APPENDIX O PRELIMINARY GEOPHYSICS

Devil's Elbow Proposed Upgrade

Geophysical Interpretive Report

Hills of Gold Wind Farm Pty Limited

Reference: SYDGE282065-AD-002

1 April 2021

DEVIL'S ELBOW PROPOSED UPGRADE

Project reference number: SYDGE282065-AD-002
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CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
BSGM	Black Snake Gold Mine
DEPU	Devil's Elbow Proposed Upgrade
ERI	Electrical Resistivity Imaging
ERM	Environmental Resources Management
GDA	Geocentric Datum of Australia
GNSS	Global Navigation Satellite System
HoG	Hills of Gold
MBG	Metres Below Ground
MGA	Map Grid of Australia
RNE	Register of the National Estate
SoHI	Statement of Heritage Impact

1. INTRODUCTION

Coffey Services Australia Pty Ltd (Coffey) has been engaged by Engie ANZ (Engie) on behalf of Hills of Gold Wind Farm Pty Ltd to provide a geophysical investigation during the concept stage of the Devil's Elbow Proposed Upgrade (DEPU) to Barry Road, east of Nundle, near Tamworth in north-eastern NSW.

As part of the proposed Hills of Gold Wind Farm project, a Statement of Heritage Impact (SoHI) investigation was completed by Environmental Resources Management (ERM) to assess any potential for heritage impact surrounding the proposed road upgrade. The SoHI report identified access tracks and one mine shaft remaining from the Black Snake Gold Mine (BSGM) along the proposed alignment of the DEPU. The SoHI report concluded that it was highly likely that other mine shafts were present within the DEPU area.

This report presents the results of the geophysical investigation to assess potential for subsurface voids relating to abandoned mine workings, and to highlight other possible anomalies that may indicate the presence of archaeological features.

2. BACKGROUND

As discussed in the SoHI report, the Register of the National Estate (RNE) listing provides the following description of Black Snake Gold Mine:

> *The Black Snake Gold Mine is a 17.5 hectare area of Public Recreation Reserve located approximately 4.5 km east of Nundle, in the shadow of Hanging Rock. Hanging Rock Road runs immediately past the north west boundary of the site, and the old workings can be accessed along old miners trails, and on other old forest tracks. The site is steep rising from about 870m in the gully at Black Snake to about 970m on the spur above Brown Snake.*
>
> *Access to the mines is variable. At Brown Snake, accessible slopes and drives are small and limited to the vicinity of the adit. At Black Snake, over 100 metres of drive is open and clear, as well as several of the stopes which have been largely back filled.*
>
> *The timber used in the construction of the mine is deteriorating and has been removed in some areas. The internal timber drainage system is not functioning.*
>
> *Vegetation on the land is moderately dense primary and secondary growth eucalypt forest; undergrowth can be intense in places, but ground traversing on foot is possible over most of the area.*

The RNE also states:

> *The front of a tunnel has caved in but the tunnel itself is in good condition. The workings are reported to be in good condition. Loose scree, timber, and other elements have been removed from the workings. Landslip material and small roof falls have been secured and accessible tunnels and stopes have been tidied up to improve drainage and access.*

The Statement of Heritage Impact (SoHI) pedestrian survey of the assessment area was undertaken by Stephanie Moore (ERM Heritage Consultant) and Aref Taleb (Someva Renewables) on Wednesday 28 October 2020 and commenced at the south-western end of the 'Devil's Elbow' proposed upgrade and moved north-east towards the tie in with Barry Road. The inspection focused on the proposed road upgrade works alignment, and did not include a comprehensive investigation of the LEP listed curtilage, or the SHI mapped area, of Black Snake Gold Mine.

It is understood that the survey identified a number of access tracks remaining from the Black Snake Gold Mine within the vicinity of the Devil's Elbow Proposed Upgrade (DEPU). Additionally, one mine shaft was located on an existing access track. The SoHI Report concluded that the existence of other mine working

related features were highly likely within the DEPU area. The report also assessed the potential to impact tunnels along the alignment as moderate.

It was from this report that a geophysical survey was selected to provide further information for assessing the potential for subsurface voids relating to abandoned mine workings, and to highlight other possible anomalies that may indicate the presence of archaeological features.

3. SITE DESCRIPTION

The site of the Devil's Elbow Proposed Upgrade is located about 7 km north-west of Hanging Rock and 6 km east of Nundle, in north-eastern NSW. This project involves the construction of a road to bypass the existing hairpin at the 'Devil's Elbow' section of Barry Road, to aid transportation during construction of the Hills of Gold Windfarm project. The layout of the DEPU is shown in Figure **1**.

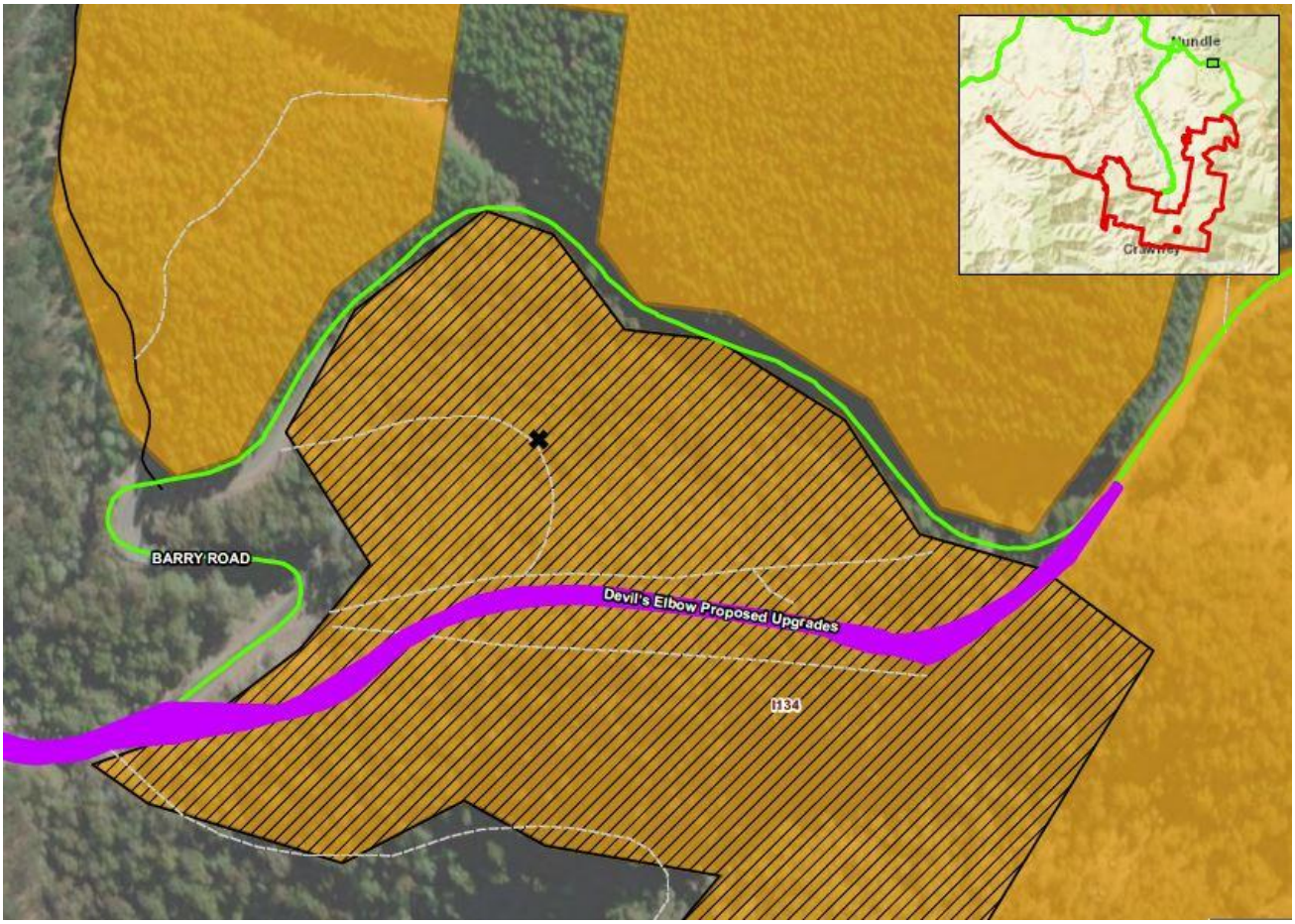

Figure 1: Devil's Elbow Proposed Upgrade Layout

The 'Devil's Elbow' section of Barry Road is characterised by hilly, thick natural bushland. Several old unmaintained access tracks are present within the project area, along with some abandoned wooden telegraph poles. The DEPU alignment runs along a ridgeline that is flanked by steep drop offs to the north and south.

Reference to the NSW Seamless Geology Database (NSW Department of Planning, Industry & Environment, 2020) indicates the project area comprises Dolerite from the Folly Volcanics, and Mudstone from the Yarrimie

Formation. The NSW Seamless Geology Database shows two units as having no continuous contact and instead form alternating bands from west to east (Figure 2).

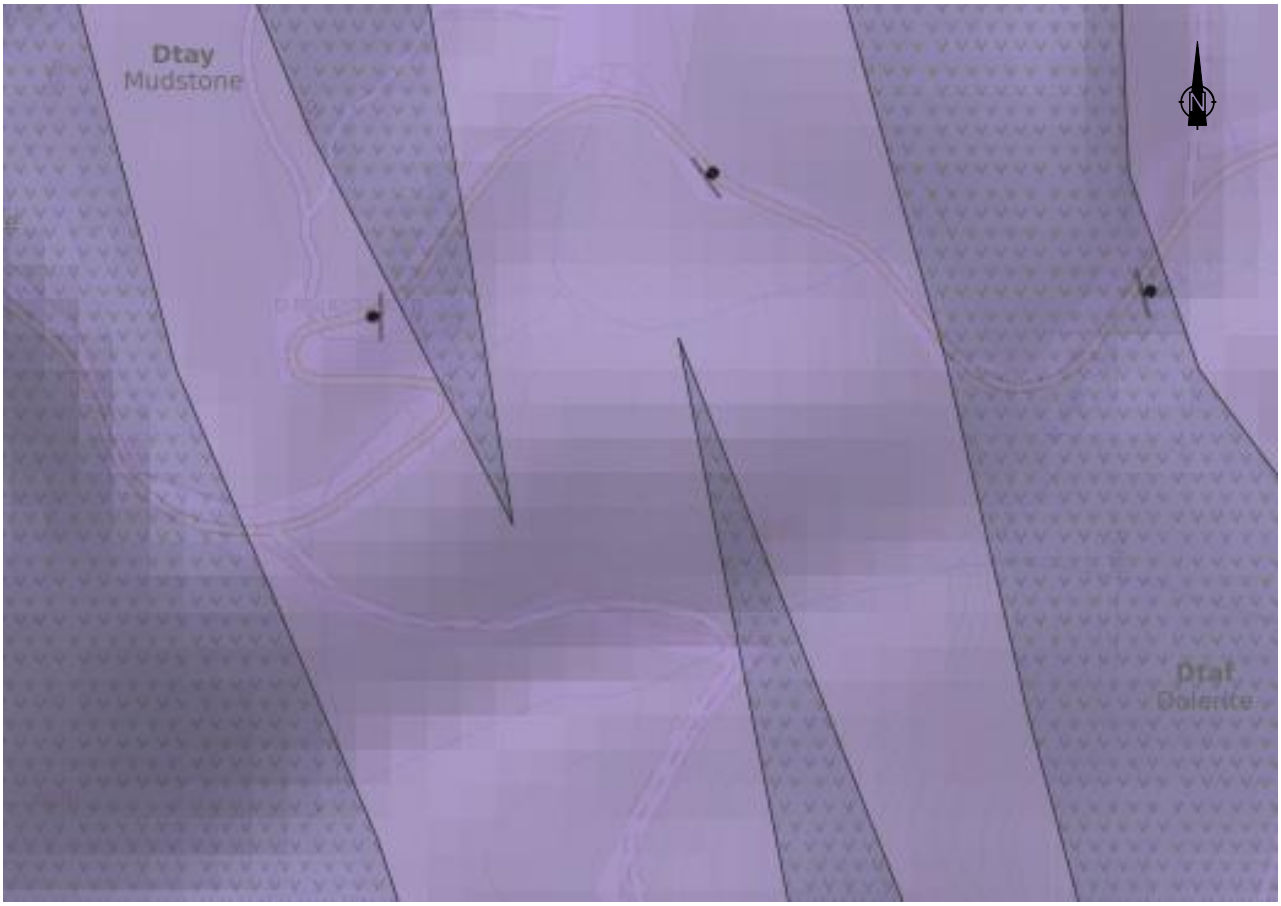

Figure 2: NSW Seamless Geology showing Mudstone (Dtay) and Dolerite (Dtaf) within the DEPU area.

4. METHODOLOGY AND FIELD PROCEDURES

4.1 FIELDWORK

Geophysics fieldwork was completed between 14-15 February 2021. Data acquisition was carried out by an experienced Coffey geophysicist in accordance with accepted industry practice. One Electrical Resistivity Imaging (ERI) profile was acquired within the project alignment. The final location and orientation was selected on site with consideration for access constraints from topography and the straight line acquisition requirements of the ERI method.

Figure GEOP-01 in Appendix A provides a site plan and the ERI survey line.

4.2 ELECTRICAL RESISTIVITY IMAGING (ERI)

The Electrical Resistivity Imaging (ERI) method measures the distribution of subsurface electrical resistivity (inverse of conductivity) from electrodes placed on the ground surface. The variation and distribution of in situ apparent resistivities can reflect changes in geological characteristics such as lithology and porosity, and can highlight large electrical contrasts such as subsurface voids of either natural or anthropogenic origin.

The ERI method utilises Ohm's Law by injecting an electric current into the ground via two (current) electrodes, and measuring the potential difference on two other (potential) electrodes. The ratio of the

measured potential difference and injected current is an indication of the electrical resistance of the subsurface.

A fully automated resistivity system (Syscal Switch Pro - 10 channel) with 72 electrodes was used to acquire the ERI data. A Dipole-Dipole electrode array configuration was selected to best highlight lateral variations. The Syscal resistivity meter can output up to 2.5 amps at 800 volts (± 0.2%) and measure resulting ground voltage drop to the nearest 1 µV (micro-volt). The spacing of the metal stake electrodes was nominally 3 m to achieve required depth of investigation. Roll-along sequences were used to create a single continuous ERI profile approximately 400m in length. Coordinates of the acquired ERI profile are provided in Table 1.

4.3 POSITIONING

The ERI profile was georeferenced using a Navcom Land-Pak Virtual Reference Station-Real Time Kinematic (VRS-RTK) system, utilising the Global Navigation Satellite System (GNSS) that comprises the U.S. GPS and Russian Global Navigation Satellite System (GLONASS) networks with RTK accuracy level achieved via the Australian (local NSW) HxGN SmartNet network. Recorded coordinates and elevations were accepted when accuracy was better than 10mm horizontally and 30mm vertically. Where insufficient satellite or internet reception was available to adequately measure seismic profile elevations, a laser level system was used to record relative heights at electrode positions.

Coordinates are provided in the Geocentric Datum of Australia (GDA) 1994, and Map Grid of Australia (MGA) Zone 56. Heights are provided in the Australian Height Datum (AHD).

Table 1 Start and end coordinates of Electrical Resistivity Imaging survey

Line	Start			End		
	Easting (m)	Northing (m)	Chainage (m)	Easting (m)	Northing (m)	Chainage (m)
ERI	326322.1	6516238.4	0	326618.8	6516297.9	393.0

5. DATA PROCESSING

In general, the acquired resistivity data were of good quality and adequate for analysis and interpretation. In situ (measured) data was iteratively processed post-fieldwork to transform measured values into outputs suitable for analysis and interpretation.

The raw ERI data was downloaded and filtered using Prosys III©, an IRIS instruments software program calibrated for the Syscal Pro unit. ERI data processing included checking the data graphically and numerically for noise levels and removing any erroneous data or outliers. The cleaned ERI data was converted to an apparent resistivity section (pseudosection) for interpretation in accordance with accepted practice using the Res2Dinv commercial inversion software.

Measured apparent resistivities were inverted using the L_1-norm inversion method to produce an inverse model resistivity section. L_1-norm inversion constraints were selected to best highlight sharp boundaries that may be present (Olayinka and Yaramanci 2000, Loke et al. 2003) between host rock and an air filled mine shaft.

6. RESULTS AND INTERPRETATION

The results of the ERI investigation are presented in figure GEOP-02 in Appendix A. As no intrusive geotechnical testing has been completed within the DEPU project area, interpretations have been made based on values of modelled resistivities and their relative spatial distribution.

Modelled resistivity values in the ERI section have a large range, varying between $5x10^0$ to $1.8x10^5$ Ωm. Resistivity values increase in places very rapidly with depth, and exhibit some lateral variation likely due to changes in geology between the Folly Volcanics, and the Yarrimie Formation. Resistivity values, while high, fall within the ranges expected from Mudstone and Dolerite (Reynolds 2011).

Two geoelectric layers have been identified and interpreted in the results. The upper layer (denoted as blue and purple on the ERI section) is characterised by modelled resistivity values <500 Ωm. The second geoelectric layer (green to red) contains resistivities ranging from ~500 to $1.8x10^5$ Ωm.

Figure GEOP-03 provides an interpretation of the modelled resistivities and the geoelectric boundaries identified. Air filled voids or abandoned mine shafts will have resistivity values considerably higher than the surrounding host rock. Three localised areas (Area 1, 2, and 3) within the second geoelectric layer have been interpreted as sub-surface voids and therefore potential mine workings, characterised by anomalously high modelled resistivity values in spatially constrained zones. Note that the size of these areas as presented in the ERI section is likely exaggerated as a result of the acquisition electrode spacing and selected inversion parameters 'smearing' the influence of the measured data points within those locations. Area 1 exhibits a more contrasting response than Area 2, or 3.

The areas of interpreted mine workings (Area 1, 2, and 3) are highlighted both in plan view and on the ERI section in figure GEOP-03. The centres of each target are located at approximately ch.175, ch.250. and ch.280 along the ERI line. Coordinates at these locations are provided in Table 2.

Table 2 Areas of interest interpreted from results of the ERI investigation.

Area of Interest	Easting	Northing	Approximate Ch. Along ERI Section	Depth (MBG)
1	326494	6516271	175 m	10 m
2	326567	6516285	250 m	15 m
3	326595	6516291	280 m	10 m

7. CONCLUSIONS

The geophysical survey line using the ERI method has identified three resistivity anomalies (Areas 1, 2 & 3) interpreted to be potential historical mine tunnels under the proposed new Devils Elbow Road realignment.

While it is possible that the anomalies identified at Areas 1, 2, and 3 are the result of natural processes and unrelated to the Black Snake Gold Mine, the discrete nature of the resistivity anomalies, their very high resistivity values, and their proximity to known abandoned mine workings indicates these anomalies are likely to be abandoned mine workings.

The location of these anomalies are highlighted on Figure GEOP-03. Their shape though, is an interpretation of the data only which can be influenced by factors such as:

- the angle at which a tunnel could cut across the survey line;
- the array type used to collect the ERI data (in this case dipole-dipole), and;
- depth of feature.

To further refine this geophysical data interpretation additional intrusive investigations (such as boreholes) and/or ground truthing, i.e. inspection and mapping of the tunnels, would be necessary.

8. RECOMMENDATIONS FOR FURTHER ASSESSMENT

We note that the ERI investigation has interpreted the presence three voids in the ground under the proposed new Devil's Elbow Road re-alignment that are expected to be old mine tunnels. To assess whether the proposed new road has a potential to impact these tunnels, or whether the tunnels have a potential to impact the new road, further investigation and geotechnical engineering modelling/assessment would be necessary.

While it is not expected to be feasible to enter, inspect and map the tunnels beneath the road alignment, it is expected that sufficient information on the tunnels geometry and ground conditions around the tunnels for a geotechnical engineering assessment could be obtained from a detailed geotechnical borehole and further geophysical investigation of the road alignment through the Black Snake Gold Mine site.

The purpose for further investigation is to;

- Assess the footprint and depth of mine tunnels beneath the proposed new road alignment; and
- obtain information on ground conditions around and between the mine tunnels, and overlying road.

We recommend the following additional investigation:

- The drilling of boreholes into the three interpreted voids to test the void depth and obtain information on ground conditions between the road and interpreted tunnels;
- Drilling of additional boreholes along the alignment to obtain general site/alignment ground information; and
- Further ERI investigation correlated against the borehole data, to assess the tunnel footprints under the road alignment

Following site investigations, the resulting information on ground conditions and tunnel layouts, together with suitable assumptions about the current tunnel conditions, would then be used to carry out geotechnical engineering modelling and assessment for guidance on;

- Whether the new road would adversely surcharge the tunnels and potentially cause localised collapse
- Whether potential long-term tunnel cave-in and/or collapse through natural degradation of the tunnel support or surrounding ground would impact the road.

From our tunnel design experience and as an initial guide, we expect that provided the tunnels have at least 5 metres of sound rock cover and have span less than 4 m then collapse of the tunnel roof would be unlikely to be caused by road excavation (provided measure such as heavy blasting are avoided) and that collapse of the tunnel would be unlikely. However, as noted above this would have to be assessed through further site investigation and geotechnical engineering modelling/assessment. If it is then subsequently determined through geotechnical engineer modelling/assessment that there is potential for the road to impact the tunnels, or the tunnels to impact the road, there are then various design or construction strategies which may be implemented to manage this such as;

- Amending the road alignment, or proposed cut/fill earthworks for road construction.
- Raising the road level with fill at critical locations.
- Ground improvement treatment to strengthen ground over the tunnels.
- Use of bridging slabs over critical sections.

9. REFERENCES

Loke, M.H., Acworth, I., and Dahlin, T. (2003). A comparison of smooth and blocky inversion methods in 2D electrical imaging surveys. *Exploration Geophysics, 34*, 182-187.

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Olayinka, A.I. and Yaramanci, U. (2000). Use of block inversion in the 2-D interpretation of apparent resistivity data and its comparison with smooth inversion: *Journal of Applied Geophysics, 45*, 63-82

Reynolds, John M. (2011). *An introduction to applied and environmental geophysics*. Chichester: John Wiley.

10. CLOSING

The description of subsurface conditions described in this report are based on discrete/specific investigation methodologies used in accordance with normal practices and standards and the information provided by the Client. Ground conditions can change over relatively short distances and timeframes. The document titled “Important Information About Your Coffey Report” presents additional information on the uses and limitations of this report.

If you have any comments or queries, or require any further information regarding the above, please contact the undersigned on 9406 1000.

APPENDIX A: FIGURES

LEGEND

- Township
- Project Site
- ERI Acquisition Footprint
- Proposed Road Alignment
- Entrance to Black Snake Gold Mine

GEODETIC PARAMETERS

Geodetic Datum:	GDA1994
Coordinate System:	MAP GRID of AUSTRALIA 1994
Projection:	Universal Transverse Mercator (UTM) Zone 56
Semi Major Axis:	6378137.0m
Inverse Flattening (1/f):	298.257222101
Central Meridian:	153°00'00 East
Reference Latitude:	00°00'00 North
Scale Factor at CM:	0.9996
False Easting:	500,000m
False Northing:	10,000,000m

revision

no.	description	drawn	approved	date
01	PRELIMINARY	JJ	SS	19-03-2021

0 50 100 150
Scale (m) 1:2500

drawn	JJ
approved	SS
date	19-03-2021
scale	1:2500
original size	A3

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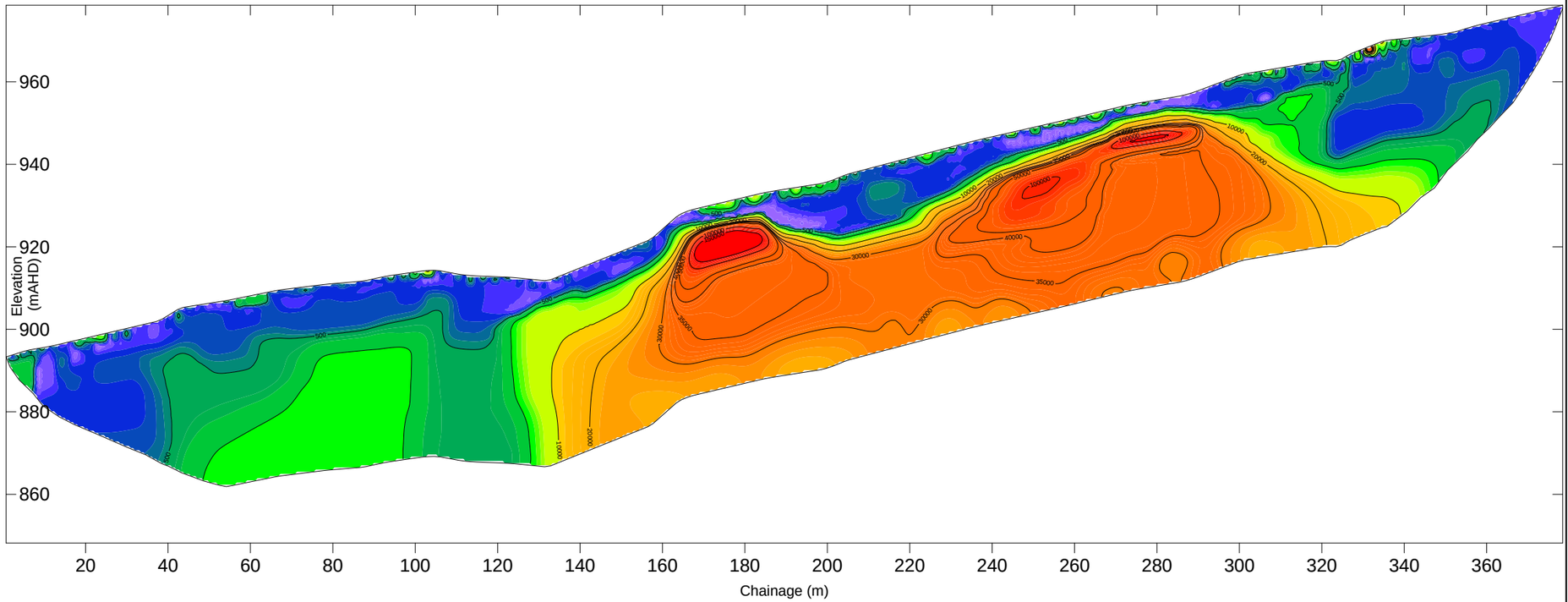
client: HILLS OF GOLD WIND FARM

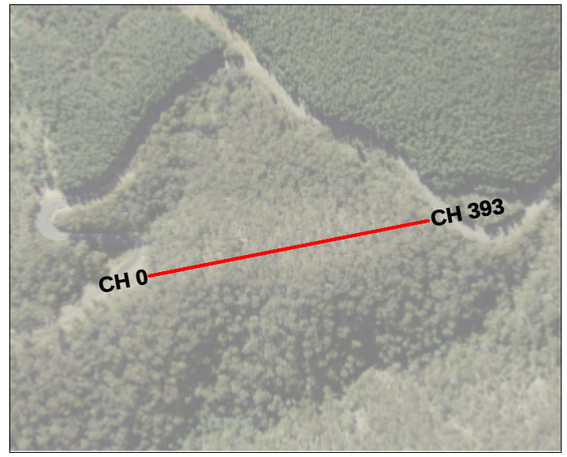
project: DEVIL'S ELBOW PROPOSED UPGRADE

title: GEOPHYSICAL SURVEY - SITE PLAN

project no: 754-SYDGE282065-AD | figure no: GEOP-01 | rev:

ERI Section

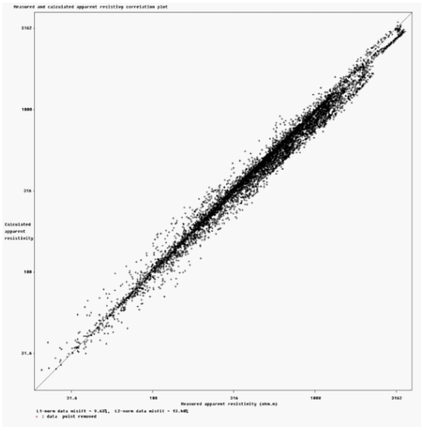




LEGEND

- Township
- Project Site
- ERI Acquisition Footprint

Measured vs. Calculated Apparent Resistivity Correlation Plot



Modelled Resistivity (Ωm)

5 20 500 2,000 10,000 20,000 30,000 50,000 100,000 150,000

revision	no.	description	drawn	approved	date
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0 20 40 60 80
Scale (m) 1:3000

drawn	JJ
approved	SS
date	19-03-2021
scale	1:3000
original size	A3

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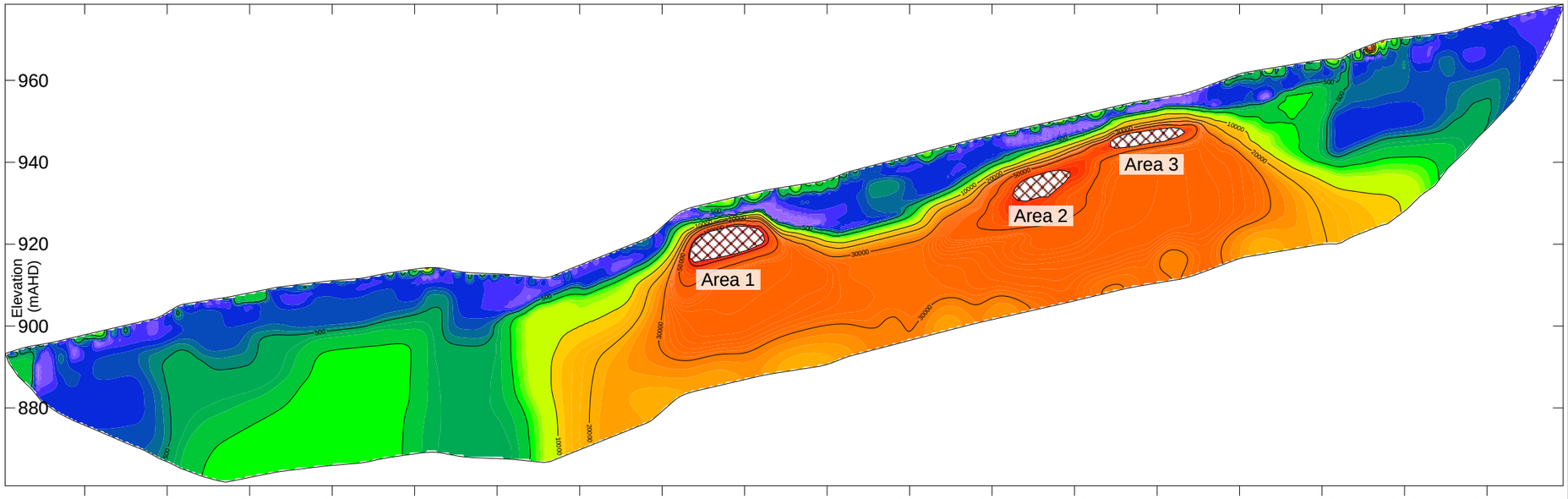
client:	HILLS OF GOLD WIND FARM	
project:	DEVIL'S ELBOW PROPOSED UPGRADE	
title:	GEOPHYSICAL SURVEY - ERI SECTION	
project no: 754-SYDGE282065-AD	figure no: GEOP-02	rev:

LEGEND

- Township
- Project Site
- ERI Acquisition Footprint
- Proposed Road Alignment
- Entrance to Black Snake Gold Mine
- Area of Interest (Plan View)
- Area of Interest (Section View)

ERI Section



revision	no.	description	drawn	approved	date
	01	PRELIMINARY	JJ	SS	19-03-2021

drawn	JJ
approved	SS
date	19-03-2021
scale	
original size	A3

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client:	HILLS OF GOLD WIND FARM		
project:	DEVIL'S ELBOW PROPOSED UPGRADE		
title:	GEOPHYSICAL SURVEY - AREAS OF INTEREST		
project no: 754-SYDGE282065-AD		figure no: GEOP-03	rev:

APPENDIX B: IMPORTANT INFORMATION ABOUT YOUR COFFEY REPORT

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.