Llywodraeth Cymru
Welsh Government

The Coal Authority

South Wales Colliery Spoil Tips

Groundsat Soil Moisture Mapping - Capability Statement and Proposal

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July 2021

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RSK GENERAL NOTES

Project No.: 2390043

Title: South Wales Colliery Spoil Tips
Groundsat – Soil Moisture Mapping Capability Statement and Proposal

Client: Llywodraeth Cymru & The Coal Authority

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1 INTRODUCTION

1.1 Background

The Welsh Government and The Coal Authority would like to undertake an assessment of colliery spoil tips in South Wales. As part of this assessment it is proposed to map soil moisture using Groundsat to allow temporal assessments of soil moisture-based landslide susceptibility to be made. RSK Environment Limited (RSK) has prepared this capability statement and proposal to allow an evaluation of the technique to be made, with view to commissioning works.

1.2 Objectives

Resilience to climate change forms a fundamental aspect of future management for asset owners. Rainfall-induced shallow landslides are hazardous phenomena triggered by intense and concentrated rainfall. These landslides develop in unconsolidated tip deposits generally in the form of translational or shallow rotational failures that can lead to debris flow type failures. The topography of South Wales and the location of many tips on natural slopes, increases the risk of failure.

The objective of the proposed Groundsat study is to provide soil moisture maps and analysis of the tips and immediately adjacent area, including catchment/watershed areas impacting, and influencing the tips. This data will assist in the evaluation of landslide susceptibility of the tips and help inform prioritisation of the sites, in terms of the location of pro-active interventions and / or more focussed monitoring.

2 CAPABILITY STATEMENT

2.1 RSK – Central Alliance

RSK is a leading integrated environmental, engineering and technical services business. With a strong geotechnical team in the UK and overseas, RSK have a wealth of experience in slope stability analysis, geotechnical design, and slope stabilisation. Subsidiary Central Alliance (CA) have gained a vast amount of experience investigating and surveying landslides and slope stability problems. This experience has included investigations of the most significant landslides on linear infrastructure in recent years, including Hatfield Colliery, Harbury Cutting, Eden Brows, Farnley Haugh, Loch Eilt and Carmont-Stonehaven. The CA geotechnical team is experienced in this field and were responsible for developing the principle of using high resolution soil moisture mapping for landslide susceptibility and geohazard assessments. The Applied Technologies division of CA was established in 2015 with the sole focus of introducing new and innovative survey and investigation techniques into the industry. Groundsat is a development of this programme and was created with the aim of providing a pro-active technique that searches for the cause of failures, rather than the effects. Central Alliance has worked closely with satellite technology specialist Utilis, to develop the technique for geotechnical and drainage purposes and culminated in a New Civil Engineer Techfest award in 2019. Our understanding of geotechnics allows us to analyse and interpret soil moisture mapping, by combining the data with other datasets, enabling susceptibility mapping to be produced.

2.2 Utilis

Founded in 2013 by a scientist who was doing his master's degree in atmospheric physics and dynamics, Lauren Guy was using the technology to detect water on the planet Mars when he realized his research could be applied to find water here on Earth.

With the potable leak detection product first commercialized in 2016, over 400 projects have been completed worldwide in countries including the United States, Italy, UK, Chile, China and South Africa, leading to almost 30,000 leaks verified and saving customers 7,000 million gallons a year. Utilis uses L-Band synthetic aperture radar (SAR) data, which is non-intrusive and requires no capital investment or device installation.

Utilis has grown to 40 employees in three offices, in Israel, the United States (San Diego), and the UK. With half the company made up of scientists, engineers, and experts in the geospatial sciences, Utilis invests heavily in research and development to continually improve current products and bring new, innovative data products to the market.

2.3 Groundsat Technology

Groundsat is based upon using innovative satellite technology and a Utilis patented new method of analysis of images captured by a satellite-borne L-Band SAR sensor. The analysis has been adapted from earlier academic projects that searched for water on other planets.

Backscatter data provides a high correlation with gravimetric measurements on field soil samples has been demonstrated by Utilis and Central Alliance as well as other world authorities on the technique (Ponganan, et al., 2016: Sekertekin, Marangoz, Abdikan & Esetlili, 2016)

The relationship between microwave and soil moisture content has been studied over several decades. The use of satellite microwave remote sensing technologies for quantitative soil moisture mapping was introduced in the 1980's with SAR (Synthetic Aperture Radar) technology.

This method was applied and proven accurately on the upper soil thin layer (5-10 cm depth) (Behari, 2005). The main limitation was the spatial resolution which was too coarse. Other limitations were soil texture, surface roughness and vegetation coverage. The use of full (Quad) polarimetry SAR imagery, and L-band, which is known for its capabilities for soil moisture content detection and penetrates of both vegetation coverage and the topsoil layer, plays a major role in the improved accuracy of the results.

2.4 Groundsat Soil Moisture Mapping

Groundsat has been commissioned by other leading asset owners and infrastructure companies including for previous, and current projects for:

- Highways England
- Network Rail
- BNSF (USA)
- EPZ (Austrian Alps geohazard mapping)

All projects have proven the strong correlation between SAR data and soil moisture content values, with algorithms developed and refined by ground truthing data and laboratory testing. High correlations of 0.83 to 0.85 have been achieved between laboratory test and SAR data, allowing a fully remote relative assessment of soil moisture to be made.

2.5 GIS Data Analysis

Processed Groundsat soil moisture data is provided as a GIS layer which can then be analysed further.

3 GROUNDSAT PROPOSAL

It is proposed to carry out a temporal study of 69no. Category D tip sites. This will comprise a baseline survey, undertaken in a drier month and a comparison survey undertaken in a wetter winter month. The sites are located at various locations within South Wales. Table 1 provides the site ID for each tip to be mapped, along with the tip area and details of availability of open source LiDAR data available from Natural Resource Wales which would be used for the Groundsat analysis. Figure 1 shows an example of SAR image geometries that would be tasked, over the geographical Area of Interest covering the sites.

Table 1 Category D Tip site details

Site ID	Tip Area (km^2)	Open source DEM available? (to include upslope and downslope areas)
2	0.072543	Yes
3	0.237454	Partial
4	0.249554	Yes
5	0.171461	Yes
7	0.049936	Yes
9	0.057135	Yes
10	0.395393	Yes
11	0.3504	No
12	0.080829	Yes
13	0.117064	Partial
14	0.06897	Yes
15	0.050423	Yes
17	0.210007	Yes
18	0.214867	Yes
19	0.169319	Yes
21	0.145552	Yes
22	0.207135	Yes
23	0.130778	Yes
24	0.048918	Yes
25	0.237896	Yes
26	0.121856	Yes
27	0.305955	Yes
28	0.207951	Yes
29	0.168584	Partial
30	0.212097	Yes
31	0.232416	Yes
32	0.229557	Yes
34	0.655206	Yes
35	0.409965	Yes
36	0.092125	Yes
37	0.1263	Yes
38	0.327466	Yes
39	0.453599	Yes
40	0.437577	Yes
41	0.165289	Yes

Table 2 (cont.) **Category D Tip site details**

Site ID	Tip Area	Open source DEM available? (to include upslope and downslope areas)
42	0.332925	Partial
43	0.439679	Yes
44	0.139435	Yes
45	0.441147	Yes
46	0.317735	Partial
47	0.040957	Yes
48	0.129854	Yes
50	0.188235	Yes
52	0.081382	Yes
53	0.514028	Yes
55	0.08461	Yes
56	0.316002	Yes
57	0.047427	Yes
58	0.084989	Yes
59	0.050661	Yes
60	0.258645	Yes
61	0.330199	Yes
62	0.124954	Yes
63	0.407789	Yes
64	0.309301	Yes
65	0.152657	Yes
67	0.12847	Yes
68	0.129559	Yes
69	0.077937	Yes
70	0.171798	Yes
72	0.139295	Yes
73	0.183194	Yes
74	0.212737	Yes
75	0.184725	Yes
76	0.067699	Yes
77	0.335839	Yes
78	0.127736	Yes
79	0.553428	Yes
80	0.086205	Yes
Sites with full DEM coverage		**63no.**
Sites with partial DEM coverage		**5no.**
Sites with no / inadequate DEM coverage		**1no.**

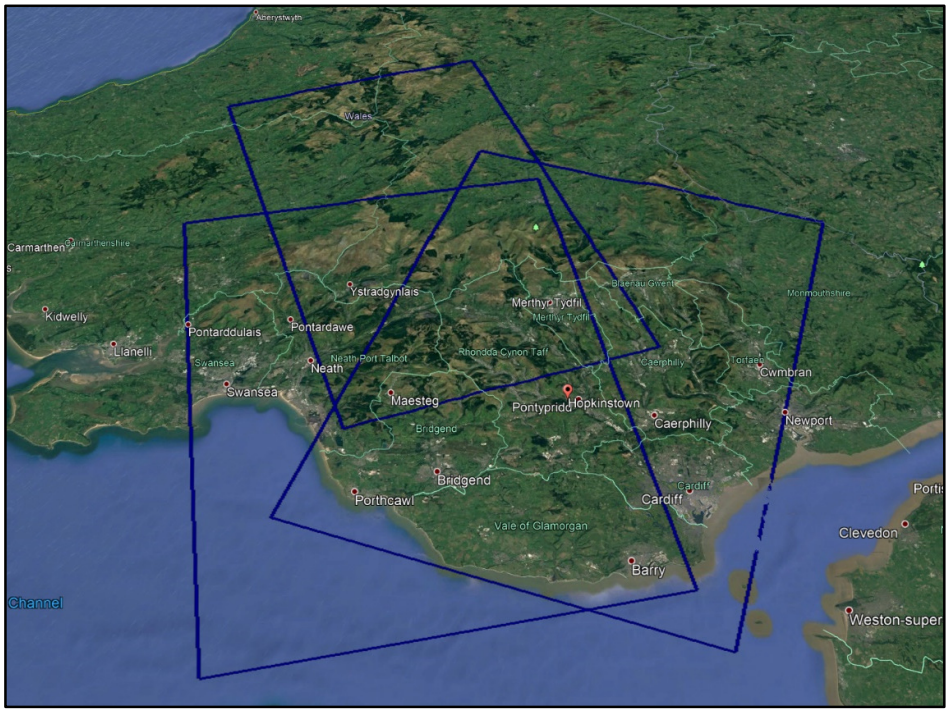

Figure 1 L-Band SAR image areas covering the Area of Interest (2no. of the 3 to be used).

3.1 Processed Groundsat Maps

The processed Groundsat soil moisture data will be provided as a GIS layer and in GISCloud to be accessible from any laptop, tablet or smart phone. Soil moisture maps of each site will be provided including up slope catchment areas and downslope areas of the slope. Where available open source LiDAR data will be used to further analyse the soil moisture mapping.

3.2 Fee Proposal

Summer baseline and Winter Comparison, new acquisitions

	Phase 1 Total			**£116,320**
	Phase 2 Total			**£111,118**
	Grand Total			**£227,438**

Staff Hourly Rates

Item.	Activities and Deliverables	Rate £ per hour
1	GIS and Data Analyst	75
2	GIS Technician	50
3	Director – Geotechnical Engineer	90

3.3 Programme

Upon receipt of an instruction and order 2-3 weeks would be required for tasking of the satellite to secure a time slot for L-Band SAR image acquisition. A further two weeks will be required for processing of soil moisture data and then 6 weeks for analysis in GIS. Data from each site will be issued separately as and when complete, with a final report summarising the findings of Phase 1, issued 12 weeks after SAR image acquisition.

Phase 2 would follow a similar programme with the image acquisition date to be agreed (potentially February/March 2022). Following Phase 2 the task report would be updated to incorporate the Phase 2 findings.