of climates and the Nimroz region appears to be more representative of the climate at the site.

The projects reported on in this section are based on the SSP2-4.5 scenario. The future projections for Nimroz are shown on figures 5.2 and 5.3. As shown on the figures, precipitation is not expected to increase significantly however the maximum temperature is expected to increase.

PE24-00070

Extreme precipitation is also expected to increase with what is currently the 100 year ARI being equivalent to a 60 year ARI by the end of the century as shown in Table 5.1.

Table 5.1: Change in Average Recurrence Intervals – 1 Day Event

Current ARI	Equivalent ARI (2010 – 2039)	Equivalent ARI (2035 – 2064)	Equivalent ARI (2060 – 2089)	Equivalent ARI (2070 – 2099)
5	4.36	4.09	3.86	3.85
10	8.28	7.44	7.28	7.32
20	15.51	14.77	14.32	14.13
50	34.09	38.04	34.21	31.69
100	62.39	73.74	64.24	59.62

Based on the above, KP Estimated the 24 hour design storm depths for 2070 – 2099 as shown in Table 5.2.

Table 5.2: Change in design storm depths

ARI (Years)	Storm Depth Current (mm)	Storm Depth (2070 – 2099) (mm)	Percent Increase
5	26	32	22%
10	41	50	21%
20	59	73	24%
50	92	116	26%
100	125	140	12%

The implications of the report with respect to Reko Diq are as follows:

- The precipitation depths for design storms may increase requiring additional stormwater capacity within the TSF; and
- Evaporation rates may increase as temperatures rise.

These implications should be considered in future design phases.

6. RECOMMENDATIONS

KP has been informed that the climate stations have been reinstated on site including a Class A Evaporation Pan. The installed monitoring equipment is shown on Figure 6.1. It is noted that the bird guard installed is unconventional. Typically, the guard is installed with the mesh elevated as shown on Figure 6.2. With the way the mesh is currently installed, it is possible that the guard will be reducing the rate of evaporation to a degree that is higher than what is typically expected.

KP recommends that the following actions be taken:

- The automatic weather station (AWS) installed on site should be maintained with the data managed in order to provide additional site data to verify design assumptions. This station should record precipitation with a temporal resolution of at least 10 minutes;
- The Class-A evaporation pan that has been installed on site should be monitored daily. Efforts should be made to ensure the quality of these data is high. The bird guard should be modified to match the conventional design as shown in Figure 6.2;

- The design climatology should be reassessed in a nominal five years' time (December 2028) or when 1 full year of data (minimum) is collected from the AWS and/or evaporation pan; and
- The wind data recorded by the new site gauge should be analysed when a minimum of two full years of wind data are available.

We trust that this memorandum is sufficient for your requirements. Please contact us if you have any queries.

Yours faithfully
KNIGHT PIÉSOLD PTY LTD

ANDREW BROWN
Senior Project Engineer

DAVID MORGAN
Managing Director

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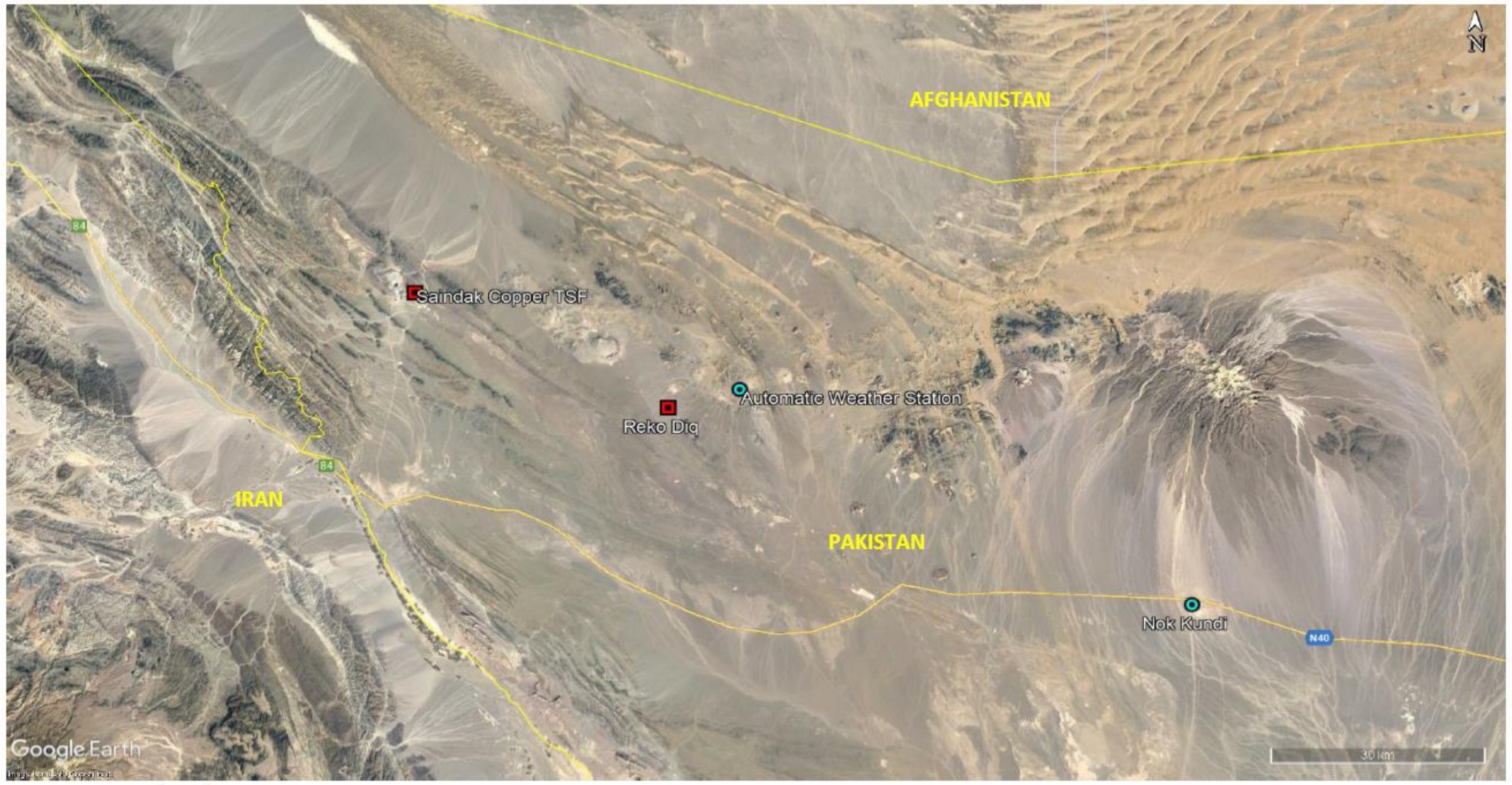

Legend:
- Site Location
- Climate Station

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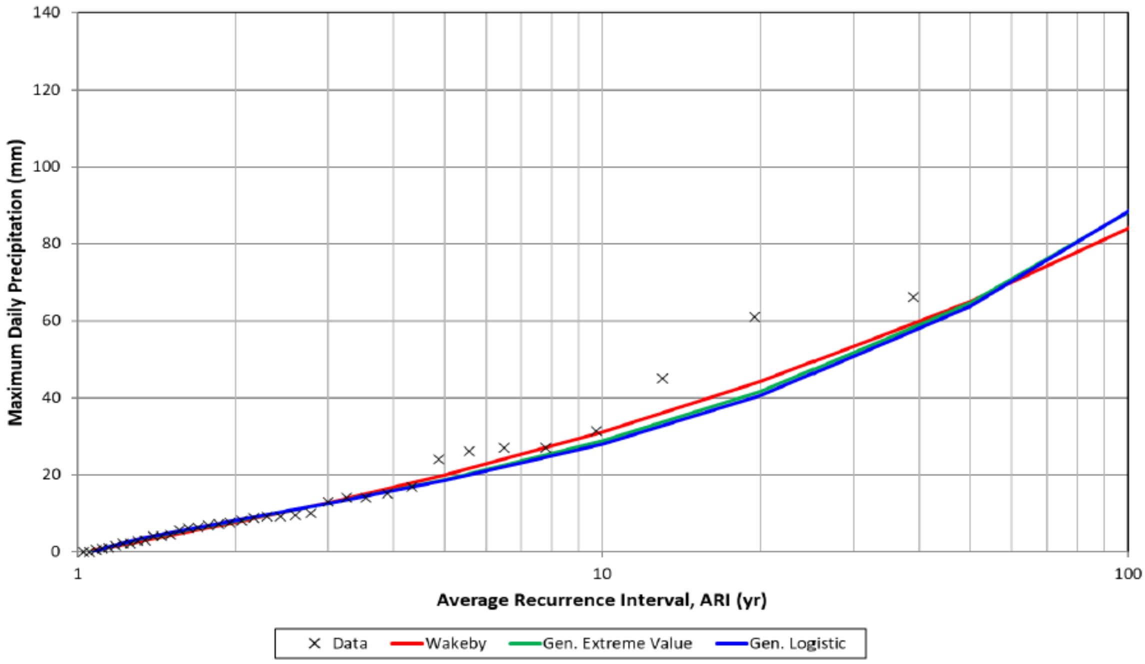
REKO DIQ PROJECT
DESIGN CLIMATOLOGY
PROJECT LOCATION AND DATA SOURCES

PE701-00020 M24006
Figure 1.1



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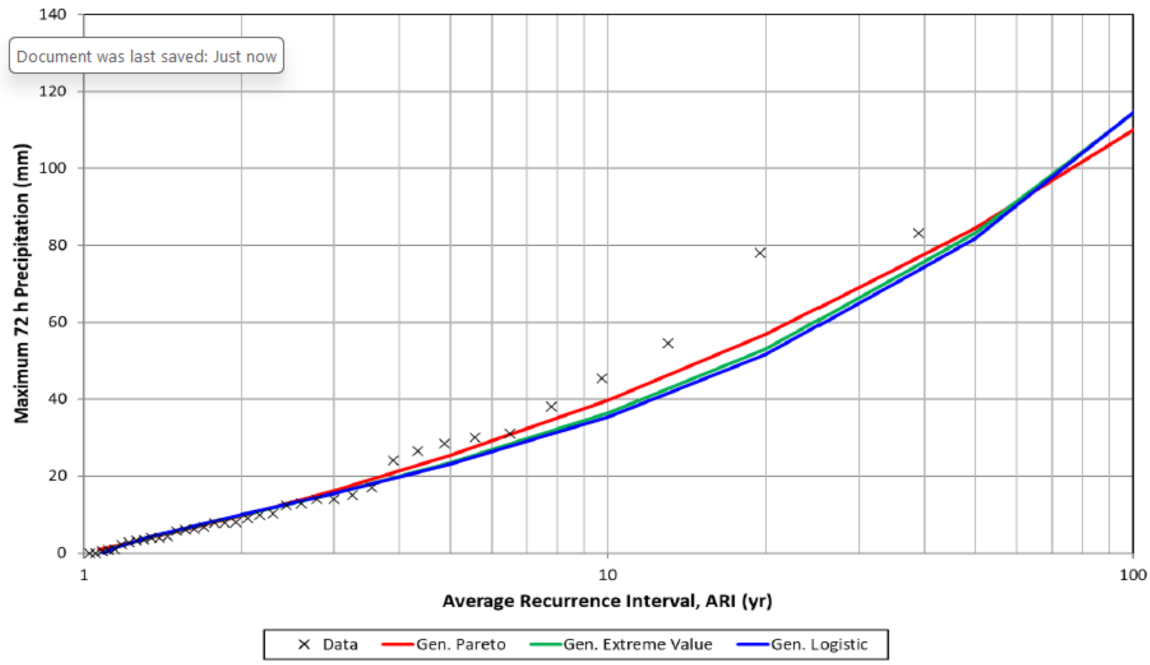
REKO DIQ PROJECT
DESIGN CLIMATOLOGY
BONDOUKOU DAILY DATASET - 24 HOUR FREQUENCY ANALYSIS

PE701-00020 M24006
Figure 2.1



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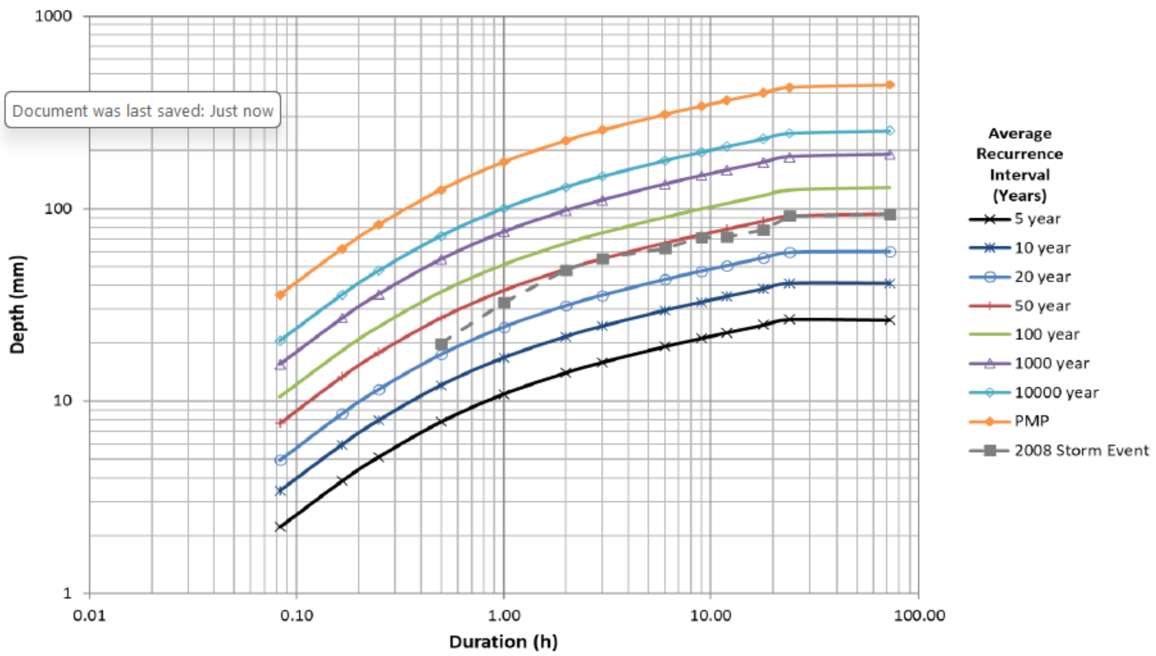
REKO DIQ PROJECT
DESIGN CLIMATOLOGY
BONDOUKOU DAILY DATASET - 72 HOUR FREQUENCY ANALYSIS

PE701-00020 M24006
Figure 2.2



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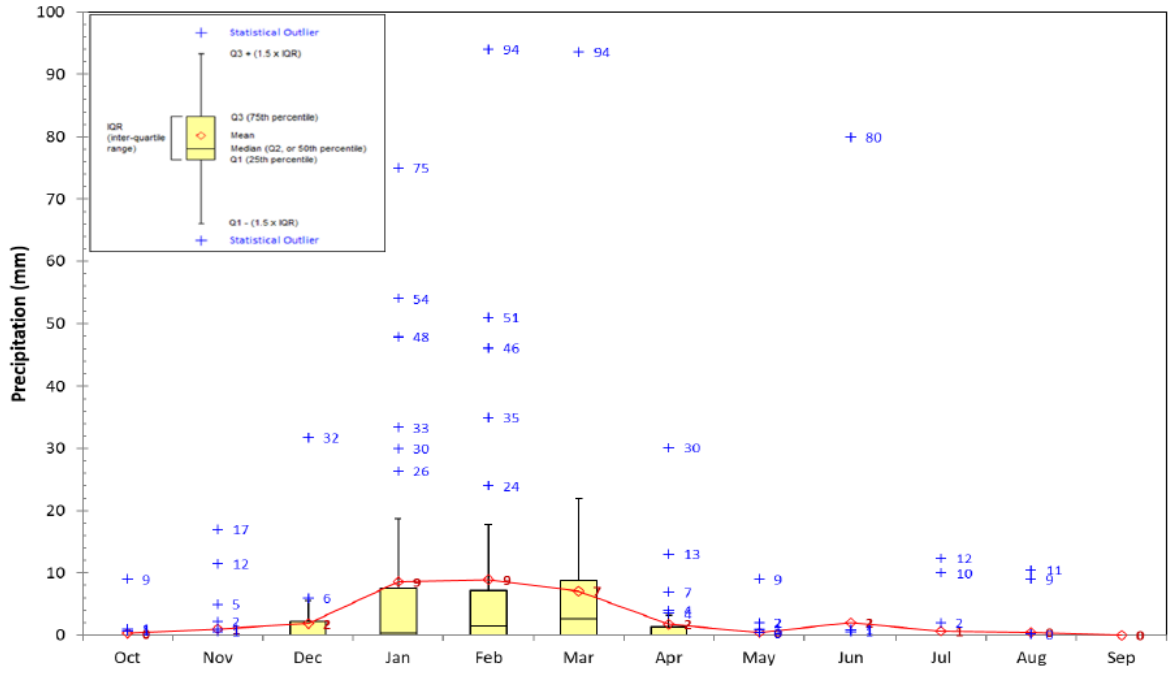
REKO DIQ PROJECT
DESIGN CLIMATOLOGY
PRECIPITATION DEPTH / DURATION / FREQUENCY CURVES

PE701-00020 M24006
Figure 2.3



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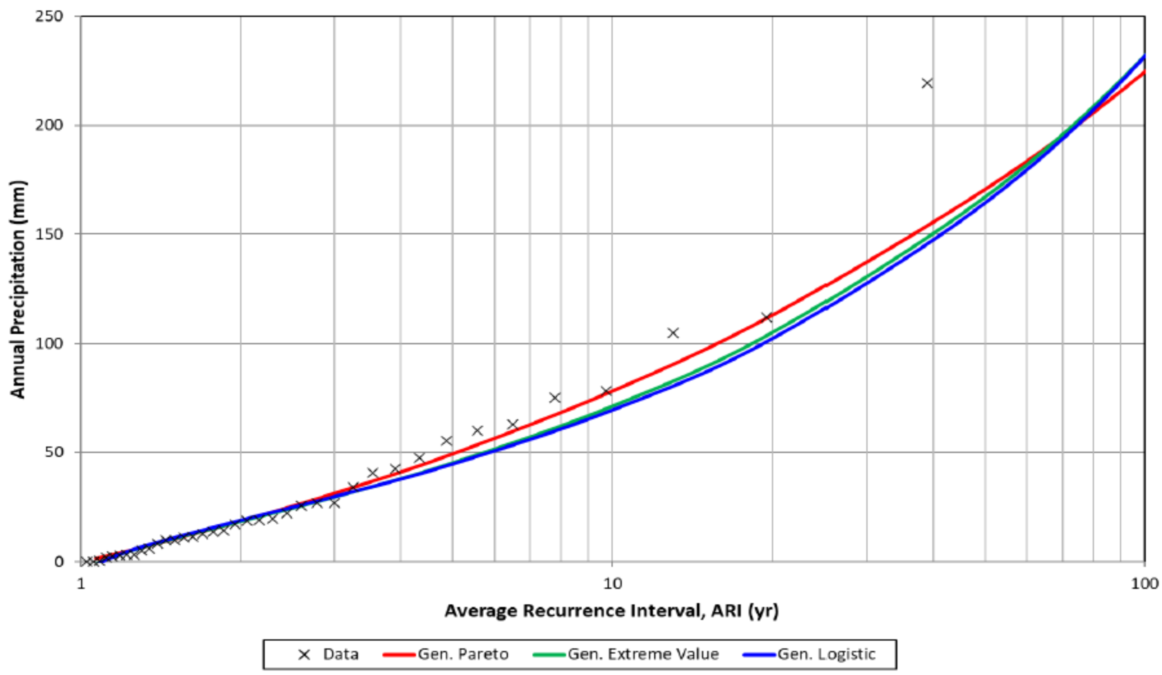
REKO DIQ PROJECT
DESIGN CLIMATOLOGY
BONDOUKOU DAILY DATASET - MONTHLY PRECIPITATION STATISTICS

PE701-00020 M24006
Figure 2.4



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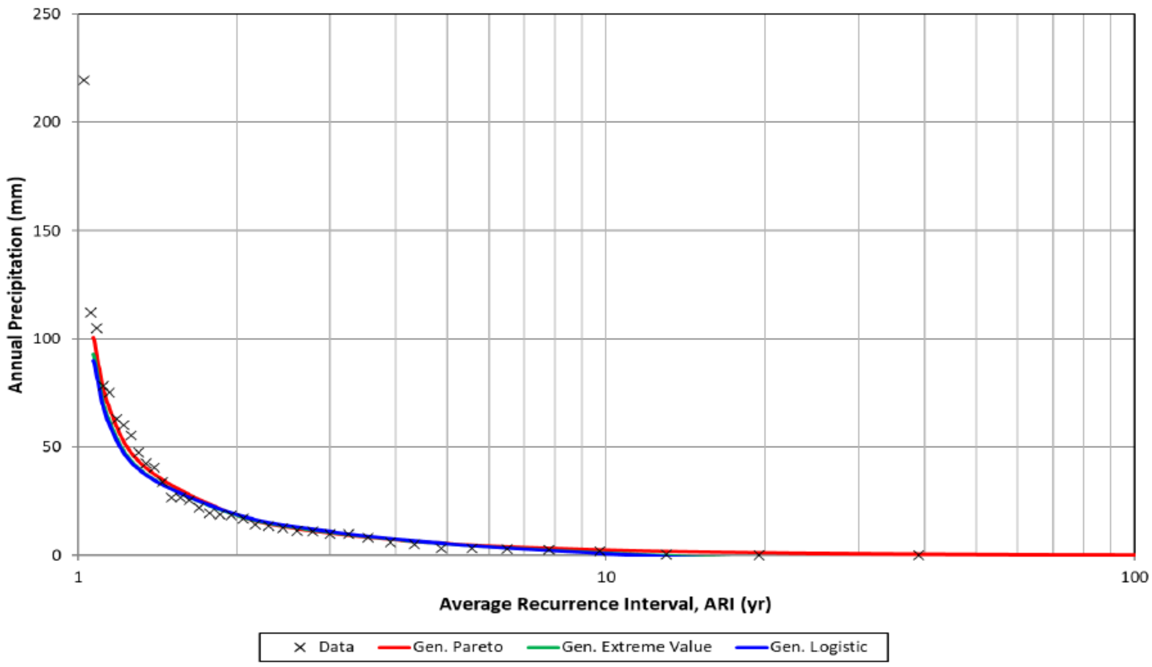
REKO DIQ PROJECT
DESIGN CLIMATOLOGY
BONDOUKOU DAILY DATASET - 1-YEAR DURATION WET SERIES

PE701-00020 M24006
Figure 2.5



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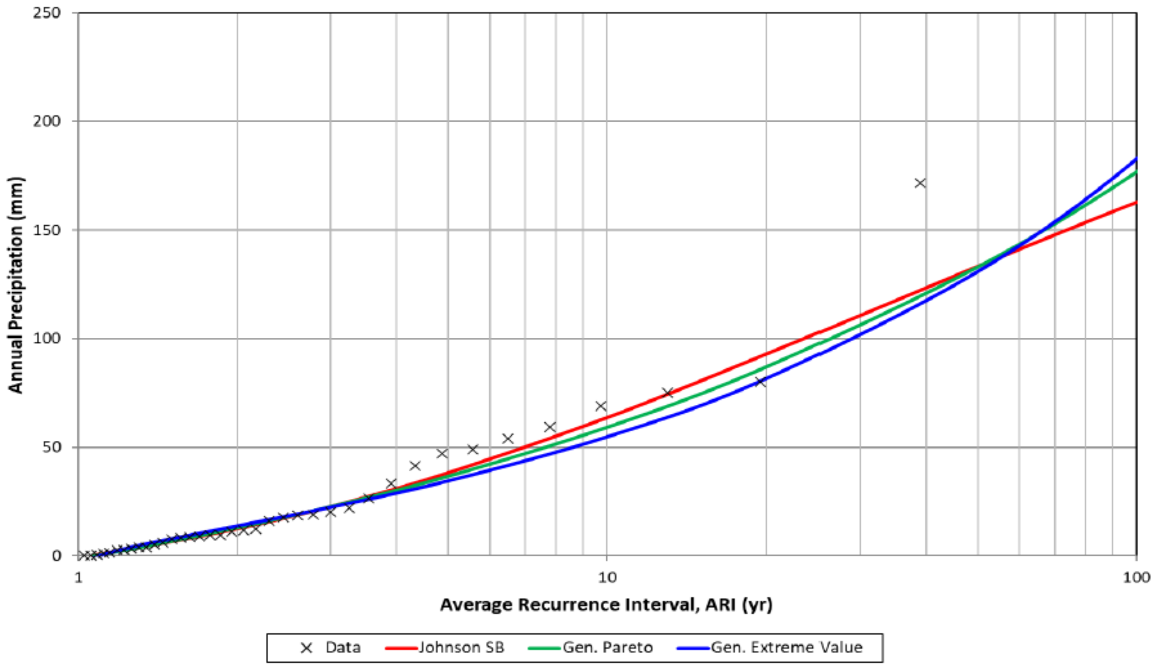
REKO DIQ PROJECT
DESIGN CLIMATOLOGY
BONDOUKOU DAILY DATASET - 1-YEAR DURATION DRY SERIES

PE701-00020 M24006
Figure 2.6



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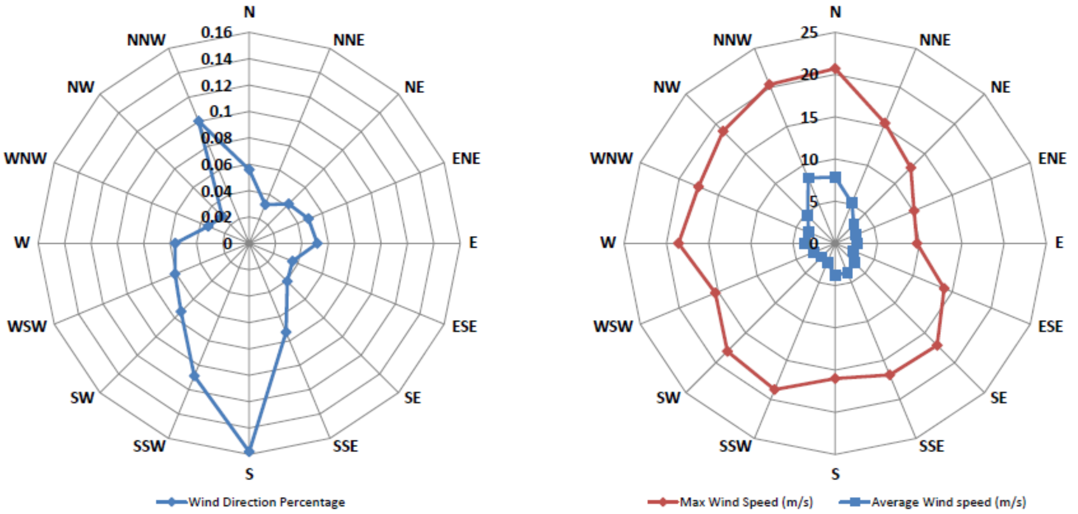
REKO DIQ PROJECT
DESIGN CLIMATOLOGY
BONDOUKOU DAILY DATASET - 5-MONTH DURATION WET SEASON

PE701-00020 M24006
Figure 2.7



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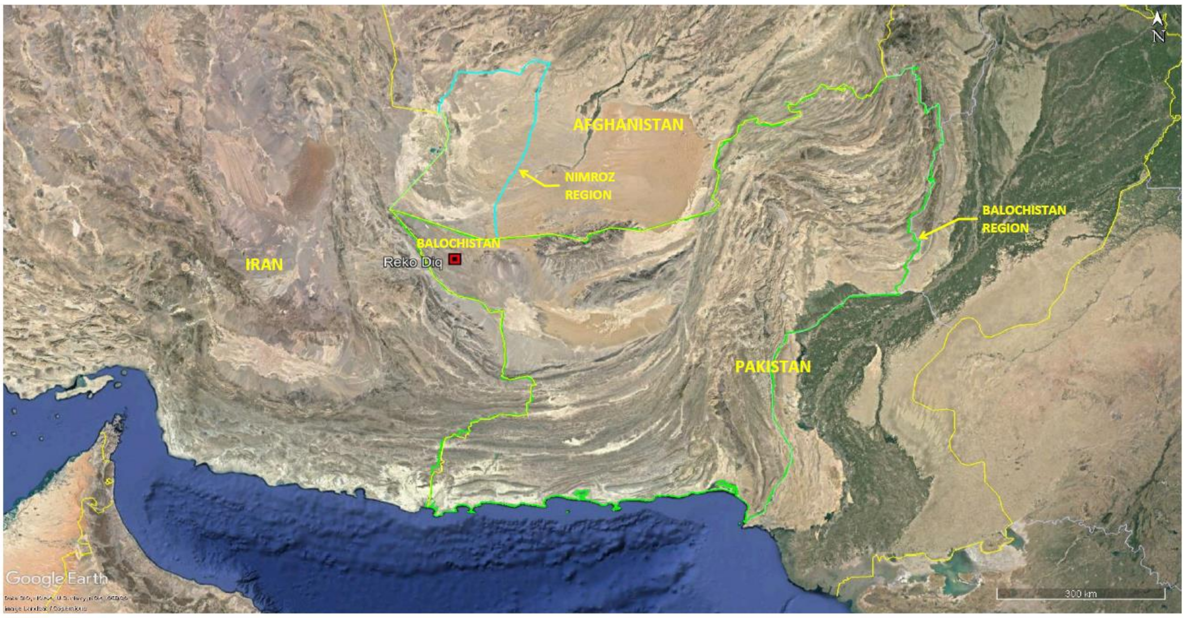
REKO DIQ PROJECT
DESIGN CLIMATOLOGY
WIND ROSE DATA (REKO DIQ 10 m)

PE701-00020 M24006
Figure 4.1



Legend:
- Site Location

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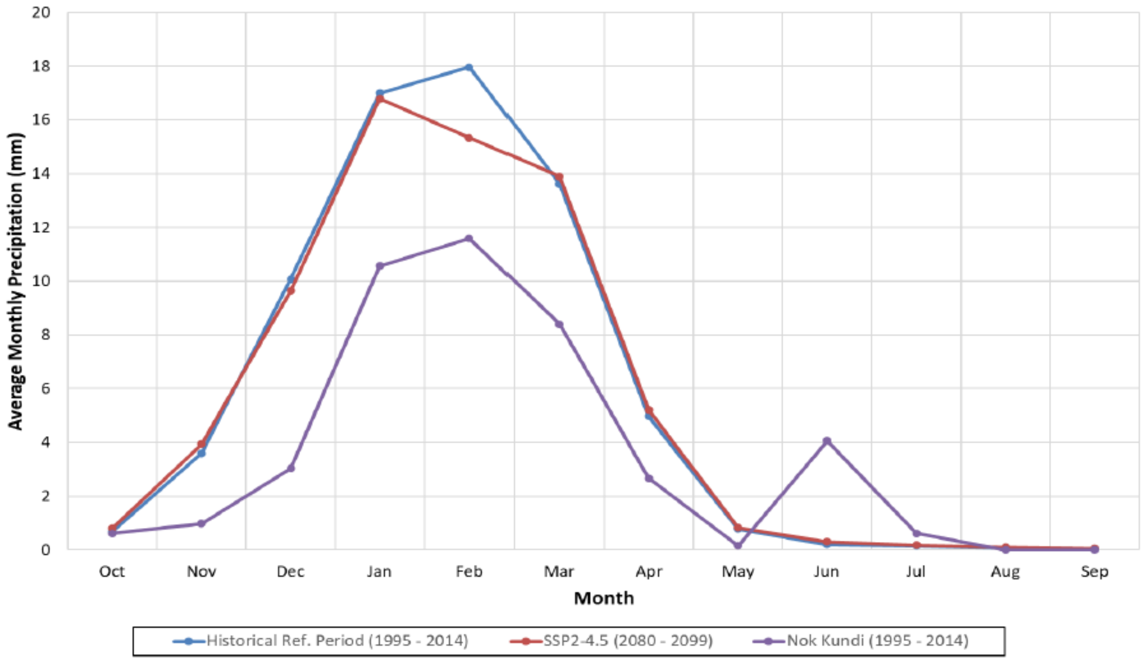
REKO DIQ PROJECT
DESIGN CLIMATOLOGY
PROJECT LOCATION

PE701-00020 M24006
Figure 5.1



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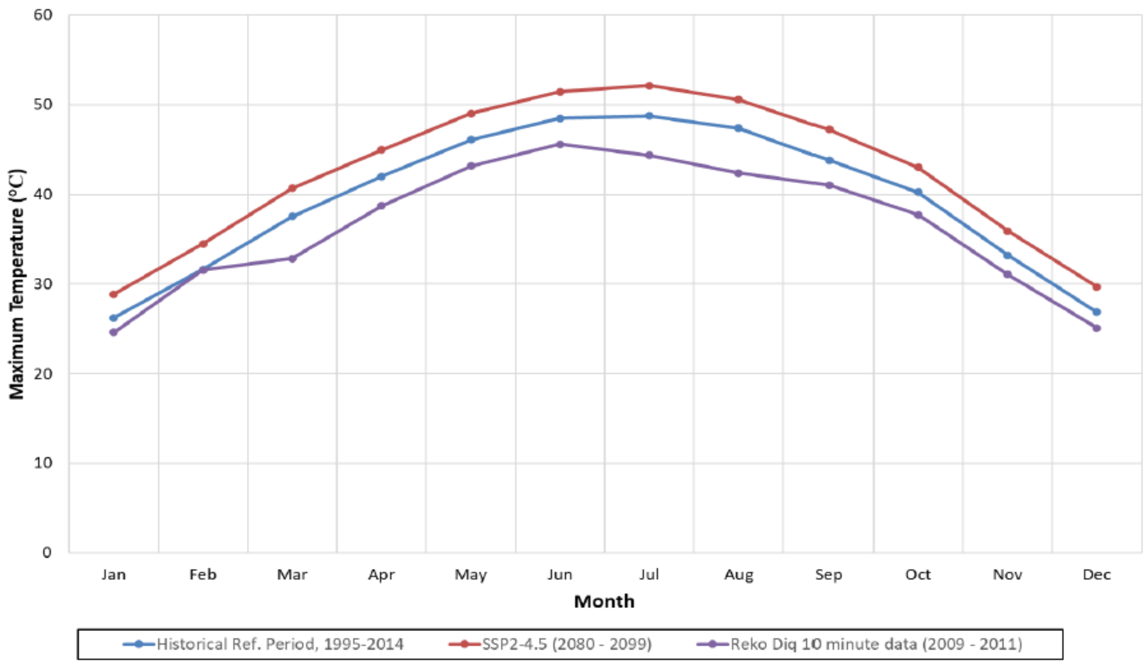
REKO DIQ PROJECT
DESIGN CLIMATOLOGY
CLIMATE CHANGE PROJECTIONS - AVERAGE MONTHLY PRECIPITATION

PE701-00020 M24006
Figure 5.2



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REKO DIQ PROJECT
DESIGN CLIMATOLOGY
CLIMATE CHANGE PROJECTIONS - MAXIMUM TEMPERATURE

PE701-00020 M24006
Figure 5.3

Precipitation Gauge

Evaporation Pan

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REKO DIQ PROJECT
DESIGN CLIMATOLOGY
CLIMATE MONITORING EQUIPMENT INSTALLED ON SITE

PE701-00020 M24006
Figure 6.1

Class A Evaporation Pan with bird guard (Source: Wikipedia)

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REKO DIQ PROJECT
DESIGN CLIMATOLOGY
CLASS A EVAPORATION PAN WITH GUARD

PE701-00020 M24006
Figure 6.2

Appendix C: Borefield Pipeline Access Surface Water Management

MEMORANDUM

To:	RDMC	**Date:**	08 May 2024
Attn:	Daniel Nel	**Our Ref:**	PE24-00573
		KP File Ref.:	PE701-00020/18-A acsb M24026
cc:	Russell Owen, Paterson & Cooke Australia Pty Ltd	**From:**	Dave Morgan

RE: REKO DIQ PROJECT - BOREFIELD PIPELINE ACCESS SURFACE WATER MANAGEMENT

Paterson & Cooke Australia Pty Ltd (PCA) is undertaking the design of the borefield pipeline access for the Reko Diq Project in the province of Balochistan in Pakistan. PCA requested assistance from Knight Piésold (KP) to undertake modelling to determine the hydrology of the catchments that the pipelines are located within. Due to the complex nature of these catchments, KP proposed completing rain on mesh modelling.

1. RAIN ON MESH MODELLING

KP developed rain on mesh models using the software package Riverflow2D, which is a two dimensional finite volume flood model that utilises an irregular triangular mesh. The area of interest was split into four parts, with a model developed for each one.

1.1 MODEL INPUTS AND ASSUMPTIONS

KP utilised the provided 1 m spaced raster as the base topography for this work. The mesh sized used was 5 m.

Key assumptions:

- Infiltration losses were estimated using the SCS Curve Number method assuming a SCS Curve Number of 86 and an Antecedent Moisture Condition (AMC) of 1.
- Design storm depths were taken from the previous work as described in the climate memo (Ref. 1).
- The Manning's roughness was assumed to be uniform over the catchment and was set to 0.024.
- The triangular distribution was assumed for all of the storm hyetographs.
- The 100 year ARI storm depths were used.

Due to the size of the area being modelled, it was split into four individual rain on mesh models. The model areas were determined based on the alignments of the Borefield Water Pipeline and Early Works (EW) Pipeline, as well as the catchment boundaries of the areas. The models are North, Camp, Center and South, as shown on Figure 1.1.

It is noted that KP did not extend the models further north as the borefield alignment moves onto alluvial fans at this point. It is expected that these areas are more likely to experience material deposition due to flow events, rather than erosion (although some localised erosion events are expected for higher rainfall intensities).

1.2 CRITICAL DURATION ANALYSIS

In order to determine which storm durations to extract results from, KP performed critical duration analysis. The storm events assessed were developed using the same methodologies and datasets as described in the Design Climatology (Ref. 1) and are summarised in Table 1.1.

Table 1.1: Assumed Storm Depths (100 year ARI)

Storm Duration (h)	Storm Depth (mm)
0.5	36.9
1.0	51.2
2.0	66.1
3.0	74.9
4.0	81.2
5.0	86.2
6.0	90.4
7.0	93.9

This was completed by outputting the flow rate across various cross sections that were added into the model prior to running them. These cross sections were placed at key locations within the model. The results from these assessments are summarised on figures 1.2 to 1.5.

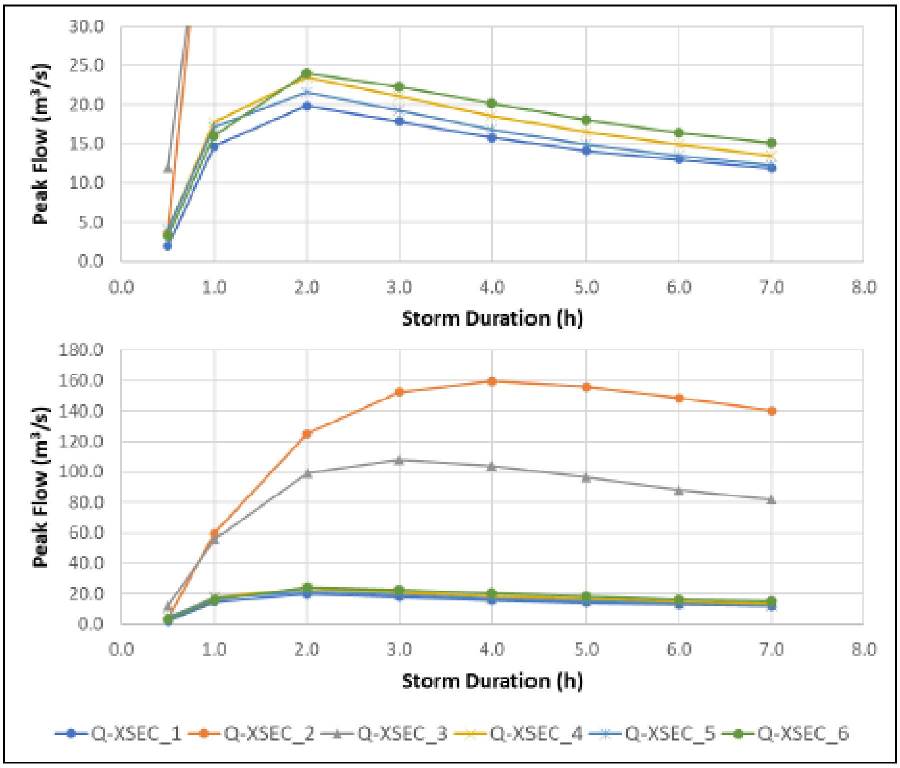

Figure 1.2: Results – North Area

PE24-00573

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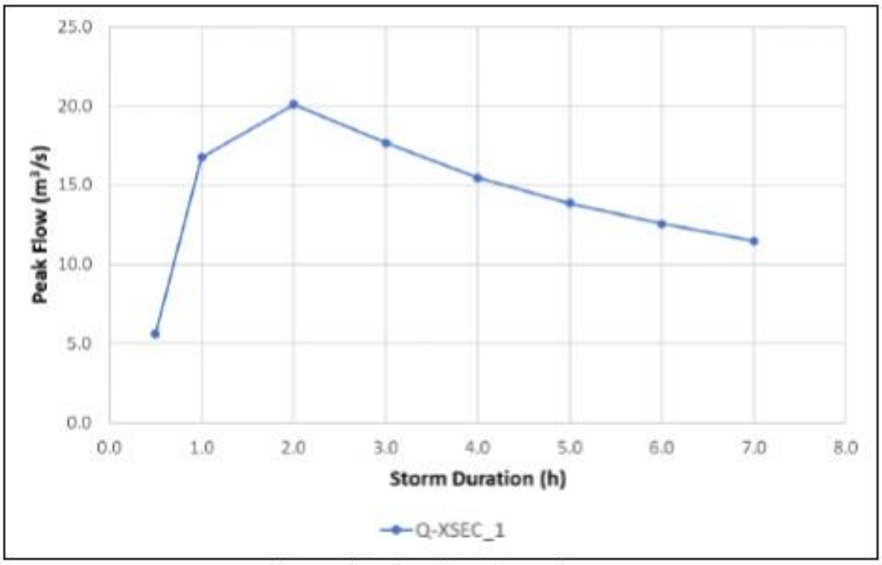


Figure 1.3: Results – Camp Area

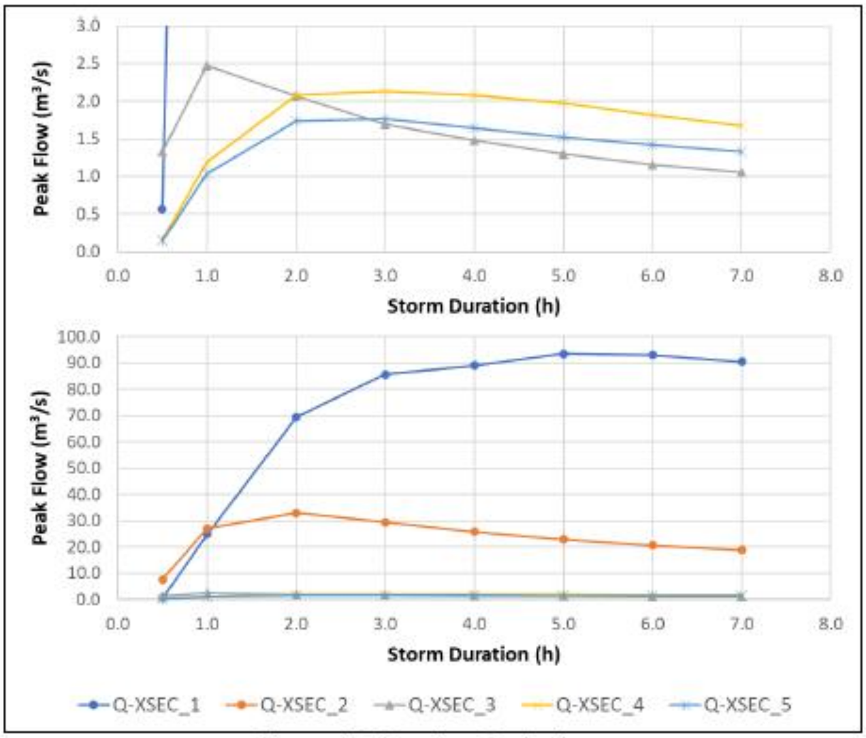


Figure 1.3: Results – Center Area

PE24-00573

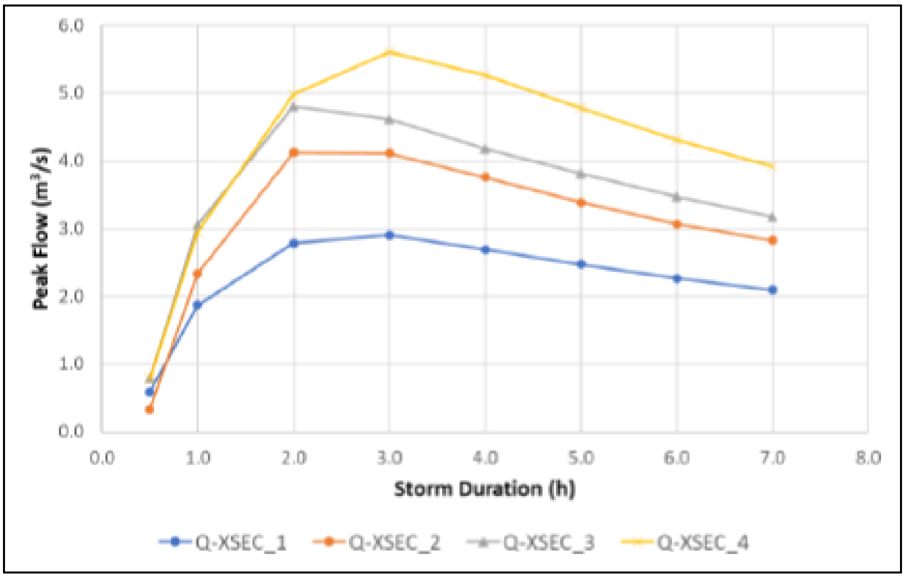


Figure 1.4: Results – South Area

Figures 1.2 to 1.5 show that the critical durations for the areas of interest lies between 0.5 hours and 7 hours. As such, KP did not run events with shorter durations than 0.5 hours or events longer than 7 hours.

1.3 MODELLING RESULTS

The modelling results were processed taking the resulting raster maps for maximum velocities for each of the events run. For each of the durations, the maximum velocity was taken to produce a combined maximum velocity map.

The maximum velocity maps are shown on figures 1.6 to 1.9. On figures 1.10 and 1.11, the velocity map is shown along with long sections of maximum velocity, for both the Borefield Water Pipeline and the EW Pipeline.

The results show that velocities of up to 3.9 m/s are possible in the locations where flow concentrates in the wadis along the borefield pipeline access alignment.

1.4 GROUND CONDITIONS

Based on the test pitting programme, the near ground conditions are broadly consistent along the pipeline alignment comprising a shallow layer of loose to medium dense gravelly sand/sandy gravel with silt overlying variably cemented medium dense to dense gravelly sand/sandy gravel, becoming increasingly dense/cemented, and/or overlying bedrock. In general terms, the-sub-surface conditions along the alignment can be divided into 3 broad sections, as follows:

- Chainage 0 to 19000 - the pipeline alignment traverses roughly flat and open plain and excavation refusal was typically encountered in cemented gravelly sand/extremely weathered bedrock at between approximately 1.5 m and 2.5 m depth;

- Chainage 19000 to 33000 - the proposed pipeline is aligned between mountainous terrain to the north and south and excavation refusal was encountered typically on bedrock at depths of between approximately 0.5 m and 1.0 m; and
- Chainage 33000 to 45300 - the pipeline alignment traverses roughly flat and open plain and excavation refusal varied between approximately 0.8 m and 3.0 m, averaging approximately 1.2 – 1.3 m.

It is noted that the points above refer to the original chainages of the original alignment as shown in the Borefield Pipeline Corridor Preliminary Geotechnical Assessment (Ref. 2) and not the chainages shown on figures 1.10 and 1.11.

Based on the geotechnical investigation, the ground conditions are expected to be reasonably resistant to scouring.

1.5 MODELLING LIMITATIONS

The modelling has the following key limitations:

- Mesh size was set to approximately 5 m. Any minor creeks and tributaries smaller than this will not have been defined accurately. Localised areas of higher velocity could be possible; and
- Adopted topography was the 1 m DTM survey for the project area, with no adjustments for any proposed infrastructure. Changes to the surface could result in higher or lower velocities in different areas.

1.6 RECOMMENDATIONS

KP notes that due to the limitations of this work it is not possible to estimate the risk of scour to the pipeline due to uncertainties regarding the rate of both erosion and deposition. For the design of open channels, velocities less than 1.5 m/s are generally considered low enough such that armouring is not required. KP recommends that this be used as a guideline in order to identify the locations that could require scour protection, as shown on figures 1.10 and 1.11. Alternatively, the observational approach could be adopted, with the “at risk” areas monitored and remediated if and when scouring is detected after significant rainfall events.

KP notes that there are portions of the alignment that could be adjusted to avoid areas with the potential to experience higher velocities. An example of this is around chainage 5700 on figures 1.10 and 1.11, where the alignments cross the wadi. This location is a point where the wadi narrows resulting in higher flow velocities. Crossing the wadi further downstream, after the constriction, is recommended.

We trust the information provided is sufficient at this stage, however, please contact us should you require any additional detail.

Yours faithfully
KNIGHT PIÉSOLD PTY LTD

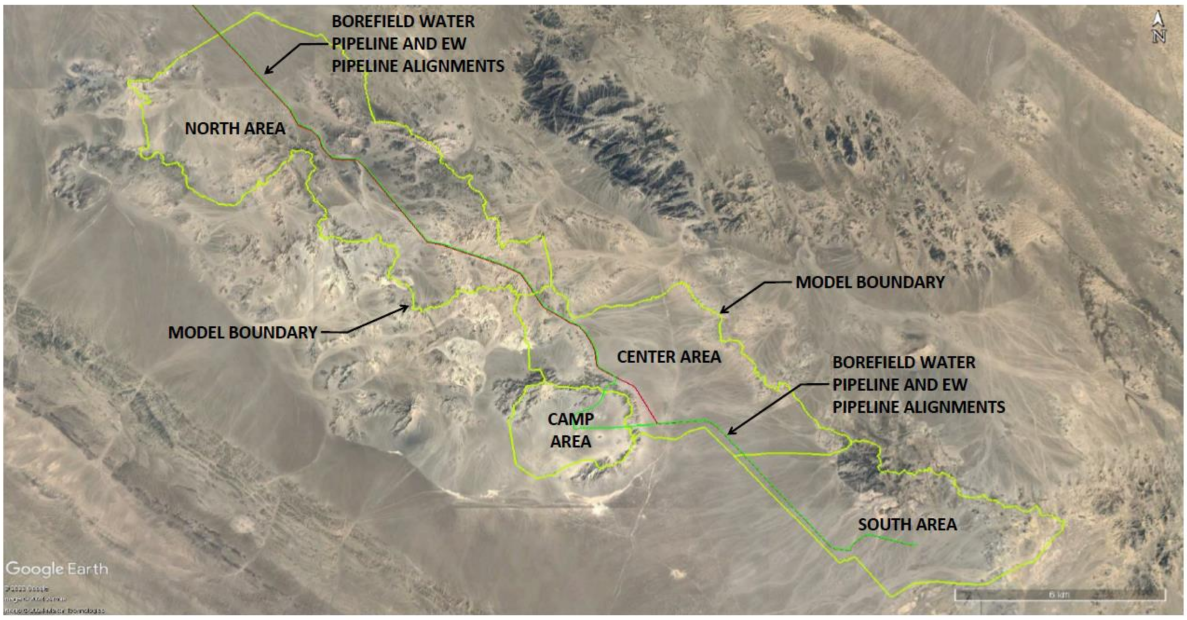
ANDREW BROWN
Senior Project Engineer

DAVID MORGAN
Managing Director

REFERENCES

1. Knight Piésold Memorandum Ref. PE24-00070, "*Reko Diq Project – Design Climatology*", January 2024.
2. Knight Piésold Memorandum Ref. PE25-00051, "*Reko Diq Project – Borefield Pipeline Corridor Preliminary Geotechnical Assessment*", January 2024.

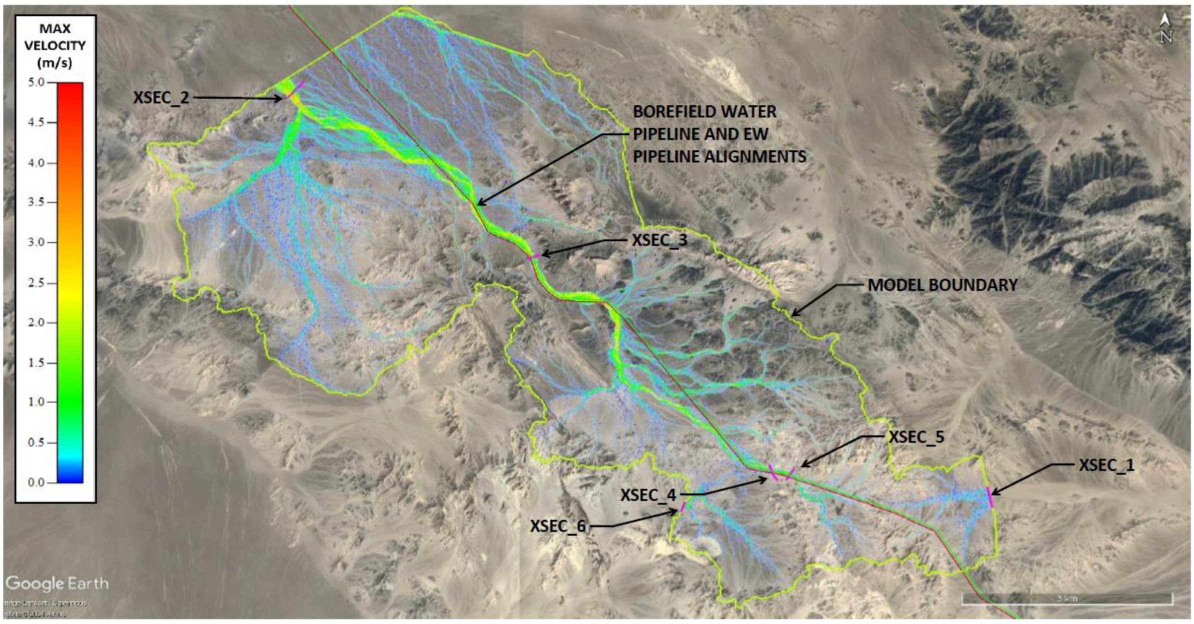
FIGURES



Knight Piésold CONSULTING

REKO DIQ PROJECT
BOREFIELD PIPELINE ACCESS SWM
MODEL LAYOUT

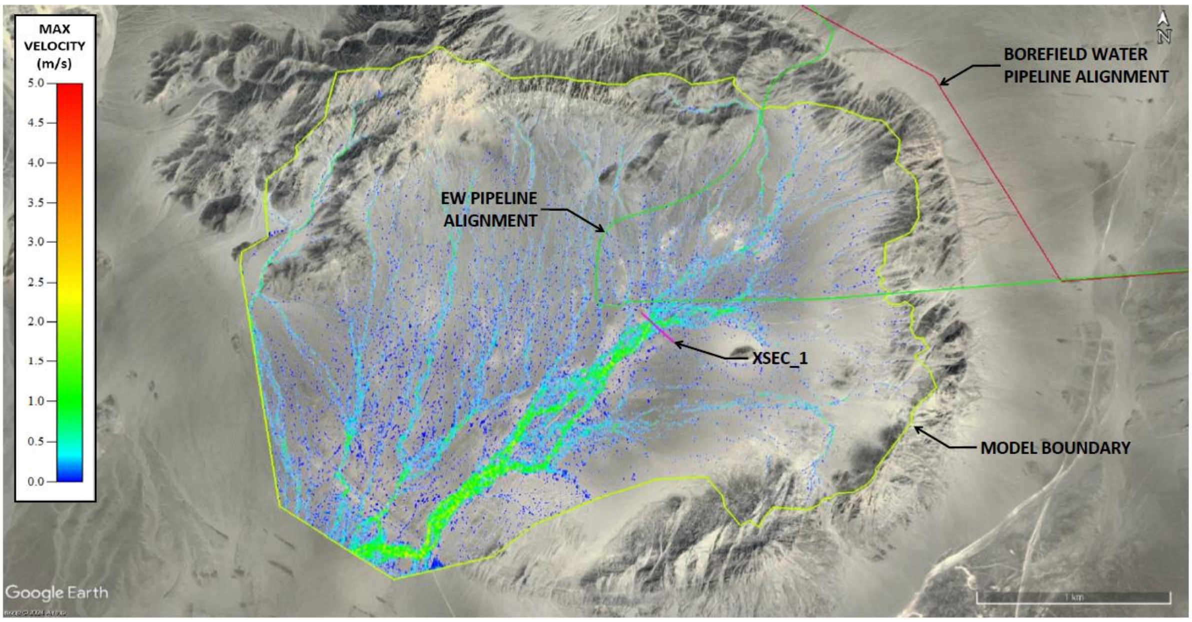
PE701-00020 M24024
Figure 1.1



Knight Piésold CONSULTING

REKO DIQ PROJECT
BOREFIELD PIPELINE ACCESS SWM
NORTH AREA

PE701-00020 M24024
Figure 1.6



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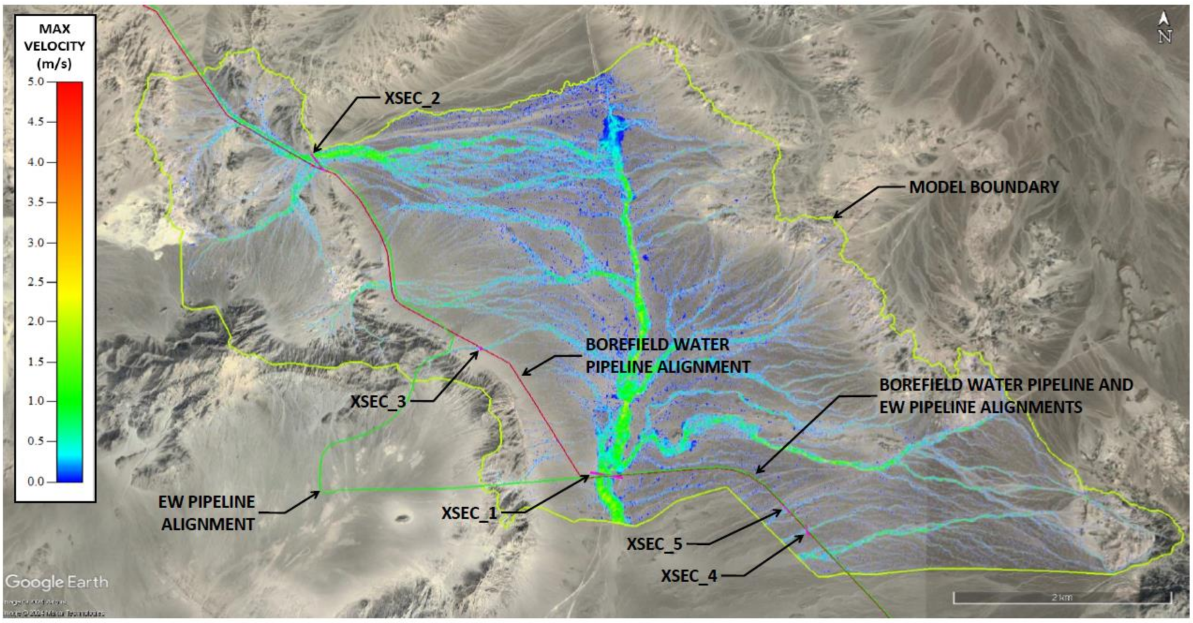
REKO DIQ PROJECT
BOREFIELD PIPELINE ACCESS SWM
CAMP AREA

PE701-00020 M24024
Figure 1.7



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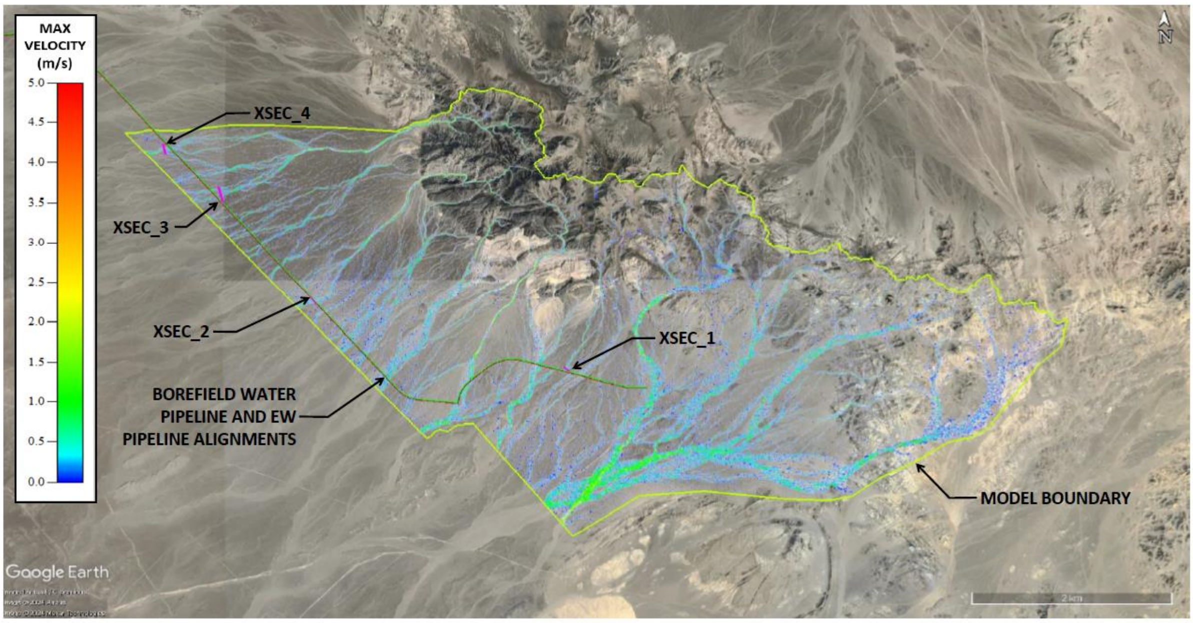
REKO DIQ PROJECT
BOREFIELD PIPELINE ACCESS SWM
CENTER AREA

PE701-00020 M24024
Figure 1.8



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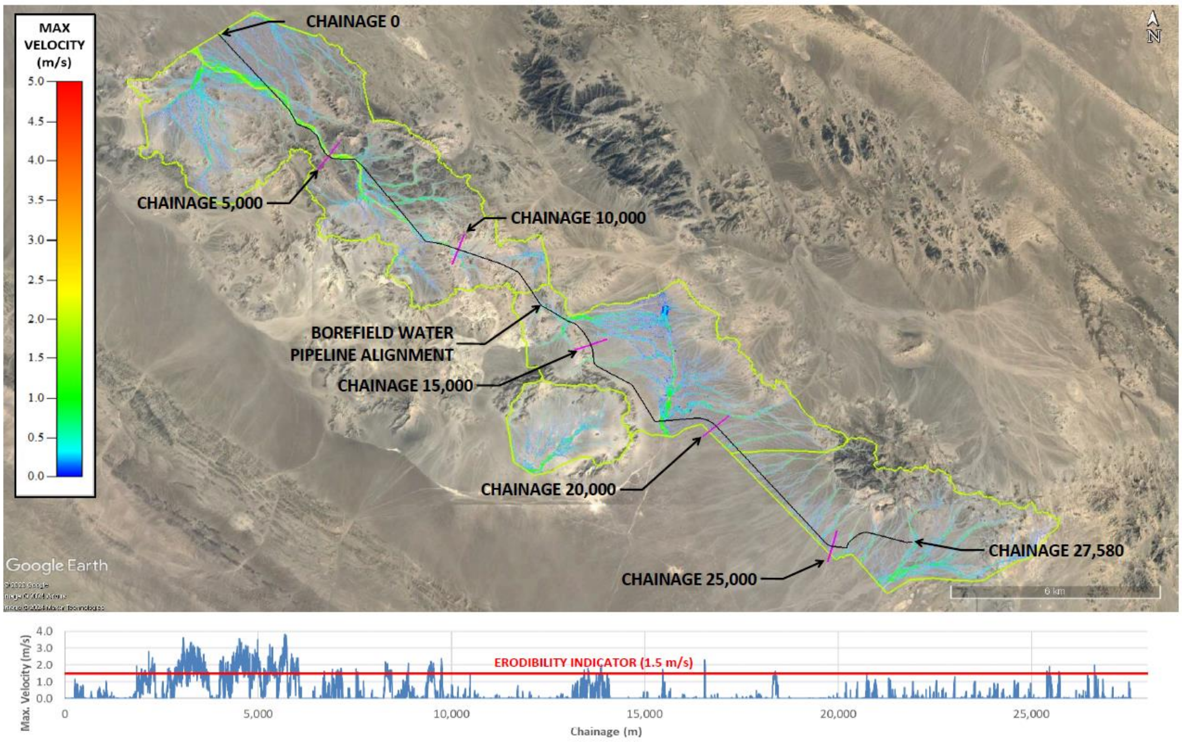
REKO DIQ PROJECT
BOREFIELD PIPELINE ACCESS SWM
SOUTH AREA

PE701-00020 M24024
Figure 1.9



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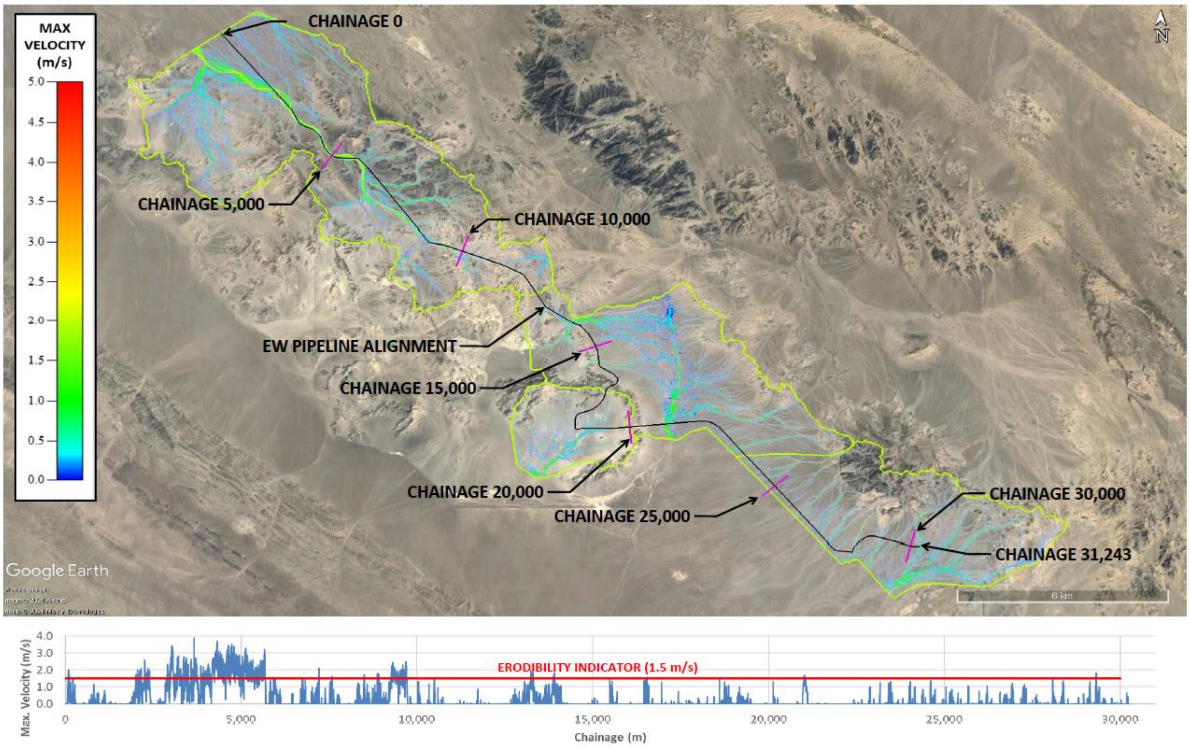
REKO DIQ PROJECT
BOREFIELD PIPELINE ACCESS SWM
MAXIMUM VELOCITY ALONG THE BOREFIELD WATER PIPELINE ALIGNMENT

PE701-00020 M24024
Figure 1.10



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REKO DIQ PROJECT
BOREFIELD PIPELINE ACCESS SWM
MAXIMUM VELOCITY ALONG THE EW PIPELINE ALIGNMENT

PE701-00020 M24024
Figure 1.11

Appendix D: Existing Surface Water Hydrology

MEMORANDUM

To:	RDMC	Date:	25 August 2023
Attn:	Daniel Nel	Our Ref:	PE23-00886
		KP File Ref.:	PE701-00020/18-A dss M23016
cc:	Ashley Price, Russell Owen	From:	Dean Sawyer

RE: REKO DIQ COPPER-GOLD MINING PROJECT – EXISTING SURFACE WATER HYDROLOGY

EXECUTIVE SUMMARY

The Reko Diq Copper-Gold Mining Project is approximately 750 km northwest of Karachi in the Chagâi District of Pakistan. Knight Piésold (KP) was commissioned by Reko Diq Mining Company (RDMC) to develop amongst other things, a surface water management plan for the site. This involved conducting an assessment and developing a strategy for managing surface water during operation and closure.

The site is located approximately 400 km inland from the Arabian Sea with very infrequent storms. As a result, the surface water management strategy is event based with monitoring occurring following rainfall events. At this stage of the project the location of key infrastructure is still being determined, as a result, an existing conditions hydrology assessment has been conducted.

The catchment areas around site vary from steep and rocky reliefs to sand dunes, resulting in variable infiltration. The majority of the infrastructure will be located within the flatter wadis or flood plains which can experience sudden and destructive flash flooding. A review of the topography highlighted critical locations and areas where significant ponding is expected to occur. The information can be used in siting structures or as part of the Multi-Criteria Accounts Analysis to compare options.

1. PREVIOUS STUDIES

As part of the 2008 works the climatic conditions of the site were assessed by Barrick Gold Corporation (Ref .1). The 24-hour design storm depth was estimated as 23 mm, 34 mm, 50 mm, 62 mm, 74 mm, and 118 mm for Annual Recurrence Intervals (ARIs) of 5, 10, 25, 50, 100 and 1000 years respectively. It is understood this will be updated with the current work plan.

The KP Feasibility Study (Ref 2) in 2010 utilised the topography available to design diversion systems upstream of the proposed Tailings Storage Facilities (TSFs). Apart from the diversions around the TSF, no significant diversion or containment structures were proposed.

2. TOPOGRAPHY

As part of the current update, revised topography was provided by Barrick (January 2023) for the local area which consisted of a Digital Terrain Model (WGS1984 UTM Zone 41N) in 1 m, 5 m and 10 m grid spacings. It is noted that for this work the 5 m DTM was utilised. In addition, Advanced Land Observing Satellite (ALOS) topography was sourced for areas not covered by the provided site topography.

The full ALOS topography area was delineated into major catchments using the computer program QGIS. The site relevant to the project was then split into east and west catchment areas for further analysis. The major catchment divides relative to the lease boundaries and detailed DTM are shown on Figure 2.1.

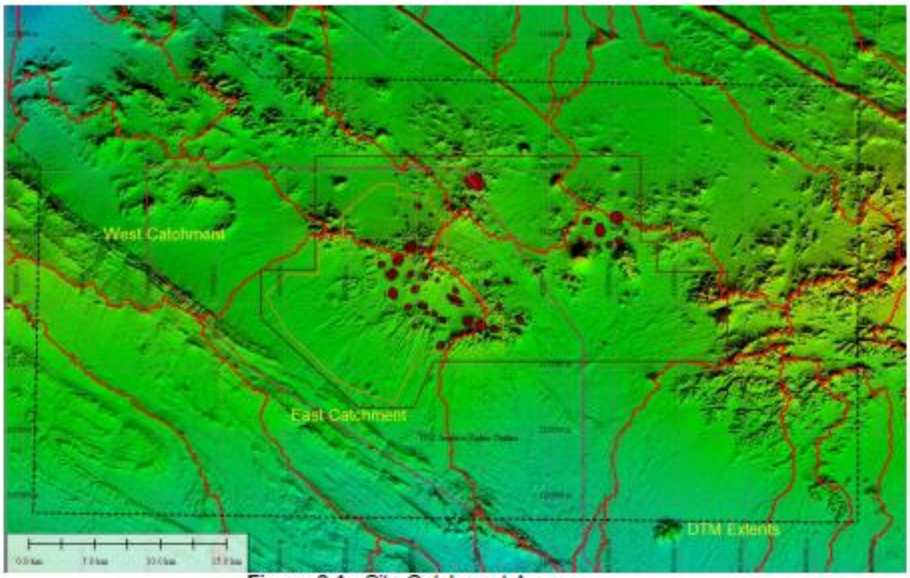


Figure 2.1: Site Catchment Areas

Smaller catchments consist of complex alluvial braided flow paths from sedimentary deposits which may change over time. As a result, instead of delineating catchments further, a rain on mesh approach was used to assess small catchments using the more detailed DTM surface.

3. RAIN ON MESH FLOOD MODELLING

Rain on mesh hydrological modelling was undertaken using the computer program, RiverFlow2D, to estimate surface water run-off flow depths and velocities based on a design rainfall event. Rain on mesh modelling simulates the addition of water volume to a triangular mesh based on its area and the rainfall depth over time. With each section of mesh having water added to it, water then flows and concentrates into streams of flows based on the topography. For this assessment the following assumptions were made:

- A 74 mm rainfall event over a 24 hour period (equivalent to 1% AEP, 100 year ARI).
- A constant rainfall pattern was assumed (3.1 mm/h for 24 hours).
- Infiltration was not accounted for in these preliminary models.
- Manning's roughness was assumed to be 0.024.
- Multiple outflow boundaries to remove water from the model where appropriate.
- No existing surface water management infrastructure were identified.

The results are provided in Figure 3.1 for maximum flow velocity for the two catchment areas. Flow velocity less than 0.05 m/s are not shown for clarity. Due to the large area of the site, more detailed maps (velocity, depth and depth x velocity) are provided in Appendix A and will be provided electronically in GIS format.

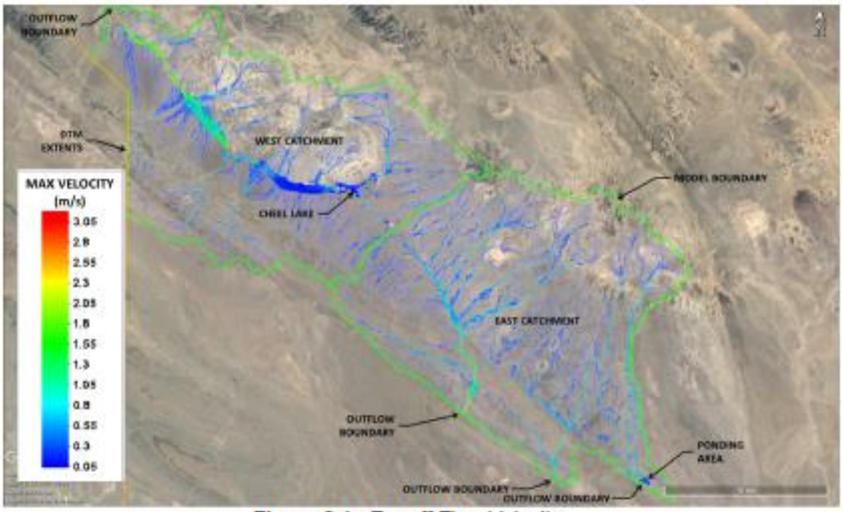


Figure 3.1: Runoff Flow Velocity

The findings from the assessment indicate the following:

- The east catchment flows off site to the south via a series of gaps in the ridge line.
- Ponding occurs in the south-east corner of the catchment. With sufficient runoff this location would overflow to the south.
- The west catchment ponds locally at Cheel Lake – East before cascading to Cheel Lake – West. Ongoing flow continues to the northwest off site.

The modelling results can be used to assess if key infrastructure will be located within areas of hydrologic concern which may require more detailed modelling. Once the location of the TSFs have been confirmed, the rain on mesh analysis will be updated with the proposed infrastructure incorporated into the model in order to assess its impact on the surface water movement. Any diversions or channels will then be sized to manage the runoff.

We trust that the foregoing provides adequate information for your current purposes. However, please contact us should you have any queries or require additional information.

Yours faithfully
KNIGHT PIÉSOLD PTY LTD

ANDREW BROWN
Senior Project Engineer

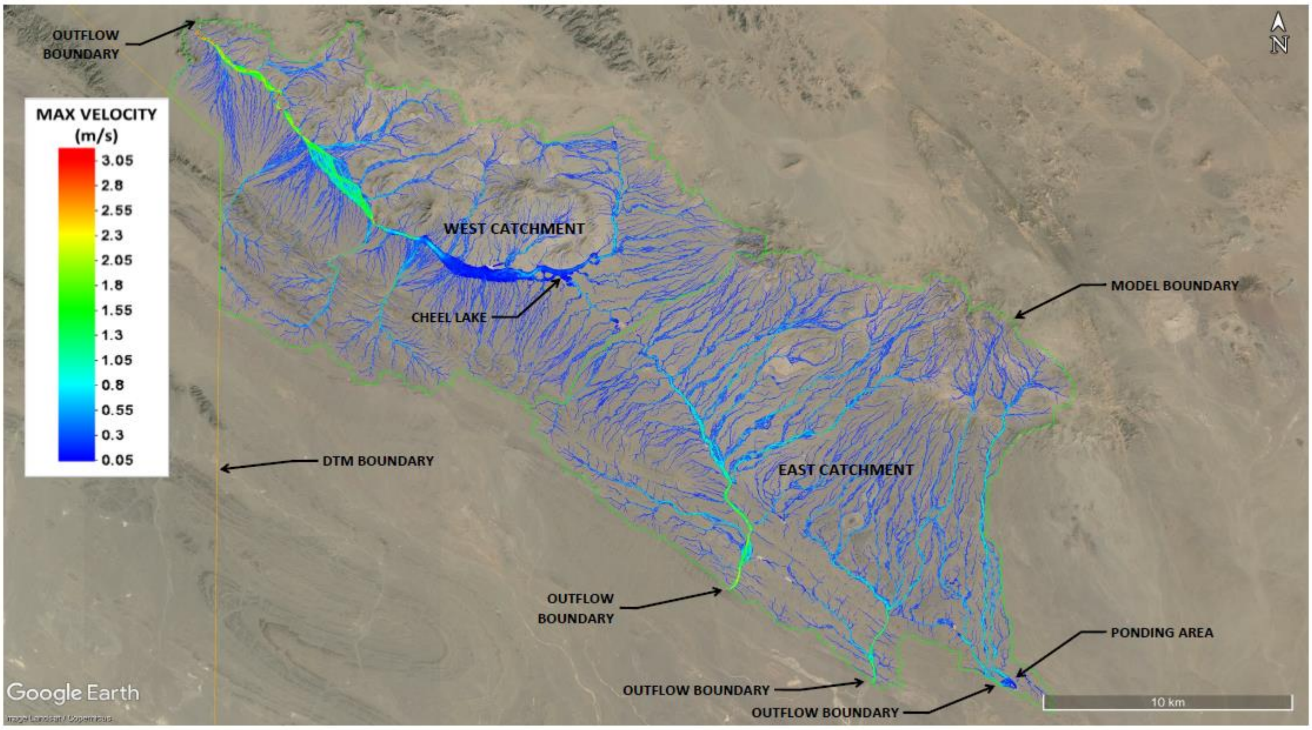
DAVID MORGAN
Managing Director

REFERENCES

1. Barrick Gold Corporation, "*Rainfall and Evaporation Study Reko Diq Project, Chagai District, Balochistan, Pakistan*", Draft January 2008.

2. Knight Piésold Pty Ltd, Report Ref. PE701-00020/20, "*Reko Diq Project – Tailings Storage Facility Initial Mining Development Feasibility Study*", Rev 0, February 2010.

APPENDIX A
Detailed Rain on Mesh Mapping



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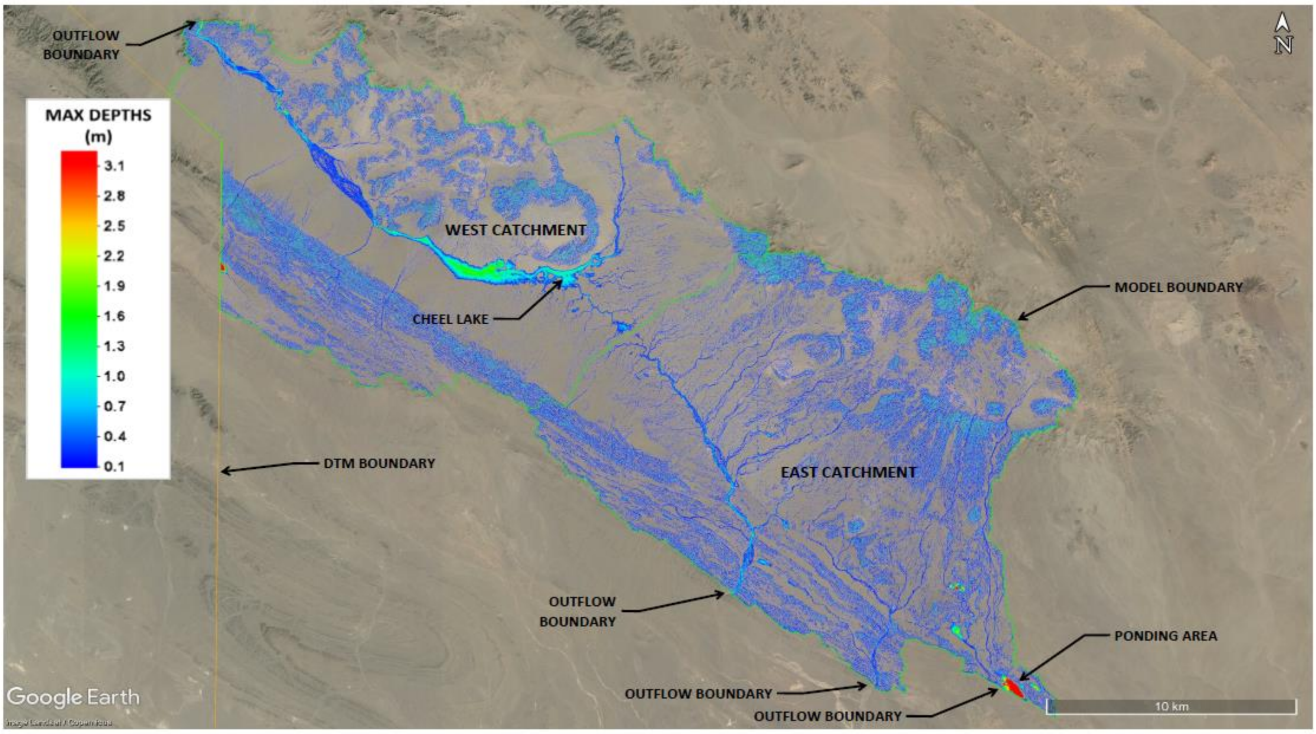
REKO DIQ PROJECT
DETAILED RAIN ON MESH MAPPING
RAIN ON MESH - 100 YEAR ARI 24 HOUR STORM - MAX VELOCITY

PE701-00020 M23016 APPENDIX A
Figure A1



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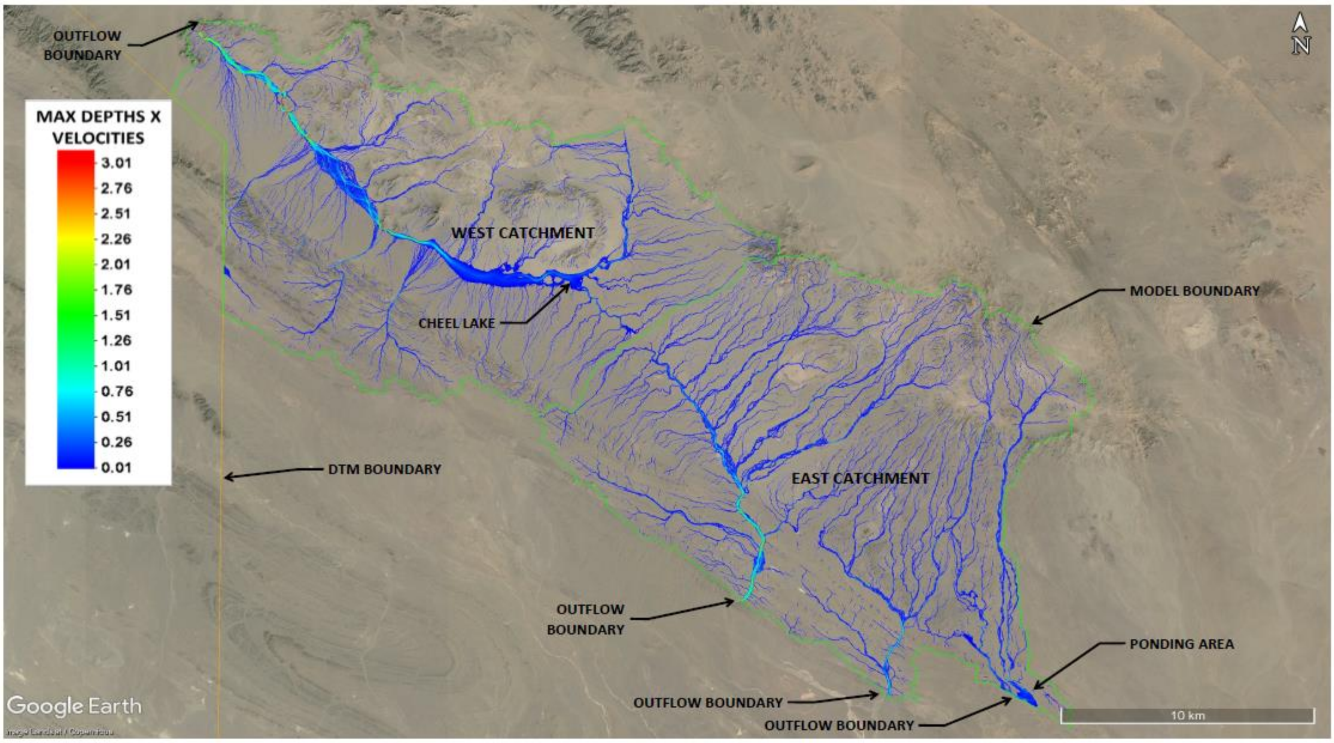
REKO DIQ PROJECT
DETAILED RAIN ON MESH MAPPING
RAIN ON MESH - 100 YEAR ARI 24 HOUR STORM - MAX DEPTHS

PE701-00020 M23016 APPENDIX A
Figure A2



Knight Piésold CONSULTING

REKO DIQ PROJECT
DETAILED RAIN ON MESH MAPPING
RAIN ON MESH - 100 YEAR ARI 24 HOUR STORM - MAX DEPTHS X VELOCITIES

PE701-00020 M23016 APPENDIX A
Figure A3

Appendix E: TSF Concept Closure Plan

Knight Piésold CONSULTING

MEMORANDUM

To:	RDMC	**Date:**	27 June 2024
Attn:	Daniel Nel	**Our Ref:**	PE24-00795
		KP File Ref.:	PE701-00020/18-A dss M24036
cc:	Ruan Pretorius, Ashley Price	**From:**	Dean Sawyer

RE: REKO DIQ – TSF CONCEPT CLOSURE PLAN

EXECUTIVE SUMMARY

The Rougher and Cleaner Tailings Storage Facility (TSF) at the Reko Diq Copper Mine is currently being designed to Feasibility level. The conceptual closure plan vision is to develop a safe, stable, erosion resistant and non-polluting landform with no requirement for ongoing maintenance post closure. The Post Mining Land Use (PMLU) is to resemble the surrounding landscape where practicable. Site trials and progressive closure of TSF cells will occur during operation and will form the basis for closure design updates as the site approaches mine closure.

The concept closure plan has been developed to meet the Barrick Tailings Management Standard (BCG-MI-ST-01 Rev. 002, 2022) of a dry closure cover regardless of the operational Failure Consequence Classification. The parallel goal is to meet the closure design for GISTM (Ref 1) Requirement 5.6 to a "*sufficient detail to demonstrate the feasibility of the closure scenario and to allow implementation of elements of the design during construction and operation as appropriate*". Integration with the site wide closure plan will be coordinated by RDMC.

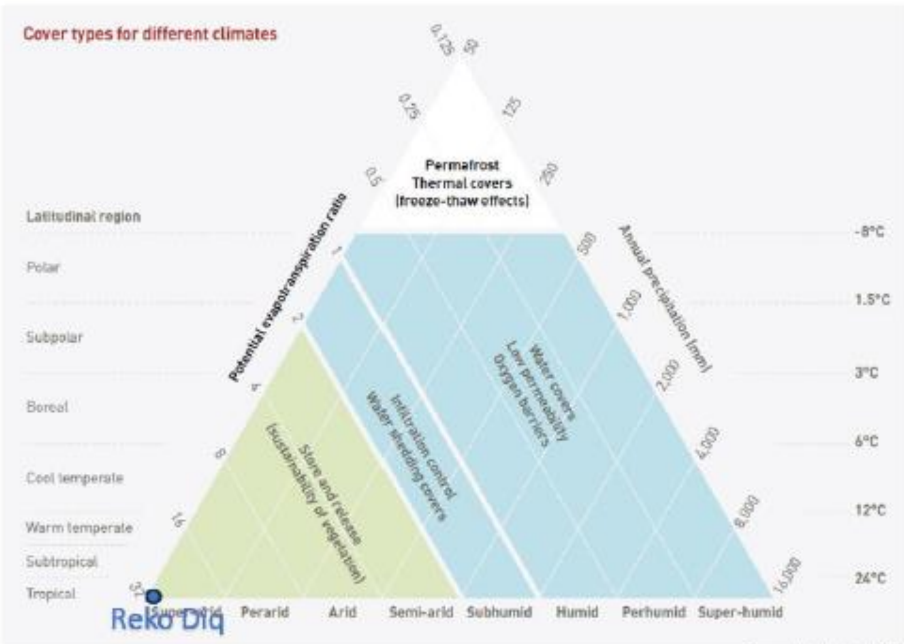
The proposed Rougher TSF closure design is contoured berms and swales over the tailings surface with exposed beaches in between. A small ephemeral pool will be located in front of each closure spillway to shed runoff from the facility. The proposed Cleaner TSF closure design is a full gravel or mine waste cover over the entire tailings surface. The surface will be profiled to a closure spillway in each cell, cascading runoff between cells before discharging off site. Downstream batters of all facilities will be profiled to an overall 3.5H:1V slope of waste rock, preferably during operation.

1. CLIMATE CONDITIONS

Climate data for design is being sourced from several locations and is being used differently by various disciplines. An assessment for rainfall and evaporation was conducted by KP (Ref 2) which indicated the site is in an "Arid, desert hot climate" (BWh) based on the Köppen climate classification.

Average annual long term rainfall was estimated to be 32 mm/year however can range from zero all year to upwards of 219 mm over about 3 months. It is noted that the operational TSF water balance assumed zero rainfall conditions. An estimated 100 year Average Recurrence Interval (ARI) 24 hour event is 125 mm and the Probable Maximum Precipitation (PMP) 24 hour event was estimated to be 425 mm. Average annual pan evaporation was estimated to be 5,026 mm/year with lake evaporation of 2,505 mm/year.

From the climate data above, the potential cover type for Reko Diq strongly indicates "Store and Release" as shown on Figure 1.1. A "Store and Release" cover design intentionally retains water on the near flat surface for evaporation, vegetation evapotranspiration to take place with some deep infiltration occurring. However, provision for water shedding will still be included for larger events.



Source: Wickland et al 2007

7. Wickland, BE, Wilson, GW, Wijewickreme, D, and Klein, B (2006). 'Design and evaluation of mixtures of mine waste rock and tailings', *Canadian Geotechnical Journal*, 43:9, pp 928–45.

Figure 1.1: Cover types for different climates

Whilst a conventional Store and Release cover aims to promote sustainability of vegetation, the surrounding landscape is generally devoid of native vegetation. Local lake beds in the area, which act as catchment termination points, show some vegetation on their periphery but generally behave as sediment accumulation areas following rainfall events. The most notable vegetation growth generally occurs when natural wadis are artificially bunded and over time, begin to support vegetation. Both of these formations will be replicated on the surface of the TSFs.

2. FINAL LAYOUT AND DEPOSITION SURFACE

The final TSF layout is based on the 3.2 Bt Option 0E-B (offset from the Tozgi Fault) presented in June 2024. It consists of two Rougher TSFs (RF1 and RF2) of total inundation area of 5,075 Ha. It also consists of three Cleaner TSFs (CF1, CF2 and CF3) of total inundation area of 934 Ha.

A concept of the final surface design is shown on Figure 2.1 assuming reprofiling of the Cleaner TSFs.

PE24-00795

3

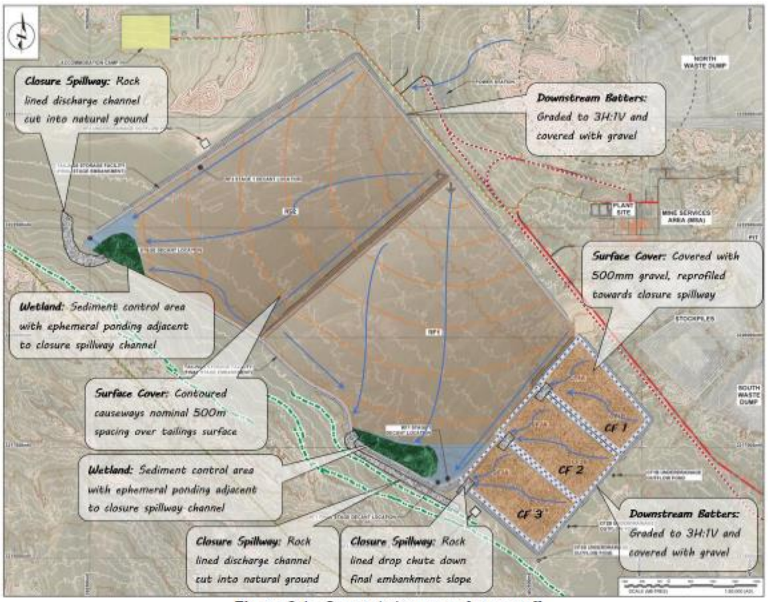


Figure 2.1: Concept closure surface runoff

PE24-00795

The final tailings beach surface of the Rougher TSFs is based on essentially a single point deposition located in the corner of each facility. The tailings will naturally deposit as an alluvial fan at approximately 1V:200H slope to the diagonally opposite corner where a low spot will form. No reshaping post closure is proposed, instead the natural contoured slope will be utilised in the cover surface. Along contour causeways will be constructed at nominally 500 m spacing across the surface to act as wind breaks and surface water bunds. Swales will be constructed within the tailings in between the bunds to promote infiltration and sediment control after any rainfall events. As the Rougher facility is predominantly unlined, infiltration will report to either the underdrainage system (gravity outlet to surface) or groundwater.

The final tailings beach surface of each Cleaner cell is based on full perimeter deposition occurring during operation. Each cell is divided in half (A and B) by the construction of a central wall where the final pond will be located. At closure, the full tailings surface will be covered with a minimum of 500 mm gravel or mine waste. Minor re-profiling by varying cover depth (thicker in the central pond) will allow shedding of runoff water via a closure spillway in the west corner of each cell for large events. As the cleaner cells will be HDPE lined, the phreatic surface in the facility post closure will fluctuate up to the base of the cover layer at times.

3. SURFACE WATER MANAGEMENT

The closure hydrology design include the spillway design, surface water runoff on the closure surface and downstream toe surface water management. Modelling will be based on using PMP design storms and runoff routing to determine critical durations for each area and event.

The Rougher TSF closure spillways will be located at the centre of the south embankment for RF1 and the west corner at natural ground for RF2. A small ephemeral pool will be located immediately upstream of each closure spillway to collect sediment from the tailings surface and to attenuate flows before discharge. Some vegetation may begin to form in this area as a result of rainfall collection but they will generally mimic the local dry lake beds. A rock lined channel will then convey runoff past the downstream toe of the embankment to the environment. The underdrainage system will continue to flow passively by gravity.

A Cleaner TSF closure spillway will be located at the west corner of each cell to cascade excess flows from CF1 to CF2 to CF3. A final closure spillway from the CF3 facility to natural ground will consist of a rock lined drop chute structure with benches to suit the embankment downstream profile. The underdrainage system will be decommissioned by sealing the outlet pipe.

The perimeter toe of the Rougher and Cleaner TSF embankments will consist of a small rock bund. This will prevent surface erosion of the toe, especially from upstream catchments to the northeast and also provide some sediment control from the embankment runoff.

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The perimeter toe of the Rougher and Cleaner TSF embankments will consist of a small rock bund. This will prevent surface erosion of the toe, especially from upstream catchments to the northeast and also provide some sediment control from the embankment runoff.

4. TIMING

The following timing is being considered for Rougher TSF closure activities:

- Continue collecting rainfall runoff (in the supernatant pond) from the dormant RF1 whilst RF2 is operational. Either allow water to evaporate or pump to the process plant. Commence closure trials on RF1 in the upper areas approximately 1 -2 years after stopping deposition.
- Continue underdrainage pumping from RF1 and measure the reduction in flow over time during the operational phase to predict long term steady state flows.
- Commence contour causeways and swale construction on remaining RF1 during operation (5 years after closure trials) to allow performance monitoring, especially dust formation, during operation.
- Commence contour causeways and swale construction on RF2 in the upper areas approximately 1 -2 years after stopping deposition (mine closure) and advance over the full area.
- Continue underdrainage pumping from RF2 for 5 years after mine closure and discharge onto upper surface. Following this, both Rougher TSF underdrainage systems will discharge passively to the environment.
- Excavate closure spillway and construct channel for both Rougher TSFs.

The following timing is being considered for Cleaner TSF closure activities:

- Continue pumping rainfall runoff (central supernatant pond) from the dormant CF1 whilst CF2 is operational. Assess water quality over time.
- Commence closure trials on CF1 adjacent to the embankments approximately 1 -2 years after stopping deposition.
- Continue underdrainage pumping from CF1 and measure the reduction in flow over time and change in water chemistry during the operational phase to predict long term steady state flows and quality.
- Commence closure cover on full CF1 during operation (5 years after closure trials) to allow performance monitoring during operation. Observation and measurement of tailings settlement and water quality will be critical.
- Excavate closure spillway from CF1 to CF2 during operation of CF2.
- Repeat activities for CF2 whilst CF3 is operational, documenting lessons learnt and changes to the closure design.
- Commence closure cover on CF3 over the full area approximately 1 -2 years after stopping deposition (mine closure).
- Progressively seal off the underdrainage systems starting at CF1, possibly before mine closure. Observe any increases in phreatic surface within the Cleaner tailings up to the base of the cover material.
- Excavate and construct closure spillway from CF3 to natural ground.

It is not expected that any significant treatment of decant water or underdrainage flow is required for both facilities for any significant amount of time. The duration of the capping period on each cell will be a function of equipment availability and ground conditions. Post closure monitoring duration will be determined based on completion criteria for each aspect. For Reko Diq, the post-closure monitoring periods have been assumed to be approximately 10 years.

5. QUANTITIES

On the basis of the above cover design and the proposed final deposition surface, the closure area is approximately 60 km^2 of exposed tailings. It is assumed that the embankment profile fill is covered under operational budgets.

The Rougher cells are based on construction of contour causeways every 500m, equating to 102 km of length. Assuming a single lane width with turning bays, depending on the construction equipment (15 m wide, 1 m thick used), approximately 1.5 Mm^3 of waste is required. An additional 406 km of swales would be constructed between the causeways.

The Cleaner cells are based on a minimum 500 mm thick gravel or mine waste cover over the tailings. Assuming this increases to 1.5 m thick in the centre of each facility, a total of approximately 7.8Mm^3 of fill would be required.

The closure spillway quantities will be relatively small and waste rock should be in abundance during operation for progressive closure. Closure specific instruments and monitoring devices will be costed as part of the trials and detailed closure designs. Ongoing post-closure monitoring costs have not been included.

6. POTENTIAL DATA GAPS

A number of data gaps have been highlighted in order to advance the concept closure cover into a feasibility level and potential government submission. This consists of the following:

- Review of the latest guidelines, closure commitments and stakeholder engagement to ensure the current post mine land use is acceptable.
- Physical and chemical testing of the tailings, potential waste rock cover materials and gravel for closure parameters, including erodibility.
- Conduct unsaturated soil numerical modelling of the various cover systems and geometries. This will estimate the performance of the different arrangements against one another for different climatic conditions.
- Conduct small scale site trials during operation in order to demonstrate different cover techniques. Typical rehabilitation trial plots will be instrumented where practicable.

There may be a requirement to conduct landform evolution modelling of the cover and downstream batters to estimate erosion rate and sediment yield. However, if rainfall is low, this is not generally required and visual assessments may be sufficient.

We trust this is sufficient information for further discussions with the RDMC team. In the meantime, please contact us should you require additional information.

Yours faithfully
KNIGHT PIÉSOLD PTY LTD

DEAN SAWYER
Principal Engineer

DAVID MORGAN
Managing Director

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