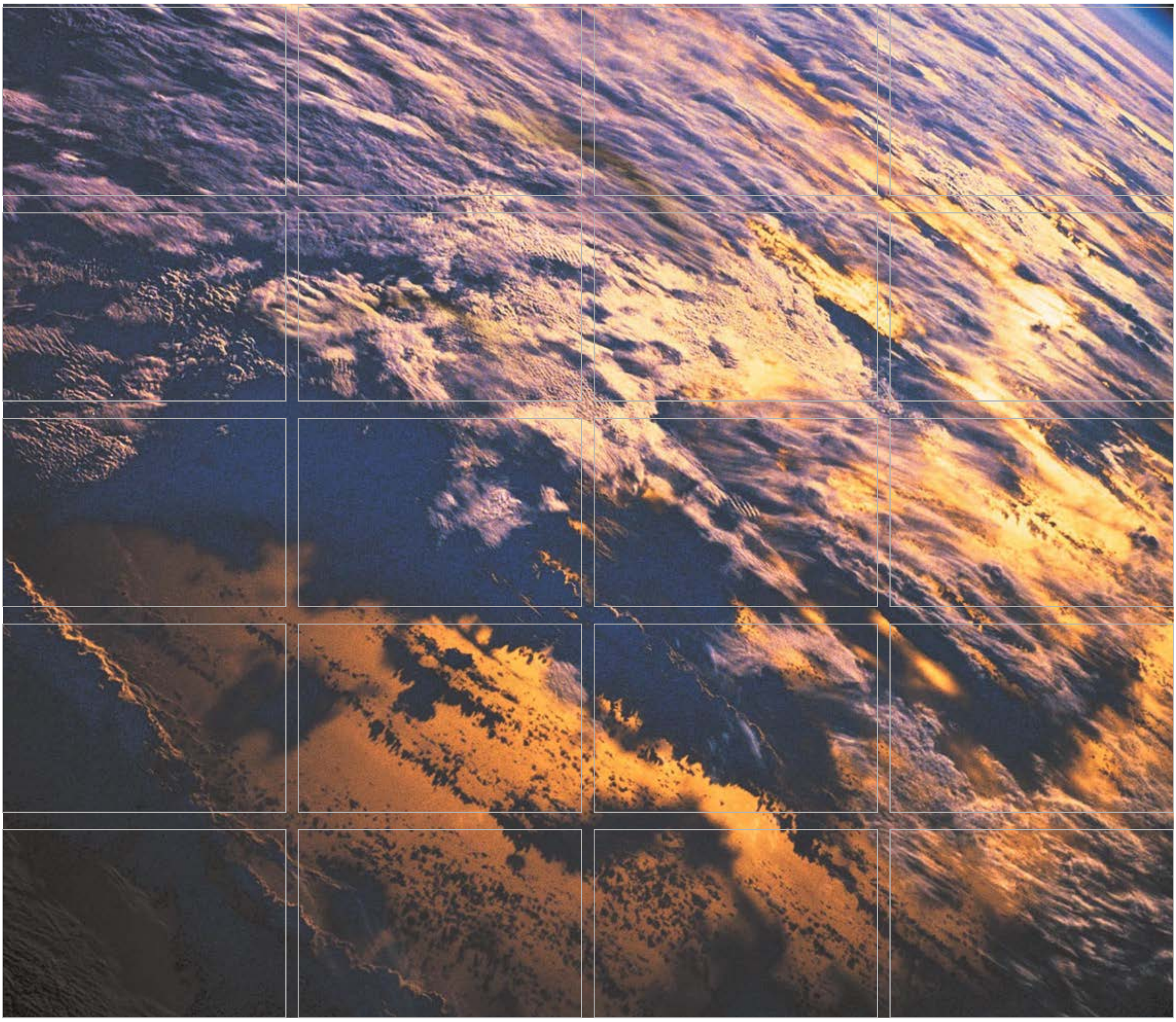

Water Resources Review for the 1 200 MW Thabametsi Coal-Fired Power Station in Lephalale, Limpopo Province, South Africa

Final Report

June 2017
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FINAL REPORT

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June 2017

For and on behalf of
Environmental Resources Management Southern Africa Pty (Ltd)

Approved by:

Sarah MacKay

Position: Partner

EXECUTIVE SUMMARY

This report provides a review of the potential impacts of climate change on water resources in the area in respect of the development of the 1,200 MW Thabametsi Power Station in Lephalale, Limpopo Province, South Africa, proposed under the South African Department of Energy (DoE)'s Coal Baseload Independent Power Producer (IPP) Procurement Programme ('Coal Baseload IPP Programme'). It is an appendix to the Climate Resilience Assessment (CRA) undertaken by ERM in 2016. The proposed Thabametsi Power Station (hereafter the ***'Project'***) will be built in two phases of 630 MW (Phase 1) and 570 MW (Phase 2). The ***Project*** will use circulating fluidised bed (CFB) technology, sub-critical steam conditions, and dry cooling technologies (ERM, 2016), which reduces overall water demand by up to 15 times compared to a conventional wet-cooled power station (Savannah Environmental, 2013).

The water requirements for the ***Project*** will be met entirely by the South African government's water transfer scheme in the region known as the Mokolo Crocodile (West) Water Augmentation Project Phase 1 and 2 (MCWAP-1 and MCWAP-2) which is being developed to meet the water needs of multiple stakeholders in the area including inter alia the Lephalale municipality, Eskom and Exxaro Coal (Pty) Ltd (Exxaro). The infrastructure options considered to augment water supply to the Lephalale area forming part of MCWAP includes the following:

- **Phase 1:** Augment the supply from Mokolo Dam; and
- **Phase 2:** Transfer scheme from the Crocodile River (West) to the Lephalale area.

The MCWAP-1 scheme has been operational since October 2015 and the available water has been fully allocated to users under water supply agreements between DWS and the users. The MCWAP-1 scheme has been supplying water to the users in accordance with the existing allocations which were determined under each water supply agreement. . This study takes into account findings from the CRA and publicly available data to assess the potential impacts of climate change on the water supply from the MCWAP-1 and MCWAP-2 schemes which will be used to meet the ***Project's*** water requirements.

In the CRA, there is good agreement between different climate models on the projected temperature increases (translating to high confidence in the projected changes) in the region, there is significant model disagreement with respect to precipitation projections, with climate models projecting both an increase and a decrease in seasonal and annual precipitation levels for the Mokolo catchment. It is noted that a change in precipitation can result in amplified hydrological impacts.

In addition to the above, in this report, an additional source of reference was used for evaluating the effects of climate change on water resources in the region. This was a study completed for the National Treasury and the National Planning Commission of South Africa with the help of the United Nations University World Institute for Development Economics Research (UNU-WIDER) in 2015 which considered impact on run off for various South African catchments including the Mokolo.

However, the climate change data currently available is not clear in respect of the probability of adverse effects and the future hydrological impacts. In light of the above, the impacts of climate change on the water resources for the MCWAP -1 scheme cannot be quantified. The MCWAP-2 scheme is currently under assessment and the climate change impact is still being assessed.

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1 INTRODUCTION

This report serves as an appendix to the Climate Resilience Assessment (CRA) undertaken by ERM in 2016, which is linked to the Climate Change Impact Assessment Report (CCIAR) completed for the 1,200 MW Thabametsi Power Station (hereafter the '***Project***') in Lephalale, Limpopo Province, South Africa, proposed under the South African Department of Energy (DoE)'s Coal Baseload Independent Power Producer (IPP) Procurement Programme ('Coal Baseload IPP Programme'). It expands on the CRA with respect to water issues, and seeks to explore what the impacts could be from climate change projections which have relevance to the *Project's* water supply and management.

The ***Project*** comprises a 1,200 MW coal-fired power station to be built in two phases (630 MW for Phase 1 and 570 MW for Phase 2 respectively), and will source its coal from Exxaro's adjacent Thabametsi coal mine.

Aspects of the other reports prepared by ERM have been drawn upon and are therefore cross-referenced within this Report.

1.1 REPORT STRUCTURE

The remainder of this report is structured into the following sections:

- *Section 2* presents the background to this study;
- *Section 3* presents the methodology and documents reviewed;
- *Section 4* presents a discussion on the potential effects of climate change on the project's water supply (MCWAP) in relation to the proposed water management for the project; and
- *Section* 5 presents the key conclusions.

2 BACKGROUND

2.1 BACKGROUND TO THE MCWAP WATER SUPPLY SCHEME

The Mokolo Dam was constructed in the late 1970s and completed in July 1980, to supply water to Eskom's Matimba Power Station, Exxaro's Grootegeluk Mine and Thabametsi Mine, the Lephalale Municipality and for irrigation downstream of the dam. It was identified in the late 2000s that the water infrastructure in the area only allowed limited spare yield for future allocations of water to support economic development in the area. The Department of Water & Sanitation (DWS) therefore commissioned the Mokolo Crocodile (West) Water Augmentation Project (MCWAP) to establish how the future water demands could be met. The infrastructure options considered to augment water supply to the Lephalale area include the following:

- **Phase 1:** Augment the supply from Mokolo Dam; and
- **Phase 2:** Transfer scheme from the Crocodile River (West) to the Lephalale area.[1]

Phase 1 of the MCWAP scheme (MCWAP-1) involved the construction of a pipeline parallel to the existing pipeline, to augment the supply from Mokolo Dam. The system utilises the available yield from Mokolo Dam. This MCWAP-1 scheme has been operational since October 2015 and the available water has been fully allocated to users under water supply agreements between DWS and each user. Water is supplied in accordance with the existing allocations which were determined under each water supply agreement.

Phase 2 of the MCWAP scheme (MCWAP-2), involves the inter-basin transfer of water (Department of Water Affairs and Forestry, 2012) from the Crocodile River (West) Catchment, at Vlieëpoort near Thabazimbi (approximately 114 km south of ***the Project***), via a pipeline to the Lephalale area. MCWAP-2 will transfer water in order to help meet the anticipated rising demands from the various water users, including potentially the Phase 2 of the ***Project*** and other proposed mining, power and industrial developments. Current indications from DWS suggest that MCWAP-2 will be operational by 2021.

2.2 PROPOSED WATER SUPPLY FOR THE PROJECT

The ***Project*** requires a total average water supply (i.e. for Phases 1 and 2) of between 1.3 million and 1.5 million cubic metres per annum (Mm^3/a) for a total power output of 1,200 MW (Savannah Environmental, 2014).

[1] (http://www.dwa.gov.za/Projects/MCWAP/overview.aspx).

The water requirement for Phase 1 of the ***Project*** will be met by MCWAP-1 and the amount of use has been determined to be up to 720,000 m^3/a. An agreement has been concluded with Exxaro such that Exxaro will cede part of its MCWAP-1 authorised water allocation to the ***Project***, out of Exxaro's total allocation.

It is important to note that only Phase 1 of the ***Project*** has been selected by the DoE under the Coal Baseload IPP Programme as a Preferred Bidder and can proceed with its Integrated Water Use Licence Application (IWULA) in terms of the Guidance Note issued by DWS under the Coal Baseload IPP Programme.

In terms of submitting the IWULA, the Limpopo North West Proto Catchment Management Agency (CMA) acknowledged the pre-application for Phase 1 and confirmed that it was "determined" that the volume of water (0.72 Mm3/a) can be available, including the utilisation in the construction, commissioning, power generation, operation, maintenance and related activities subject to any catchment management and/or site specific qualifications and assumptions (DWS, 2015). As the water will be supplied from the ceded allocation from Exxaro, groundwater resources will not be required for Phase 1.

Phase 2 of the ***Project*** will only progress when the DoE proceeds with the next phase of the Coal Baseload IPP Programme and DWS will consider the water availability for these subsequent projects at that stage. The water consumption requirements and assurances for Phase 2 will likely be sourced from MCWAP-2 and will only be considered and analysed by DWS in accordance with the requirements for the next bid window under the DoE's Coal Baseload IPP Procurement Programme and in terms of any subsequent Guidance Notes which is assumed to be published by DWS under the Coal Baseload IPP Procurement Programme.

3 METHODOLOGY

ERM undertook a detailed review of the publicly available information and data provided in the MCWAP Technical Reports dated 2010 and other reliable data available, as listed below in Table 1.

Table 1 Documents reviewed

Title	Description	Used for:
MCWAP Phase 1 Final EIA Report (Sept, 2010).	EIA for MCWAP-1 (Mokolo Dam) produced by Nemai Consulting in August 2010 for Department of Water Affairs.	Description of MCWAP-1 Initial water supply and demand projections. Environmental impacts of MCWAP-1 including potential downstream impacts.
Main Report MCWAP Feasibility Study, Technical Module Summary Report (Sept, 2010)	Mokolo and Crocodile (West) Water Augmentation Project (MCWAP) Feasibility Study: Technical Module produced by several consultancies in September 2010 for Department of Water Affairs.	Description of MCWAP-1 and MCWAP-2. Water supply and demand projections for MCWAP-1 and -2. Mokolo Dam Yields. Mokolo catchment water sources and demands from water users up to 2030. Summary of main environmental impacts of MCWAP-1.
Water Impact Assessment for Environmental Impact Assessment Purposes (2013).	Appendix L to the FEIR. Water Impact Assessment of the Thabametsi Project completed by Savannah Environmental in June 2013.	More detail on the water baseline environment and potential impacts / mitigation measures. Project details include water-related activities and processes.
Final Environmental Impact Assessment Report (FEIR) (2014).	Final EIA of the Thabametsi Project completed by Savannah Environmental in May 2014.	Overview of baseline environment and general list of impacts / mitigation measures. Project details include water-related activities and processes.

Title	Description	Used for:
Limpopo Water Management Area North Reconciliation Strategy (Final) (February 2017).	Limpopo Water Management Area North Reconciliation Strategy (Draft) prepared by AECOM for the DWS to support the implementation of water strategies for the wider Limpopo area, including the catchments of Matlabas, Mokolo, Lephalala, Mogalakwena, Sand and Nzhelele of which the MCWAP-2 from the Crocodile West system is discussed.	Description of MCWAP-1 and MCWAP-2. More recent estimations of the water supply and demand projections for MCWAP-1 and MCWAP-2. Mokolo Dam Yields. New allocations for MCWAP-1.
Climate Resilience Assessment (CRA) (2016).	Climate Resilience Assessment of the ***Project*** completed by ERM in 2016 in order to understand the climate change related risks associated with the project.	Summary of future water demands. Water-related risks to ***the Project*** from future climate change impacts (2040 – 2060).
An uncertainty approach to modelling climate change risk in South Africa, April 2015	Study completed for the National Treasury and the National Planning Commission of South Africa with the help of the United Nations University World Institute for Development Economics Research (UNU-WIDER)	Potential implications of climate change on runoff in Mokolo Catchment
Greenhouse Gas Assessment for the 1 200 MW Thabametsi Coal-Fired Power Station in Lephalale, Limpopo Province, South Africa (May 2017).	Climate Change Impact Assessment Report, Final Report Version 2.	Rationale behind use of water saving technologies in terms of quantum of energy and water usage.
Power Generation Technology Data for Integrated Resource Plan of South Africa Technical Update (August 2015)	Analysis completed by the Electric Power Research Institute (EPRI) on performance data for a range of power generation technologies	Comparison to the ***Project*** estimated water consumption per MWh

4 THE EFFECTS OF CLIMATE CHANGE ON PROJECT WATER SUPPLY

4.1 CLIMATE CHANGE AND THE IMPACT TO MCWAP SCHEME

The National Climate Change Response White Paper (2011) suggests that all Government departments and state owned enterprises will need to review the policies, strategies, legislation, regulations and plans falling within their jurisdictions to ensure full alignment with the National Climate Change Response. DWS has committed to considering the effects of climate change on water resources in South Africa, but there is no reliable promulgated data which can assess such climate change impacts to the water resource accurately on a basin scale, at the time of writing.

As part of DWS's assessment of climate change impacts, the National Water Resources Strategy (NWRS2) (2013) for Water Resources, notes that efforts will include more research on climate change considerations including the short-, medium-, and long-term water planning process for all water users, but these actions are still being implemented. This is apparent from the Final Limpopo Reconciliation Strategy (2017) as the study did not integrate climate change into its assessment noting that the "impact of climate change on the availability of water is uncertain" (p. 8-1).

In the climate resilience assessment (CRA) (ERM, 2016) for the ***Project,*** climate change projections were obtained for the period 2040-2060 to allow overall trends for the ***Project*** to be identified. Whilst there was good agreement between different climate models on the projected temperature increases (translating to high confidence in the projected changes) in the region, there was significant model disagreement found with respect to precipitation projections, with climate models projecting both an increase and a decrease in seasonal and annual precipitation levels.

Furthermore, catchment runoff is very sensitive to changes in precipitation and the current relationship between precipitation and runoff for all catchments in South Africa is not linear. Runoff is more sensitive to increases in precipitation than a reduction in precipitation, so that specifically increases in precipitation generally result in a much higher proportional increase in runoff.

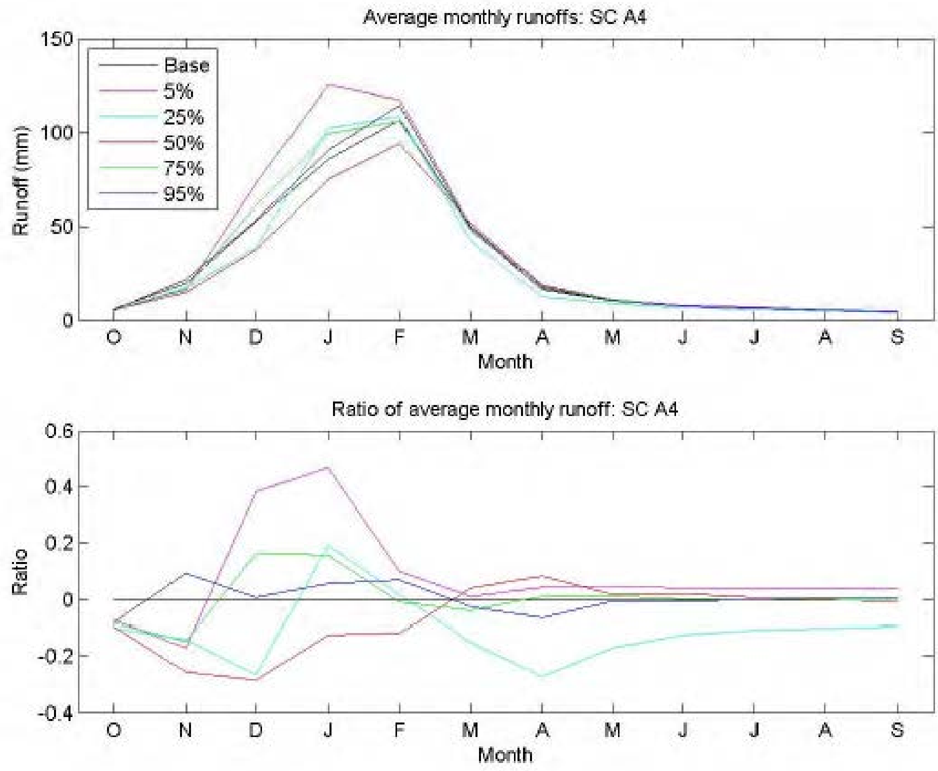
Increases which can be successfully captured and stored in the MCWAP system (as opposed to very heavy rain events which largely run off and cannot be captured) may lessen the stress on the MCWAP system. Conversely, a decrease in annual precipitation or irregular, heavy downpours, will result in stresses in the MCWAP system. The uncertainty in the projections suggests that the region may experience either a decrease or an increase in future precipitation and hence runoff which can be captured by the MCWAP system.

It illustrates that it is currently difficult to project how resources are likely to change with sufficient certainty.

These findings are in line with another study completed to assess climate change risk (UNU-WIDER, 2015) [1] which considered impact on annual catchment runoff in two future global emissions scenarios[2].

For the Mokolo catchment, the observation in the two scenarios is that there is "Even distribution of potential increases and decreases in annual precipitation with the impact being most significant in the early part of the wet season (December and January)" (p.27). This is illustrated in Figure 1 below which presents the outputs of different models for the "high" emissions scenario.

Figure 1 ***Assessed impacts on monthly runoffs for the Mokolo catchment***



(Source: figure 19, UNU-WIDER 2015 presenting impact of the UCE scenarios on the time series of average annual flow up to 2050 and the average monthly flows for the period to 2040-2050 specifically for the Mokolo catchment)

Specifically, the time series analysis presented in the figure above demonstrates the distribution of modelled outputs for monthly runoff for the period 2040 to 2050 for the UCE scenario (conservative case) showing both potential increases and decreases in runoff with a much wider range in terms

[1] Completed for the National Treasury and the National Planning Commission of South Africa with the help of the United Nations University World Institute for Development Economics Research

[2] An Unconstrained Emissions Scenario (UCE) where global policies to reduce emissions fail to materialize and a Level 1 Stabilisation Scenario (L1S) where aggressive emissions are pursued.

of potential variability in runoff for the months of December, January and to a smaller extent February.

Climate-related variables will also have an impact on the water resources in the area, notably, higher temperatures, which the climate model projections suggest, are likely to both increase evaporation losses from dams and rivers in the catchment, and also increase evapotranspiration by plants, and so increase the need for irrigation water requirements for agriculture, livestock and ecological habitats.

To date, the MCWAP feasibility studies (Department of Water Affairs, 2010) and the Reconciliation Strategies for Limpopo Water Management Area North (DWS, 2016) and the Crocodile West River (Department of Water Affairs and Forestry, 2012) have also not factored in future climate change into their water supply scenarios. And at the scale of climate projections produced to date, and with the uncertainties over changes in rainfall and runoff in the projections, it is not straightforward to consider the impact of climate change on the scale for the specific catchment and project use.

4.2 *PROPOSED WATER MANAGEMENT FOR THE PROJECT*

Due to the point that water is a scarce resource in South Africa, including the Lephalale municipality of Limpopo Province where the ***Project*** is situated, the ***Project*** (Phase 1) has considered the technical specification to minimise the water requirement during its' lifetime. As the solution, the ***Project*** (Phase 1) will use circulating fluidised bed (CFB) technology, sub-critical steam conditions, and dry cooling technologies (ERM, 2016), which reduces overall water demand by up to 15 times compared to a conventional wet-cooled power station (Savannah Environmental, 2014).

Further, the ***Project*** (Phase 1) has been designed to be a zero liquid effluent discharge plant, requiring all plant processes to be optimised for minimisation of water demand. All effluents will be collected and either re-used or evaporated on site (Savannah Environmental, 2014). As a consequence, there are predicted to be no impacts to local water resources arising from water use within the ***Project*** (Savannah Environmental, 2014).

Taking into consideration the above choice of technology, the ***Project*** (Phase 1) has enabled the water requirement to be reduced to 720,000 m^3/a, which would take up less than 1.8% of the Mokolo Dam's water yield (in a 1 in 200 scenario which is used for planning purposes) When comparing the use of water as per the generation output, the ***Project's*** water consumption is estimated to be 119.5 liters per MWh which is significantly lower to the average use of 231 liters per MWh for a pulverized coal power station using dry cooled system with Flue Gas Desulfurization (FGD) (EPRI, 2015).

Another point to note for the water use of this ***Project*** is that the water requirements for Phase 1 of the scheme will be met by the existing approved allocations for MCWAP-1 (based on Exxaro ceding part of their allocation to the ***Project***) and this would mean that the use of 720,000 m^3 would not affect the water constraints in MCWAP-1.

5 CONCLUSIONS

Based on the above, the long term impact from climate change on water resources in the ***Project*** area, and especially in relation to MCWAP, is uncertain. Whilst there is good agreement between different climate models on the projected temperature increases (translating to high confidence in the projected changes) in the region, there is significant model disagreement with respect to precipitation projections. Climate models project both an increase and a decrease in seasonal and annual precipitation levels for the Mokolo catchment. The impact of changes in precipitation on hydrology are therefore still uncertain as the climate change data available is not of sufficient granularity to comment on the probability of adverse effects on the water resources for the area.

Because of the uncertainty of the impact of climate change to the water resources, and the fact that the ***Project*** (Phase 1) is in a water scarce area, the ***Project*** have worked to select appropriate technology and optimise the design (including planning for water storage) to ensure the plant can be operated under more water scarce conditions than currently exist.

5.1 LIMITATIONS

The following limitations to this study should be noted:

- The report is based on publicly available documentation as referenced in Table 1. The assumptions made in these documents and studies have been relied upon in this report.
- This study has not acquired new data.

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