DESKTOP GROUNDWATER FEASIBILITY ASSESSMENT FOR CHOJE WINDFARM PROJECTS, EASTERN CAPE

Ref 005020R01.2
September 2019

For:

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VERIFICATION PAGE	Form 4.3.1
	Rev 13

TITLE:
DESKTOP GROUNDWATER FEASIBILITY ASSESSMENT FOR CHOJE WINDFARM PROJECTS, EASTERN CAPE

JG AFRIKA REF. NO.	DATE:	REPORT STATUS
005020 1817205R01.2	25/09/2019	Third Issue

CARRIED OUT BY:

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SYNOPSIS

Preliminary groundwater feasibility report

KEY WORDS:

Groundwater feasibility, geology, geohydrology, hydrocensus, groundwater potential

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QUALITY VERIFICATION

This report has been prepared under the controls established by a quality management system that meets the requirements of ISO9001: 2015 which has been independently certified by DEKRA Certification

Verification	Capacity	Name	Signature	Date
By Author	SNR GEOHYDROLOGIST	R SCHAPERS		25 Sep 19
Authorised by	EXECUTIVE ASSOCIATE			

Filename:	D:\SCR\005020 - Small Geohydro Projects 2019\01. Choje WF GW Feasibility (RS)\report\005020R01 Groundwater Feasibility - Choje.docx

DESKTOP GROUNDWATER FEASIBILITY ASSESSMENT FOR CHOJE WINDFARM PROJECTS, EASTERN CAPE

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EXECUTIVE SUMMARY

This report presents the results of a desktop groundwater feasibility assessment and review of groundwater potential for the Choje Windfarm Project area in the Eastern Cape.

This report presents the results of a desktop groundwater feasibility assessment for the Choje Windfarm Project, located in the Eastern Cape. The project area comprises a western priority area made up of four (4 No.) wind farms, and an eastern priority area made up of three (3 No.) wind farms.

Groundwater is being considered for batching plants located within the project area. The final locations of the batching plants was still undecided, thus a review of the groundwater potential throughout the priority areas was made. The aim of the assessment was to establish the preliminary groundwater potential.

The project areas are typically underlain by a fractured aquifer type which is characterised as having median borehole yields in the range 0.5 to 5.0l/s. Between 40 and 50% of boreholes within the Beaufort Group and Dwyka Formation lithologies yield under 0.5l/s. The Ecca Group shows an improvement with only 41% of boreholes yielding less than 2.0l/s. Arenaceous lithologies within the Witteberg Group also show more success with borehole yields often being above 2.0l/s. It was calculated that <0.7% of the groundwater recharge would be required to meet a single batching plant demand of 30m^3/d. Regional groundwater resources would not be stressed by such a low utilisation of the aquifer recharge. Groundwater is considered a suitable supply option for the project.

Water quality within the Beaufort, Ecca and Witteberg Groups is often poor, with elevated EC, Na, Mg, Ca, Cl and SO4 being expected. Groundwater quality in terms of use for concrete batching, and aggressiveness should be assessed during borehole implementation.

Structural geology was assessed through satellite photo interpretation and target areas were identified throughout the west and east priority areas. The desktop feasibility should be augmented with geophysical surveys to characterise geological structures and identify optimal drilling locations.

DESKTOP GROUNDWATER FEASIBILITY ASSESSMENT FOR CHOJE WINDFARM PROJECTS, EASTERN CAPE

1 INTRODUCTION

This report presents the results of a desktop groundwater feasibility assessment and review of groundwater potential for the Choje Windfarm Project area in the Eastern Cape.

We refer to our proposal reference 004748 1817205, titled " Provision of Geohydrological Services for Implementation of Groundwater Supply for Choje Windfarm Projects, Eastern Cape", dated 15 January 2019. JG Afrika (Pty) Ltd were requested by DNV GL South Africa (Pty) Ltd to undertake the desktop groundwater review and preliminary site inspection as confirmed by the Subcontract (Short Format Agreement) reference PP225941/02/A, titled "Choje Wind Farm Preliminary Geotechnical Investigation", dated 26 February 2019.

2 INFORMATION SUPPLIED

The following information has been used in the preparation of this report:

Maps and Figures

- Map Sheet titled "3224 Graaff Reinet", at a scale of 1:250000, digital version, of the Geological Map Series, supplied by the Department of Mineral and Energy Affairs
- Map Sheet titled "3324 Port Elizabeth", at a scale of 1:250000, digital version, of the Geological Map Series, supplied by the Department of Mineral and Energy Affairs
- Map Sheet titled "33 26 Grahamstown", at a scale of 1:250000, digital version, of the Geological Map Series, supplied by the Department of Mineral and Energy Affairs
- Map Sheet titled "3122 Beaufort West", at a scale of 1:500000, first edition, dated 2002, of the Hydrogeological Map Series of the Republic of South Africa, supplied by the Directorate: Geohydrology, of the Department of Water Affairs and Forestry
- Map Sheet titled "3324 Port Elizabeth", at a scale of 1:500000, first edition, dated 1998, of the Hydrogeological Map Series of the Republic of South Africa, supplied by the Directorate: Geohydrology, of the Department of Water Affairs and Forestry.

Data

- National Groundwater Archive (NGA) digital information, as supplied by The Department of Water Affairs (DWS) as at September 2019.
- Eastern Cape Groundwater Resource Information Project (GRIP) digital information, as supplied by the Department of Water and Sanitation (DWS) as at July 2014.

3 SITE DESCRIPTION

The project area falls within the Blue Crane Route and Makana Local Municipalities of the Cacadu District Municipality. The project area comprises the Western Block Priority area (west site) made up of four (4 No.) wind farms, and the Eastern Block Priority area (east site) made up of three (3 No.) wind farms.

The west sites covers 450km^2 and extends from 30 to 70km north of Paterson towards Somerset East. It is bounded by the N10 on the eastern side, the R335 beyond the western side and the Boesmans River beyond the south side. The east site covers 133km^2 and is located from 7 to 20 km north west of Grahamstown. The site is bisected by the R350 from Grahamstown to Bedford.

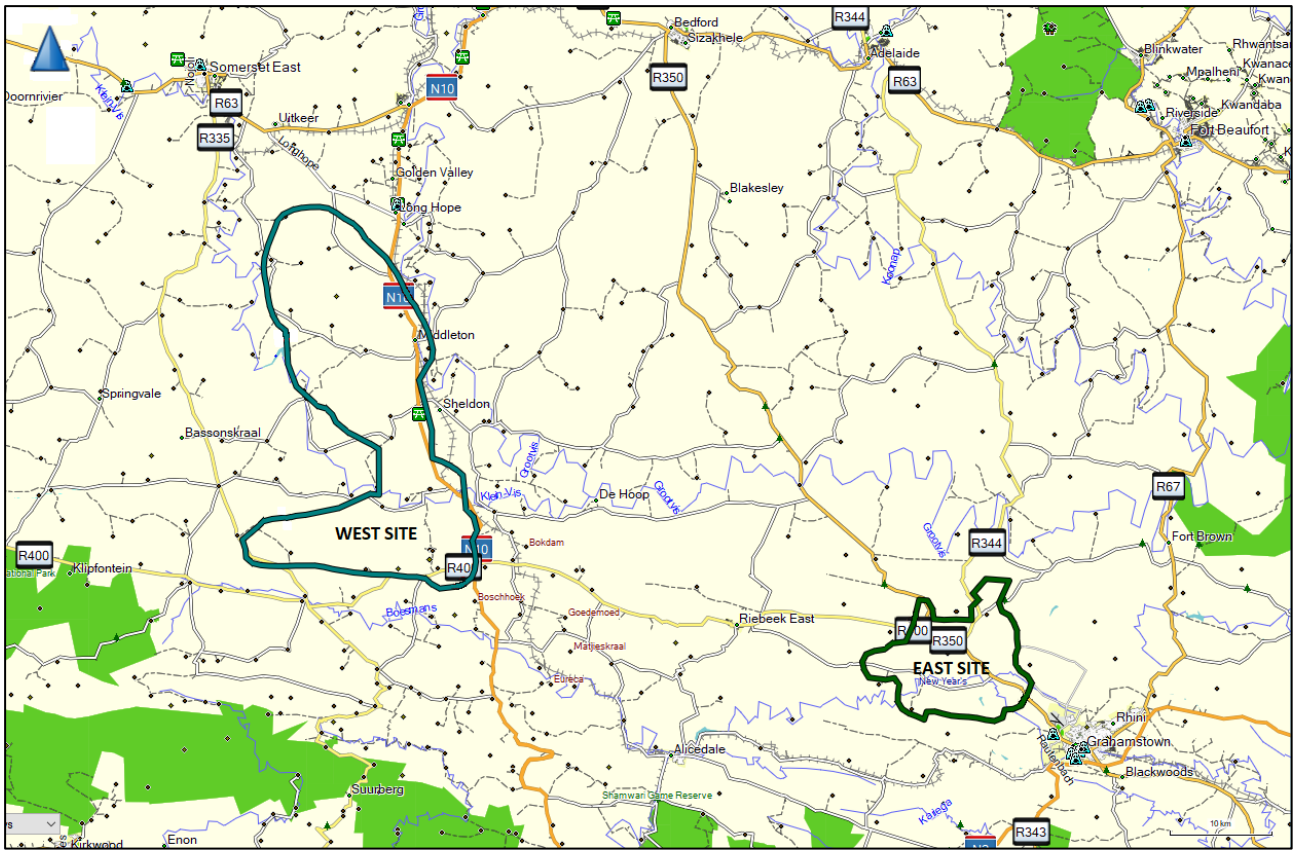

Figure 1: Site Locality

Based on DWS data, the west site project area falls within the P10C, P10D, Q70B, Q70C, Q80E, Q80F and Q80G quaternary catchments. Groundwater in all catchments is classified as under utilised except in Q80F, which is heavily utilised. The dominant groundwater use is for livestock watering except in Q80F which has a large irrigation use portion. The east site falls within the P10A, P10B, Q91B and Q91C quaternary catchments. Groundwater in all catchments is classified as under utilised. The dominant groundwater use is for livestock watering.

The project area is made up of the Nama Karoo, Thicket and Fynbos Biomes. The predominant landcover is summarised by percentage of the total project area as follows:

Landcover Description	% Area	
	West Site	East Site
Cultivated: temporary - commercial irrigated	1.47	0
Forest and Woodland	2.26	0
Forest plantations	0.01	0
Shrubland and low Fynbos	86.45	64.41
Thicket & bushland (etc)	9.76	35.51
Waterbodies	0.05	0.04
Unimproved grassland	0	0.04

The west site project area has an elevation range of 480 to 920mAMSL (metres Above Mean Sea Level) while the east site project area has an elevation range of 400 to 720mAMSL.

4 DESKTOP GROUNDWATER FEASIBILITY

4.1 Recharge

Based on WR90 data (WRC; Surface Water Resources of South Africa 1990 Study) the area weighted Mean Annual Precipitation (MAP) for the quaternary catchments in the west site is 371 mm/a and the area weighted recharge is 4.24 mm/a. The area weighted MAP for the quaternary catchments in the east site is 548mm/a and the area weighted recharge is 13.58 mm/a. The area weighting is presented in Table 1. The first estimate of recharge for each project area is presented in Annexure A.

Table 1: Area Weighted Recharge

Project Area	Quaternary Catchment	% Total Area	Area Weighted Mean Annual Precipitation (mm/a)	Area Weighted Recharge (mm/a)
West Site	P10C	5.96	23.00	0.32
	P10D	7.90	34.14	0.52
	Q70B	18.47	69.27	0.93
	Q70C	13.36	48.49	0.53
	Q80E	13.79	51.83	0.61
	Q80F	9.42	33.45	0.31
	Q80G	31.10	111.34	1.02
Totals		100	371.52	4.24
East Site	P10A	45.18	271.09	7.39
	P10B	25.00	132.74	3.60
	Q91B	3.77	16.99	0.26
	Q91C	26.05	127.92	2.32
Totals		100.00	548.74	13.58

Using an inferred maximum demand of 30 m^3/d at the construction / laydown area, the percentage recharge utilised will be 0.61 and 0.57 % for the east and west site respectively, per construction / laydown yard supplied. The initial recharge calculations indicate groundwater will adequately meet the demand, however, several borehole attempts may be required to provide adequate supply. The percentage of demand calculation is presented in Table 2.

Table 2: Demand Calculation

Project Area	Recharge Area for Project Area	MAP	Available for Recharge	Recharge		Estimated Demand	% of recharge required to meet demand
	(km^2)	(m/a)	(m^3/d)	%	m^3/d	m^3/d	
West Site (1 farm)	452	0.371	459430	1.15	5260	30	**0.57**
East Site (1 farm)	133	0.548	199682	2.48	4942	30	**0.61**

4.2 Regional Geology and Structures

West Site

The regional geology of the west site comprises Beaufort and Ecca Group mudstone, shale, sandstone and tillite, which in turn is underlain by Witteberg Group sandstone, shale and siltstone. The north and central parts of the site are dominated by Beaufort and Ecca Group lithologies with Dwyka Formation tillite and Witteberg Group lithologies dominating in the southern parts. Regional geological structures comprising faults and dykes are nearly absent in the project area with only a single regional west to east oriented fault being mapped to the west of the project area. The southern limit of dolerite intrusions is evident from the west to east oriented regionally mapped dolerite feature through the northern portion of the project area.

East Site

The regional geology of the east site comprises Beaufort and Ecca Group mudstone, shale, sandstone and tillite, which in turn is underlain by Witteberg Group sandstone, shale and siltstone. Ecca and Beaufort Group lithologies occur to the north of the project area while Dwyka Formation dominates the central and part of the north region of the project area. Witteberg lithologies occur in the northern and southern parts. Regional geological structures are nearly absent in the project area with only a single regional small fault located in the west part and a single small fault to the west of the project area. Dolerite intrusions are absent. The regional geology and structure are presented in Figure 2 and Figure 3.

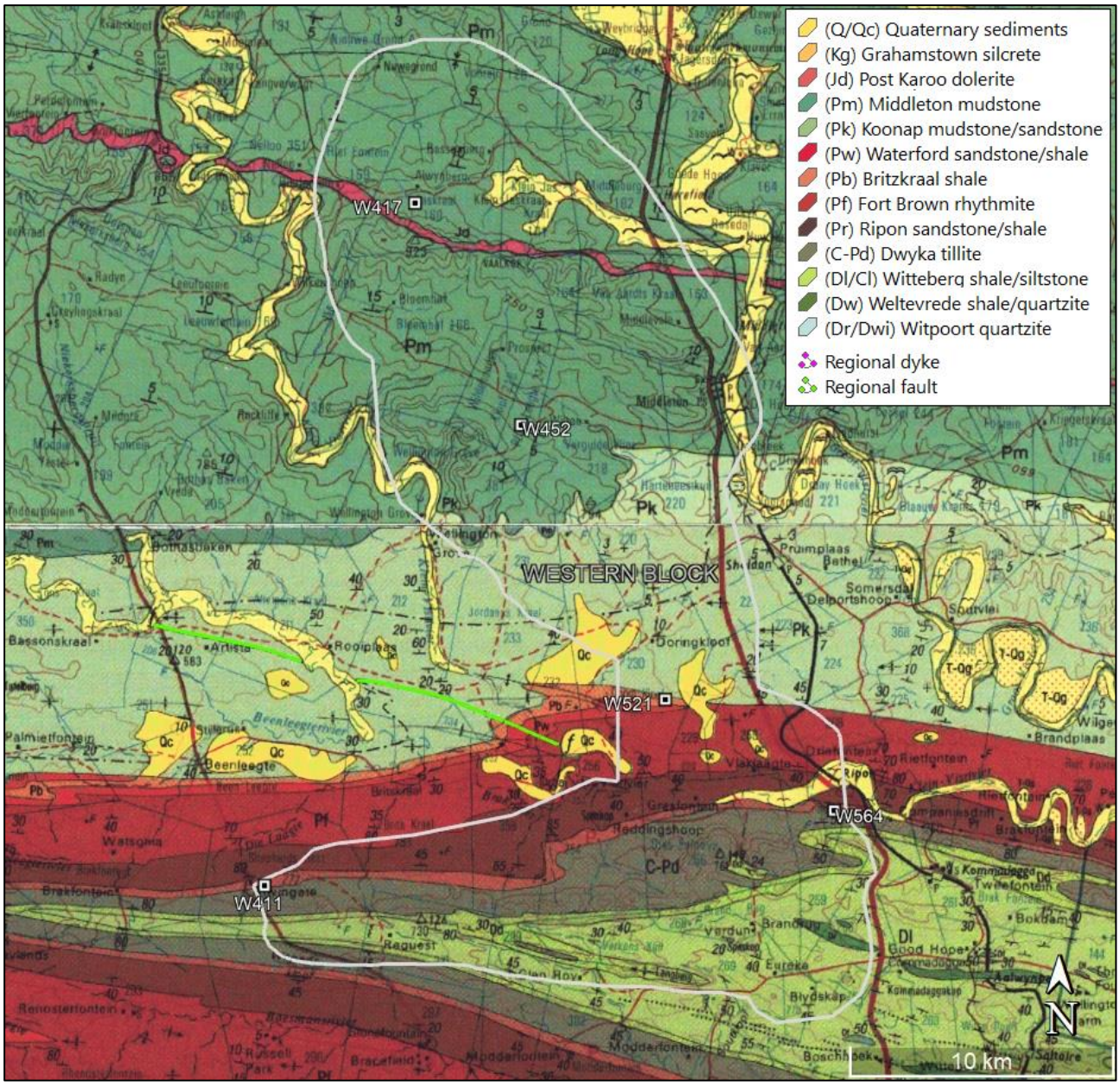

Figure 2:Regional Geology and Structures - West Site

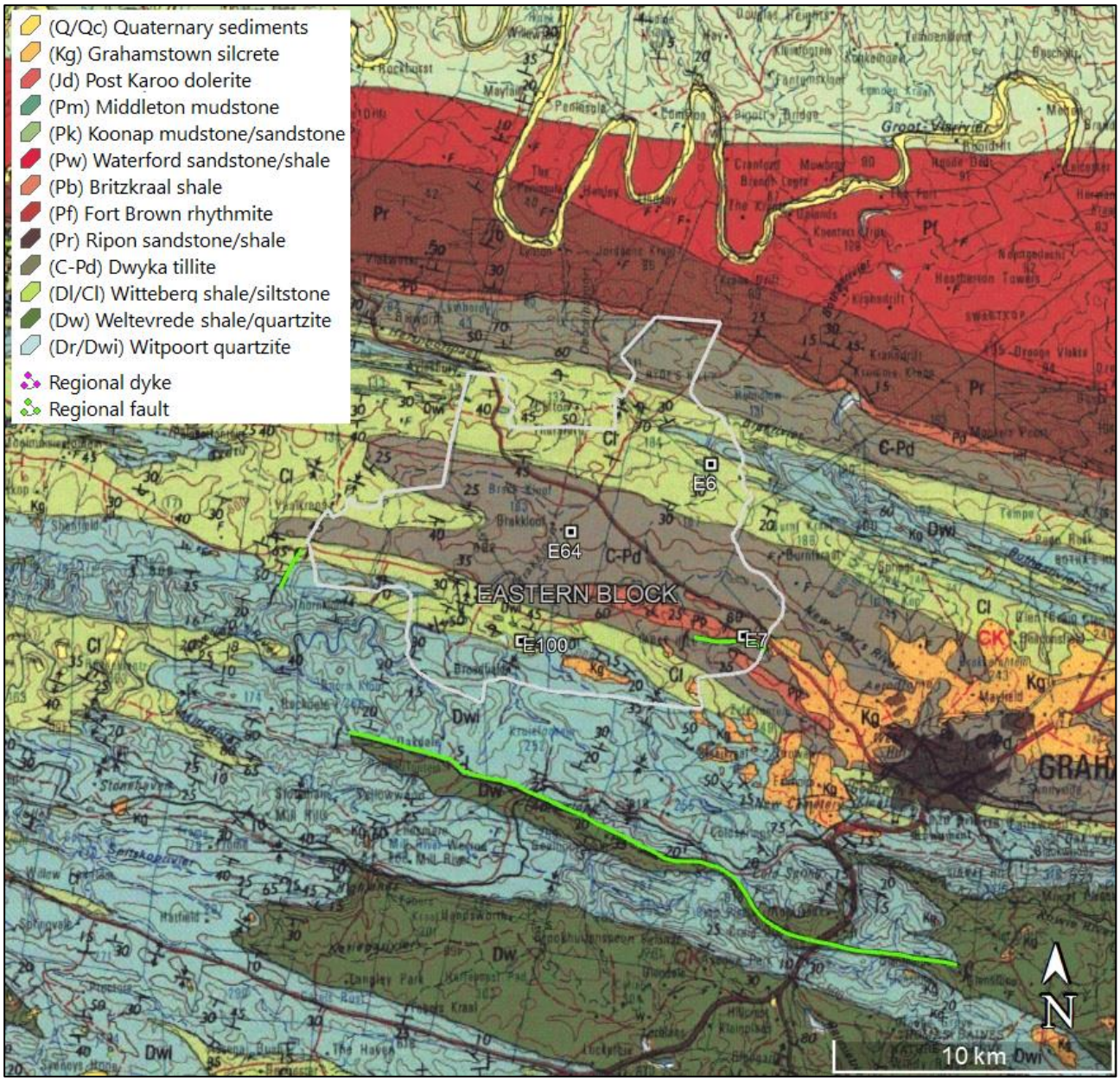

Figure 3:Regional Geology and Structures - East Site

4.3 Regional Geohydrology

The regional geohydrology of the west site project area is variable. It can be broadly described as predominantly argillaceous rocks comprising shale and siltstone over the northern parts, and as undifferentiated rock and mixed lithologies comprising mudstone, siltstone, shale, tillite, sandstone and conglomerate over the southern parts. The principal groundwater occurrence is from a fractured aquifer type, with median borehole yields in the expected range of 0.5 to 2.0, and 2.0 to 5.0 litres per second.

The regional geohydrology of the east site project area is variable. It can be broadly described as predominantly undifferentiated rock and mixed lithologies comprising mudstone, siltstone, shale, tillite, sandstone and conglomerate over the central and northern parts, and predominantly arenaceous rocks comprising sandstone in the southern parts. The principal groundwater occurrence is from a fractured aquifer type, with median borehole yields in the expected range of 0.5 to 2.0 litres per second. The regional geohydrology of the project areas is presented in Figure 4 and Figure 5.

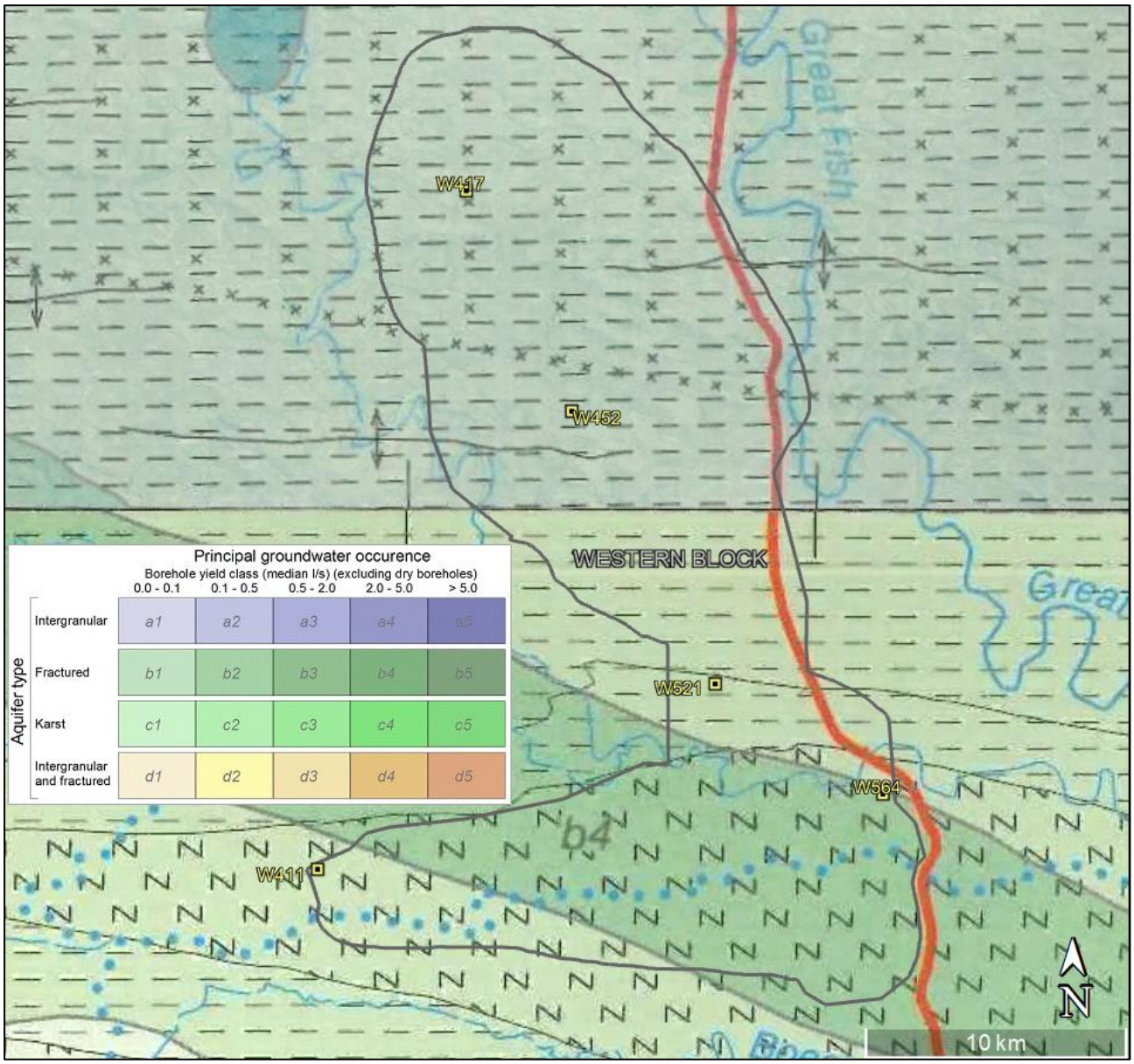

Figure 4: Regional Geohydrology - West Site

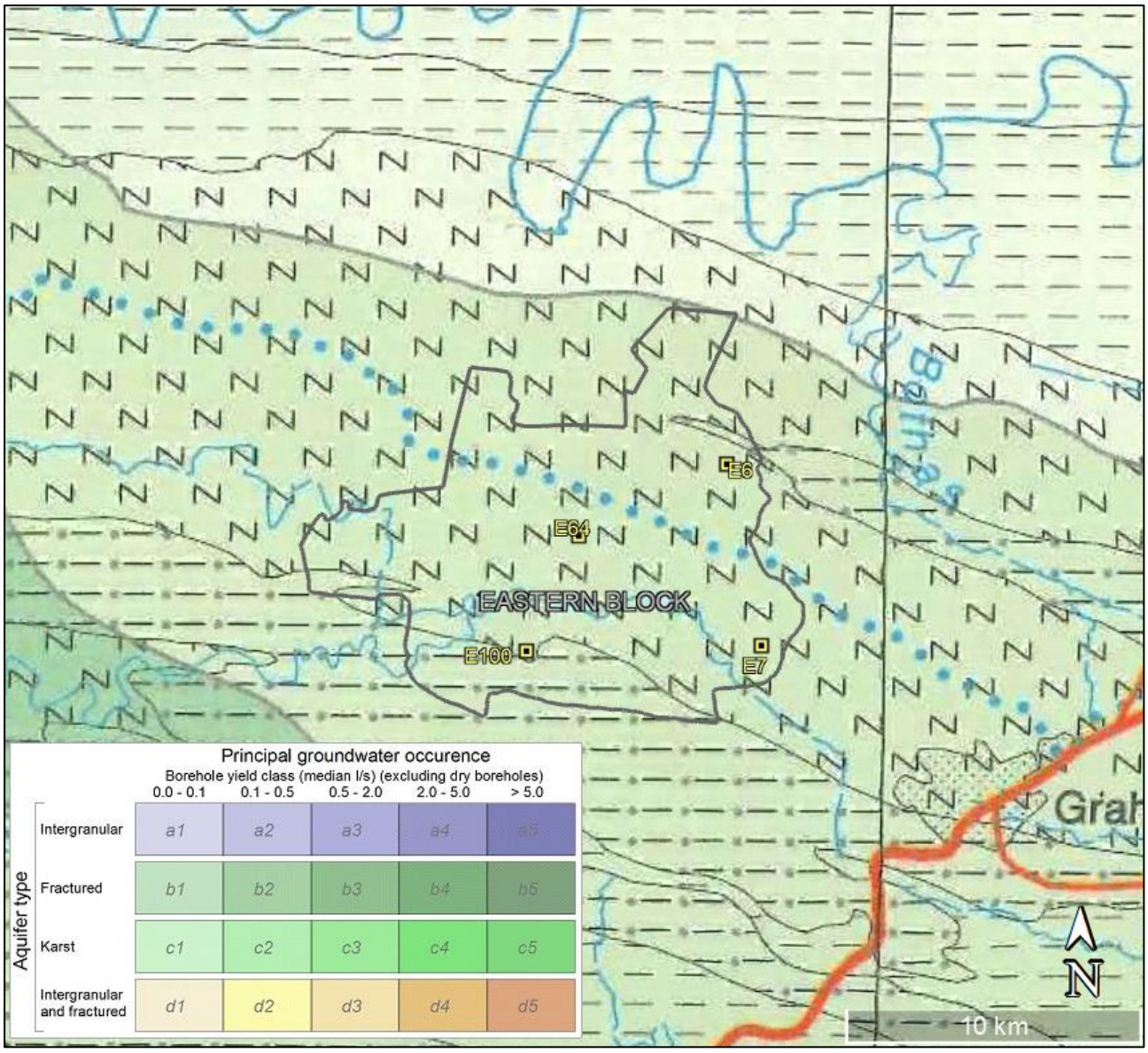

Figure 5: Regional Geohydrology - East Site

Fractured Aquifer Systems

The rock mass of the project area was formed several million years ago and endured numerous deformation phases. The deformation, orogenesis, uplift, weathering and erosion all contribute to the present day groundwater environment. Brittle failure of competent rocks has resulted in numerous fracture structures within the arenaceous materials which in turn has resulted in fracture porosity. Incompetent rocks being more flexible have inhibited fracture porosity formation. Fracture structure and groundwater recharge therefore plays a decisive role in groundwater occurrence within the region.

Beaufort Group

The Beaufort Group typically occurs in the northern part of the west site. It is an argillaceous aquifer with approximately 42% of boreholes in the group yielding less than 0.5l/s. The groundwater potential is considered relatively low. Boreholes above 3.0l/s can be associated with joint, fold and fracture structures. Water quality is expected to have elevated EC, Na, Cl and F.

Ecca Group

The Ecca Group typically occurs within the central portion of the west site and to the north of the east site. It is an argillaceous aquifer with approximately 41% of boreholes in the group yielding less than 2.0l/s. The groundwater potential is considered medium to good. Boreholes above 5.0l/s can be associated with joint and fracture structures. Water quality is expected to have elevated EC, Na, Mg, Cl and SO_4.

Dwyka Group

The Dwyka Formation typically occurs over the southern portion of the west site and central portion of the east site. It is an argillaceous aquifer with 45% of boreholes in the formation yielding less than 0.5l/s. The groundwater potential is considered poor due to the impervious nature of the rock. Water quality is expected to have elevated EC, Na, Ca, Mg, Cl and SO_4.

Witteberg Group

The Witteberg Group typically occurs over the southern portion of the west site and north and south portions of the east site. It is an argillaceous and arenaceous aquifer with argillaceous lithologies generally producing boreholes that yield less than 2.0l/s, while the arenaceous lithologies can yield greater than 2.0l/s. The groundwater potential is considered moderate. Water quality in the shale lithologies is expected to have elevated EC, Na, Mg, Cl and SO_4.

4.4 Existing Groundwater Resources

The National Groundwater Archive (NGA) and Eastern Cape Groundwater Resource Project (GRIP) of the DWS were interrogated to establish the existence of any water resources in the project area and to review the expected geohydrological conditions.

A total of 144 (No.) NGA resources and no GRIP resources were identified within 1km of the west site. A total of 13 (No.) NGA resources and one (1 No.) GRIP resource were identified within 1km of the east site. For the west site, borehole discharge rates were only reported in 66 (No.) records. 41 (No) boreholes reported a yield of <1.0l/s, 12 (No.) between 1.0 and 2.0l/s, and 13 (No.) >2.0l/s.

For the east site, borehole discharge rates were only reported in four (4 No.) records. Three (3 No.) boreholes reported a yield of <1.0l/s, and one (1 No.) >1.0l/s.

During the next phase, a field hydrocensus survey should be carried out to verify selected resources based on the information provided by the datasets. Additional resources that are not currently presented in the datasets will likely be found during the site hydrocensus. The distribution of the DWS resources are shown in Figure 6 and Figure 7.

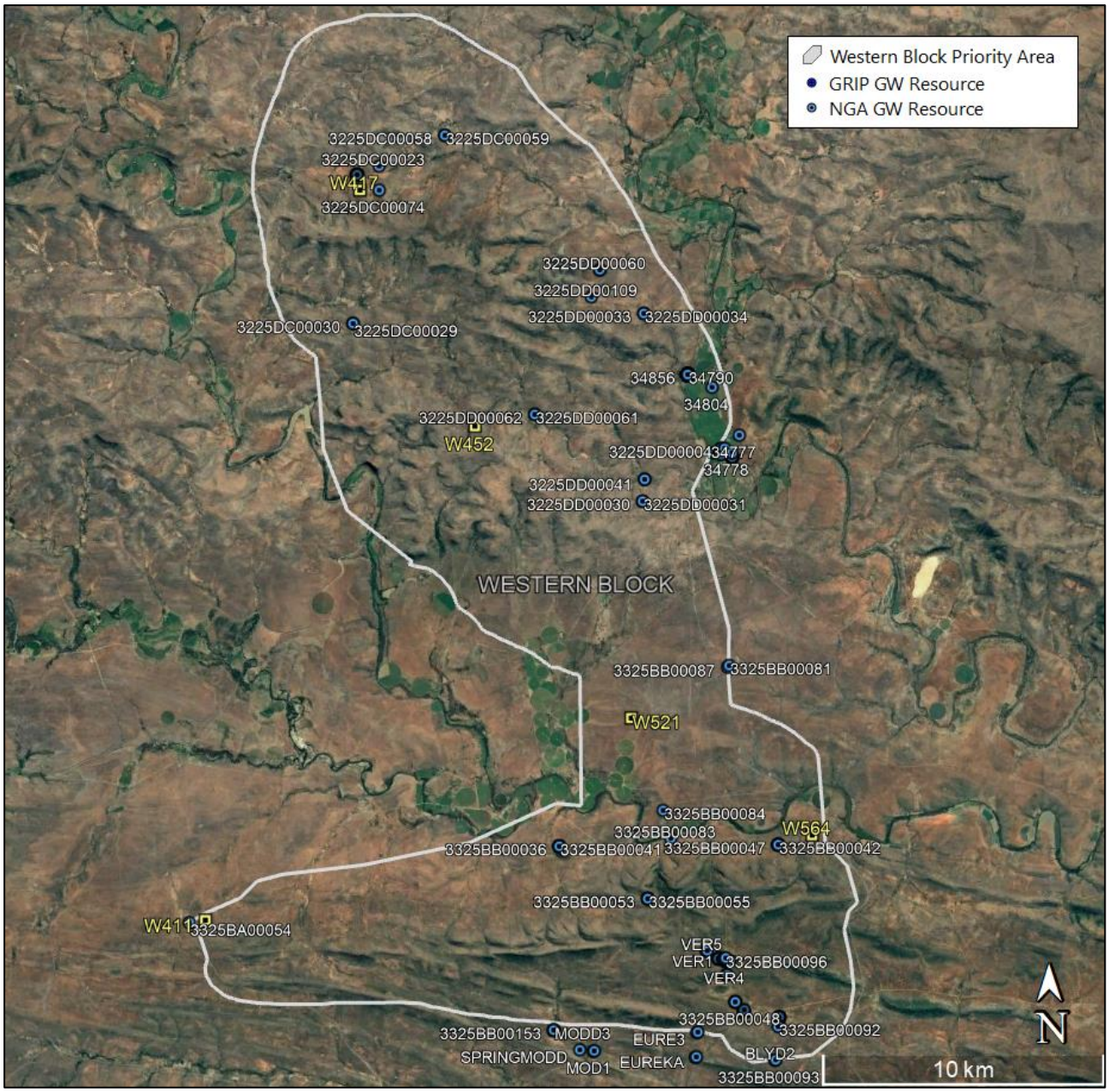

Figure 6: Existing Groundwater Resources (DWS) - West Site

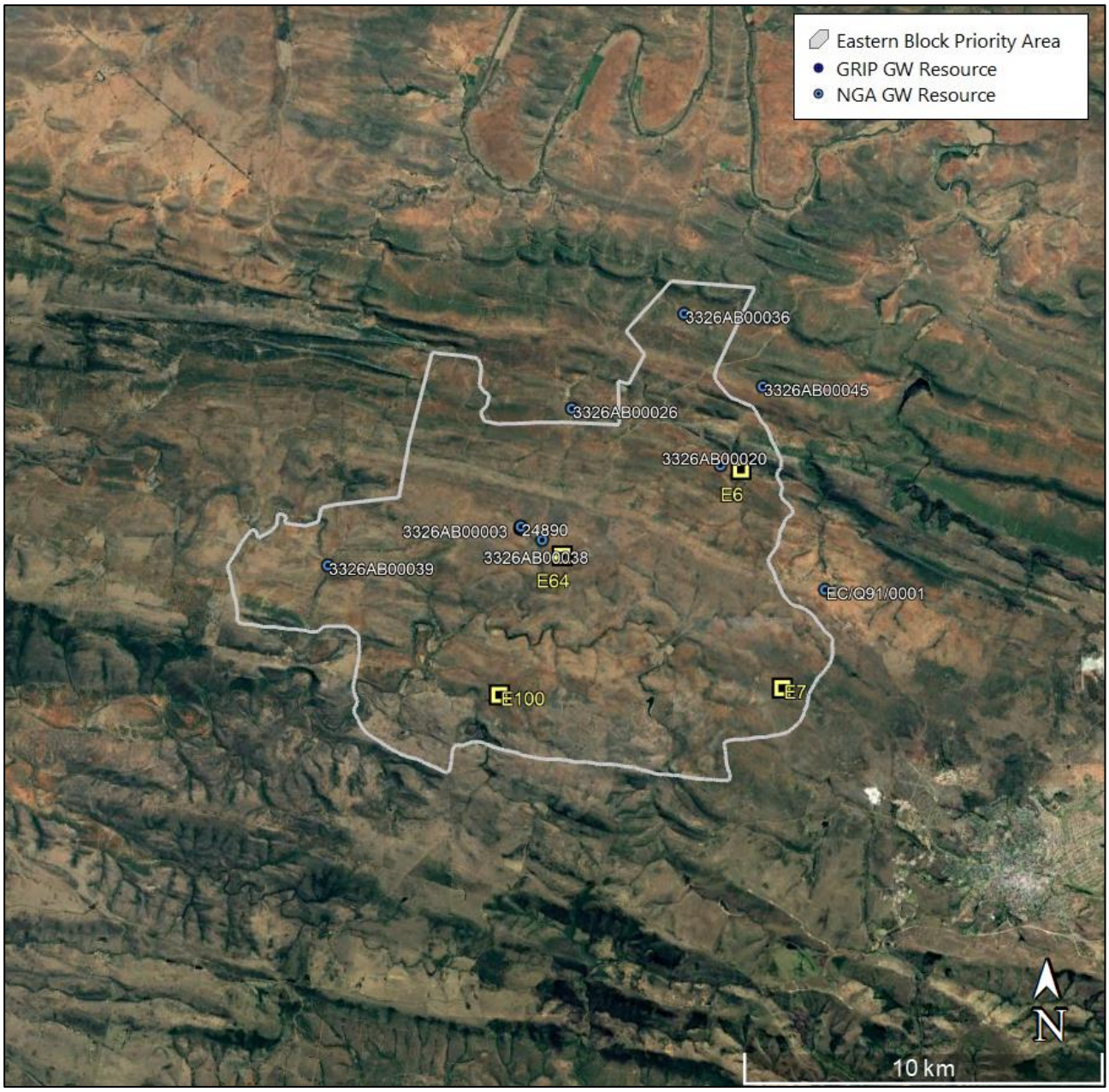

Figure 7: Existing Groundwater Resources (DWS) - East Site

4.5 Groundwater Targets Areas and Groundwater Potential

Fractures and joints in the host rock form primary groundwater targets in the project area. Geological contacts between different lithologies form secondary targets. Localised geological structures were mapped across the west and east priority areas and target areas spread across each site identified based on the air photo interpretation. Targets occurring within the tillite lithology were removed. A list of preliminary targets is summarised in Table 3 below and presented in Figure 8 and Figure 9.

Noting that these have been developed at a desktop level, the targets are not prioritised and have been numbered sequentially. The on site assessment of geological features may influence the final location and number of target areas. The groundwater potential across the project area is considered moderate to good in respect of the project demand of 30m^3/d per batching plant. The west site has better potential than the east site.

Some compartmentalisation may be expected with the linear nature of some geological structures in the project area. Water quality is expected to be poor, and the assessment of aggressiveness and suitability for concrete batching should to be carried out.

Table 3: Preliminary Target Areas Identified for Geophysical Survey

Target Id	South	East	Target Id	South	East
West Site Project Area			East Site Project Area		
W1	-32.88900	25.69103	E1	-33.18591	26.35165
W2	-32.89167	25.70636	E2	-33.19035	26.34977
W3	-32.88673	25.74757	E3	-33.19587	26.42252
W4	-32.95899	25.68772	E4	-33.21088	26.44167
W5	-32.96383	25.74431	E5	-33.23542	26.29210
W6	-33.04633	25.77571	E6	-33.23556	26.32691
W7	-33.05888	25.79746	E7	-33.23305	26.37665
W8	-33.08542	25.80030	E8	-33.25975	26.36557
W9	-33.07785	25.85251	E9	-33.26662	26.36865
W10	-33.11825	25.64339	E10	-33.25345	26.40110
W11	-33.13315	25.63844	E11	-33.27665	26.40741
W12	-33.13388	25.69441	E12	-33.28061	26.42274
W13	-33.13290	25.72031	E13	-33.25744	26.45008
W14	-33.10739	25.78972	E14	-33.26478	26.45846
W15	-33.12389	25.84676			
W16	-33.14457	25.82241			
W17	-33.14333	25.86282			

Tillite geology; target area to be excluded

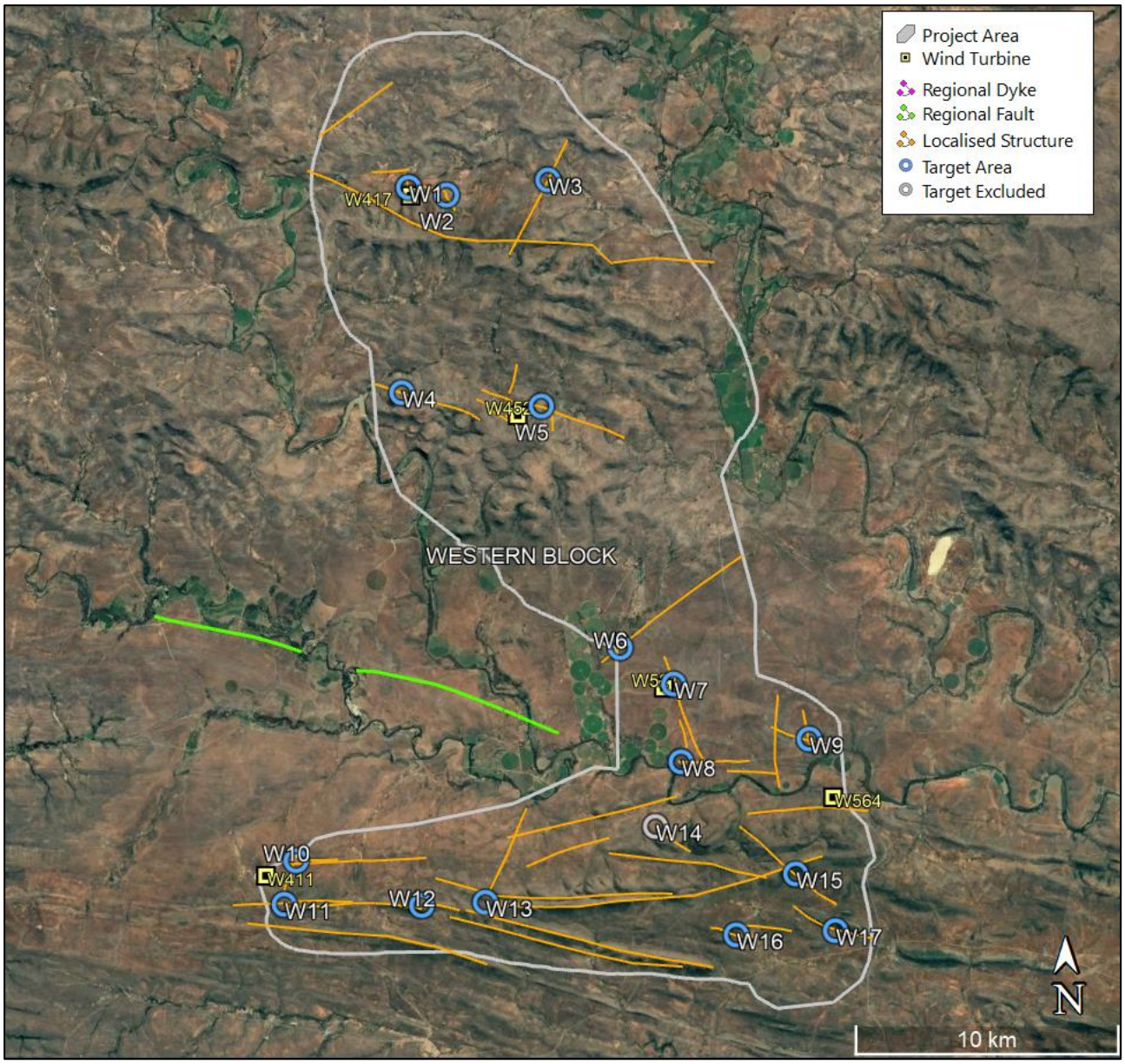

Figure 8: Proposed Target Areas for Further Investigation - West Site

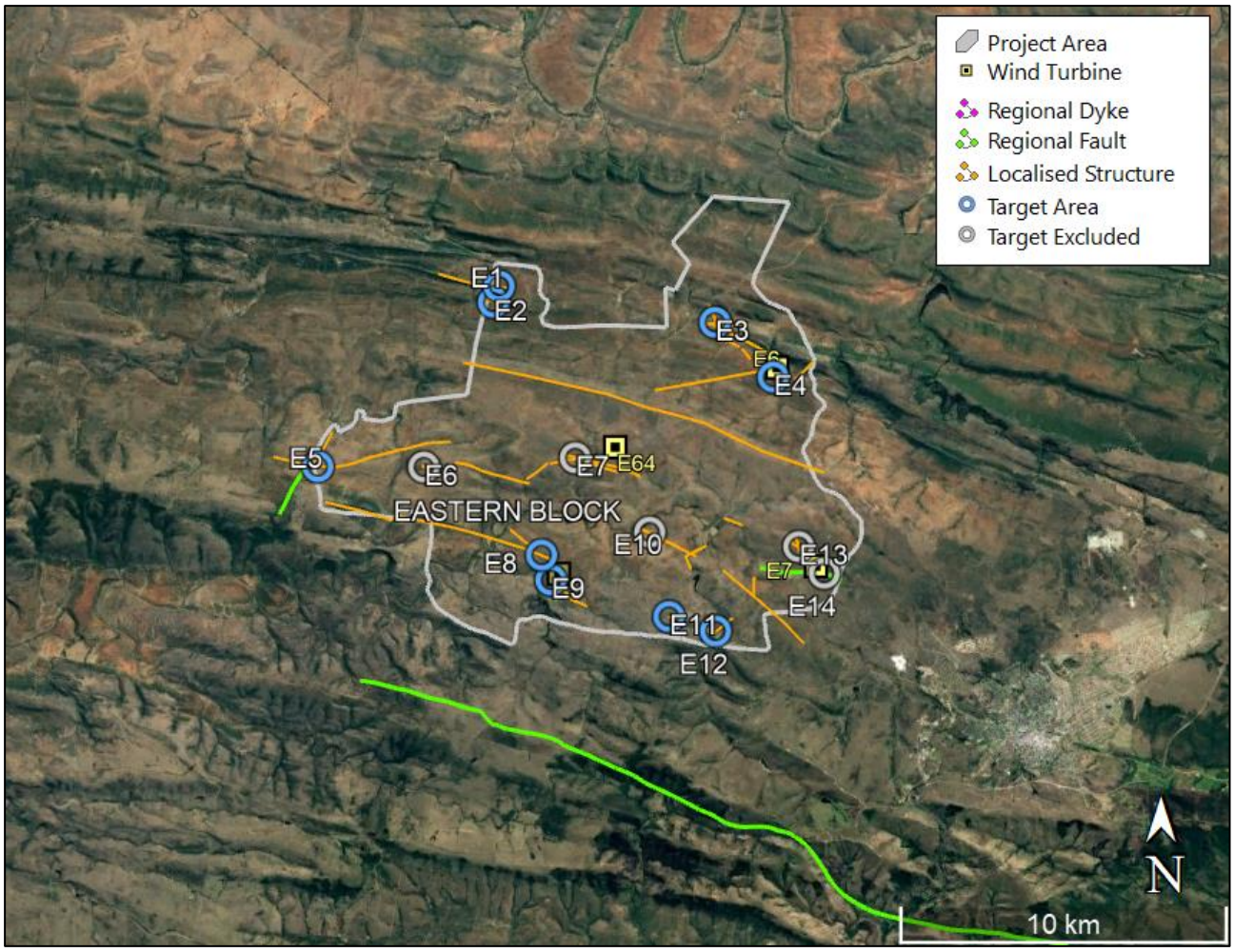

Figure 9: Proposed Target Areas for Further Investigation - East Site

5 CONCLUSIONS

This report presents the results of a desktop groundwater feasibility assessment for the Choje Windfarm Project, located in the Eastern Cape. The project area comprises a western and eastern priority area, with four (4 No.) and three (3 No.) wind farms in each area respectively.

Groundwater is being considered for batching plants located within the project area. The aim of the assessment was to establish the preliminary groundwater potential within each priority area. Since the location of the batching plants was still undecided, a spread of target areas throughout the areas was provided. The project areas are typically underlain by a fractured aquifer type which is characterised as having median borehole yields in the range 0.5 to 5.0l/s. Between 40 and 50% of boreholes within the Beaufort Group and Dwyka Formation lithologies yield under 0.5l/s. The Ecca Group shows an improvement with only 41% of boreholes yielding less than 2.0l/s. Arenaceous lithologies within the Witteberg Group also show more success with borehole yields often being above 2.0l/s.

From a recharge perspective it was calculated that <1.0% of the recharge would be required to meet a batching plant demand of 30m^3/d. On this basis, the groundwater resources would not be stressed by the specified demand and groundwater is a suitable supply option to be considered. Single or multiple borehole attempts may be required at each plant site to meet the demand criteria.

Water quality within the Beaufort, Ecca and Witteberg Groups is often poor, with elevated EC, Na, Mg, Ca, Cl and SO_4 being expected.

Target areas were identified at a desktop level throughout the priority areas. The target list would be augmented with a site review, following which a geophysical survey should be conducted at target areas to identify optimal drilling locations.

An additional consideration would be to review existing borehole resources in the project area subject to landownership agreement. Existing resources would need to be subjected to yield and water quality tests to assess the suitability of use within the project.

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Annexure A: First Estimate of Recharge

MAIN

West Site

Method	mm/a	% of rainfall	Certainty (Very High=5 ; Low=1)
CI			
SVF: Equal Volume			
SVF: Fit			
CRD			
Qualified Guesses :			
Soil			
Geology			
Vegter			
Acru			
Harvest Potential			
Expert's guesses	4.2	1.1	5
Base Flow (minimum Re)			
^{2} H displacement method			
Carbon 14 method			
EARTH Model			
Groundwater Flow Model			
Average recharge	4.2	1.1	
Recharge =	4.2		= 1.92 Mm^3/a
			= 5260.48 m^3/d
			= 60.89 L/s

Area (Km^2) =	452
Annual Rainfall (mm) =	371

MAIN

East Site

Method	mm/a	% of rainfall	Certainty (Very High=5 ; Low=1)
CI			
SVF: Equal Volume			
SVF: Fit			
CRD			
Qualified Guesses :			
Soil			
Geology			
Vegter			
Acru			
Harvest Potential			
Expert's guesses	13.6	2.5	5
Base Flow (minimum Re)			
^{2} H displacement method			
Carbon 14 method			
EARTH Model			
Groundwater Flow Model			
Average recharge	13.6	2.5	
Recharge =	13.6		= 1.80 Mm^3/a
			= 4942.13 m^3/d
			= 57.20 L/s

Area (Km^2) =	133
Annual Rainfall (mm) =	548