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NWE-REGENERATIS
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D.I1.3.1 Site specific report on excavation activities and civil engineering methods to be applied on Teeside site

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Version 1

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SUMMARY

LIST OF FIGURES

1 INTRODUCTION

The South Tees Development Corporation (STDC) site is a large site of 1500 ha. Its long 160-year history of industrial activity dates back to the mid-19th century and included iron and steel production and the processing of finished products. At its peak, 91 blast furnaces were active.

The STDC site is divided into several areas of previous industrial activity: the Redcar works complex, the Lackenby steelmaking complex, the Grangetown Prairie, the "Landfill and Waste Management facilities" zone and the South Bank zone. The potential of STDC site as a source of secondary raw materials has led it to be part of the three pilot sites of the NWE-REGENERATIS project, as many of these areas are likely to contain significant quantities of waste products that can potentially be valorised, particularly the large zone called "Landfill and Waste Management facilities", and also the smaller zone designated as the Teardrop site and CLE31. Based on estimates from historical studies and previous investigations, 62 million t (25Mm³) of residual slag are spread on an average thickness of 2.5m over the site, the dispersal area having been estimated at about 1000 -1070 ha, comprising Redcar (670 ha), South Bank (270 ha), Grangetown (70 ha) and Lackenby (160 ha).

This site specific report is a continuation of the previous geophysical, historical and analytical investigations carried out on the site (deliverables D.I2.1.1, D.I2.1.2, D.I2.2.1, D.I2.2.2 and D.T2.1.1.) (Capstick, 2020b, 2020a, 2020c; Wagland et al., 2022). The methodology used in this deliverable and the conclusions drawn were developed on the strength of other deliverables (DI3.3.1. and DI2.3.1.) produced for the other two pilot sites, Duferco and Pompey (Lommel, De Rijdt, & Dumont, 2023; Lommel, De Rijdt, Kessouri, et al., 2023). It aims at evaluating the most relevant excavation and civil engineering method to be applied on site before the extraction activities. This report is intended to provide, based on available information, (1) a site description focusing on the most relevant parameters for excavation and civil engineering works, (2) an excavation plan, including a description of the methods and equipment to be preferably used on the area of interest.

2 DESCRIPTION OF THE AREA OF THE TEESIDE SITE ALLOCATED TO THE REGENERATIS PROJECT

The main areas of landfill and waste management inside the Teeside site are shown in Figure 2.

The CLE31 zone was allocated to the REGENERATIS project for the site investigation work (Figures 1 and 2), both in terms of geophysical investigations and material recovery tests. CLE31 mostly comprised of deposited slag materials, though various pieces of scrap materials were also noted. Vegetation growth existed in some areas within the CLE31 zone. While most of the area was flat and accessible, there were some piles and evidence that the deposits were not fully secured, probably due to the layers of slag and resulting air pockets. Those observations are shown in the following images (Figure 3).

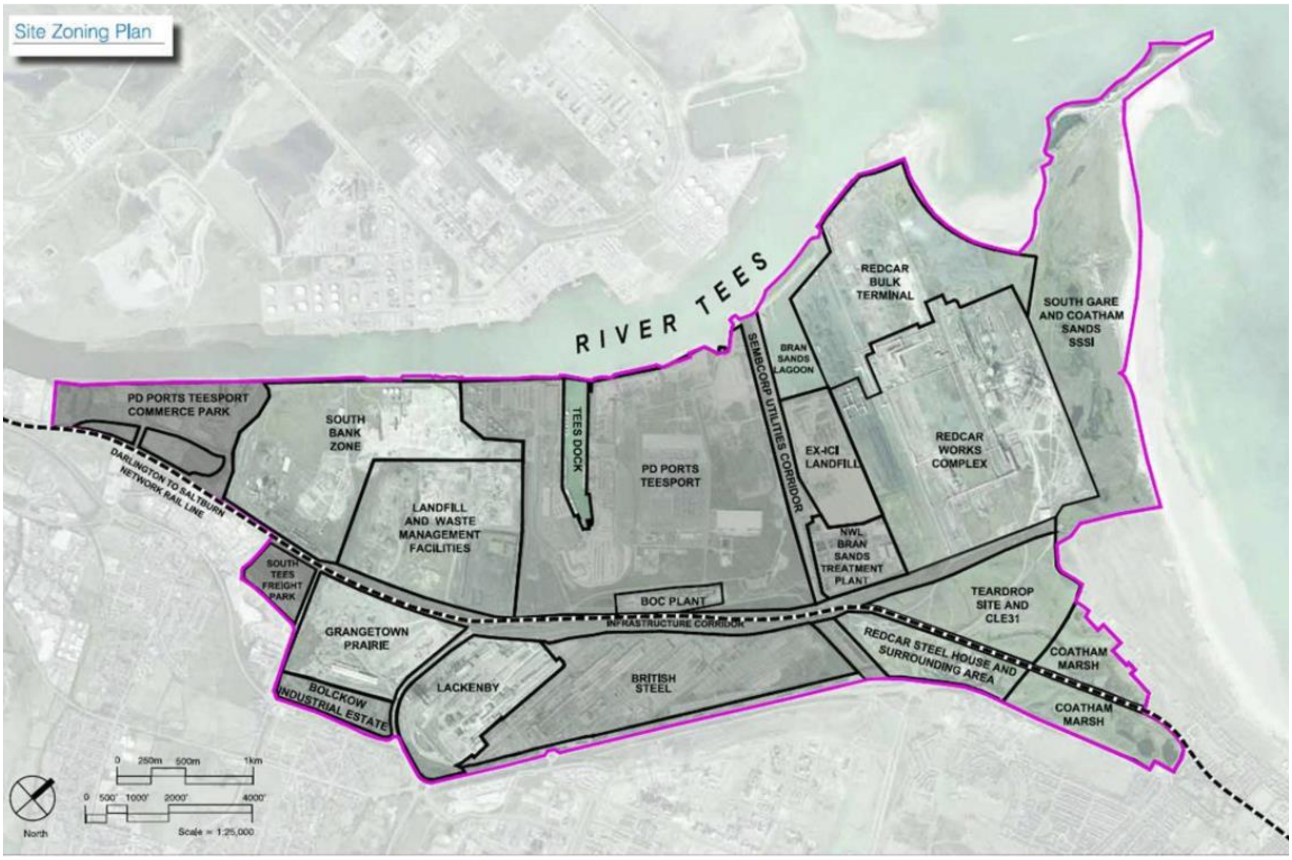

Figure 1 : Complete Teesite PMSD site, from I1.1.2. (Wagland et al., 2022)

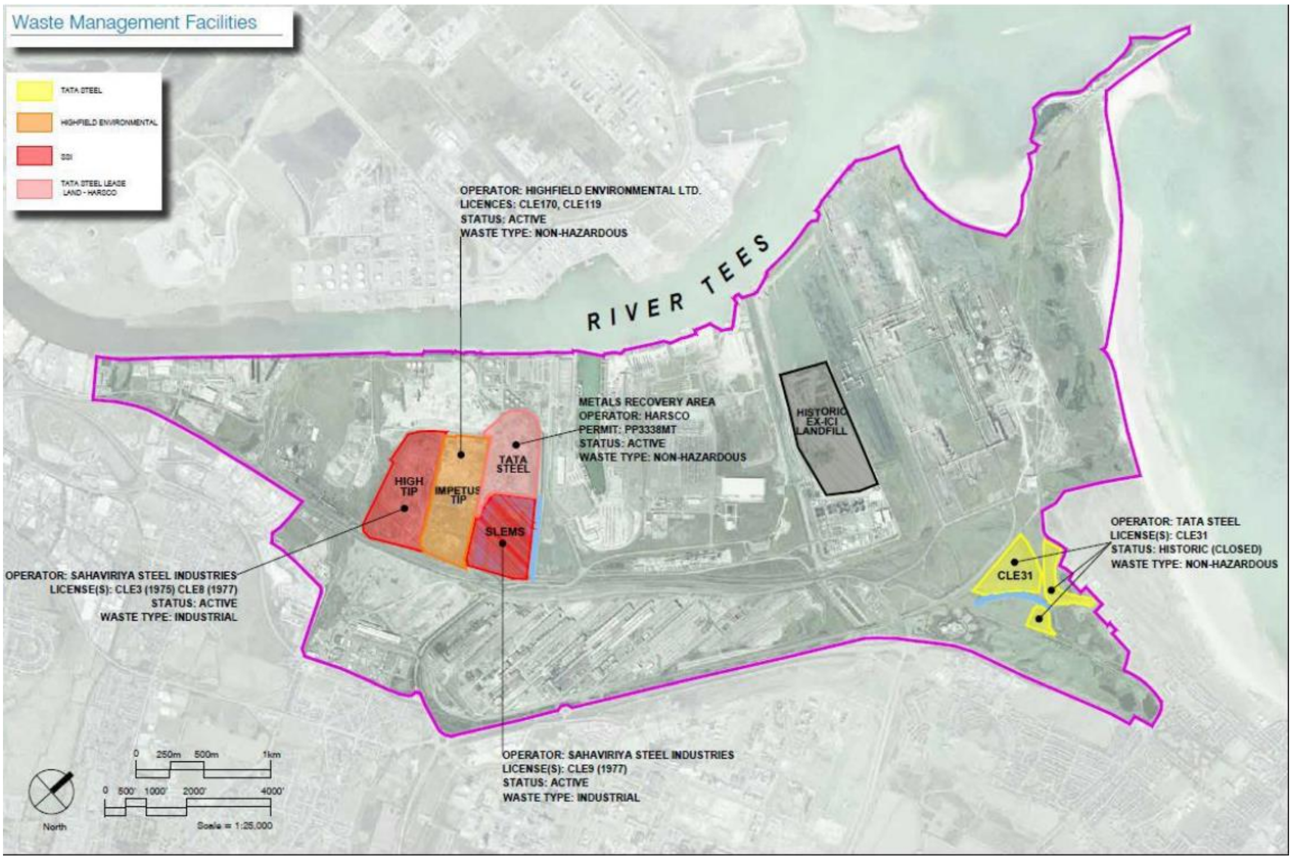

Figure 2 : Waste management facilities inside STDC site, from I1.1.1. The investigated zone in the framework of NWE-REGENERATIS is the CLE31-zone, formerly operated by Tata Steel, CLE31 (Capstick, 2020b)

Figure 3: General photographic overview of the CLE31 area on the Teeside site (above) and appearing layers of slag within the area (below), from I1.1.2.

3 Excavation and civil engineering methods to be applied on site, based on available information

3.1 Volume estimates and excavation plan

The excavation map of the CLE31 area of the Teeside site proposed in this report is based on the GIS processing of the maps extracted from geophysical data. The GIS processing methodology is similar to the methodology used for the first part of deliverable I3.3.1. (Lommel, De Rijdt, & Dumont, 2023).

The geophysical data points were collected using the investigation plan and schedule described in deliverable I1.1.2 (Wagland et al., 2022). At the end of the geophysical investigation, the altitudes of the boundary between the deposit and the natural ground were collected at each measurement point (on the profiles), as shown on Figure 5. GIS geoprocessing of the data then began, by interpolating (IDW), at a resolution of 5 m, the data to the scale of the estimated deposit area (Figure 6). Given that the surface of the ground is relatively flat, it is only necessary to geoprocess the raster by subtracting the altitude of the ground (18 m in asl reference) and the interpolated raster of the boundary between the deposit and the natural ground to obtain the raster of the estimated deposit thickness. The deposit thickness raster was then divided into deposit depth classes according to pixel values: 5 classes of 7m thickness were constituted (Figure 7).

By combining the information from the geophysical GIS geoprocessing (Figure 7) and the cross-section provided by Teesworks (Figure 4), several hypotheses were put forward to calculate the volume. The classes obtained by geophysics (yellow, green and blue classes on Figure 7) expressing a depth of deposit greater than 15 m do not seem to correspond to the cross-section given by Teesworks (Figure 4). It is reasonable to assume that the entire deposit is above the water table, which appears to be 13 m deep according to the Teesworks cross-section. This depth of 13 m will therefore be the maximum depth selected for excavation. This depth of 13 m will therefore be the maximum depth selected for excavation (even in the case of classes expressing a depth greater than that).

The volume is therefore calculated as follows: for thickness classes of less than 15 m (red and orange classes), the corresponding areas are multiplied by the mid-point of the thickness classes; the area of thickness classes of 15 m or more (yellow, green and blue classes) is multiplied by 13 m to obtain the volume to be excavated.

Based on these assumptions, the volume is calculated using the following formula:

$$V_{total} = A_{zone1} * 10.5m + A_{zone2} * 3.5m + 13m * (A_{zone3} + A_{zone4})$$

with V representing the volume (V_{total} the total volume), and A_{zonex} the areas of the different zones defined in Figure 7.

So, knowing that the areas of the zones 1 to 4 delimited by QGIS are respectively equal to 6342 m²; 4849 m², 9660 m² and 19 408 m², the total deposit volume should be 461 446.5 m³.

In conclusion, despite the care taken to select the most plausible assumptions for the excavation plan, there is a high likelihood that the geophysical signal data is not entirely accurate for several reasons. The substantial variability and heterogeneity in the composition of the wasted materials at different scales made it difficult to establish a correlation between the laboratory analyses and the geophysical data, regardless of the methods employed. Additionally, the lack of a secondary campaign to verify the signals further contributes to the limitations of the data. Utmost caution must therefore be exercised when interpreting and utilizing the data for subsequent works.

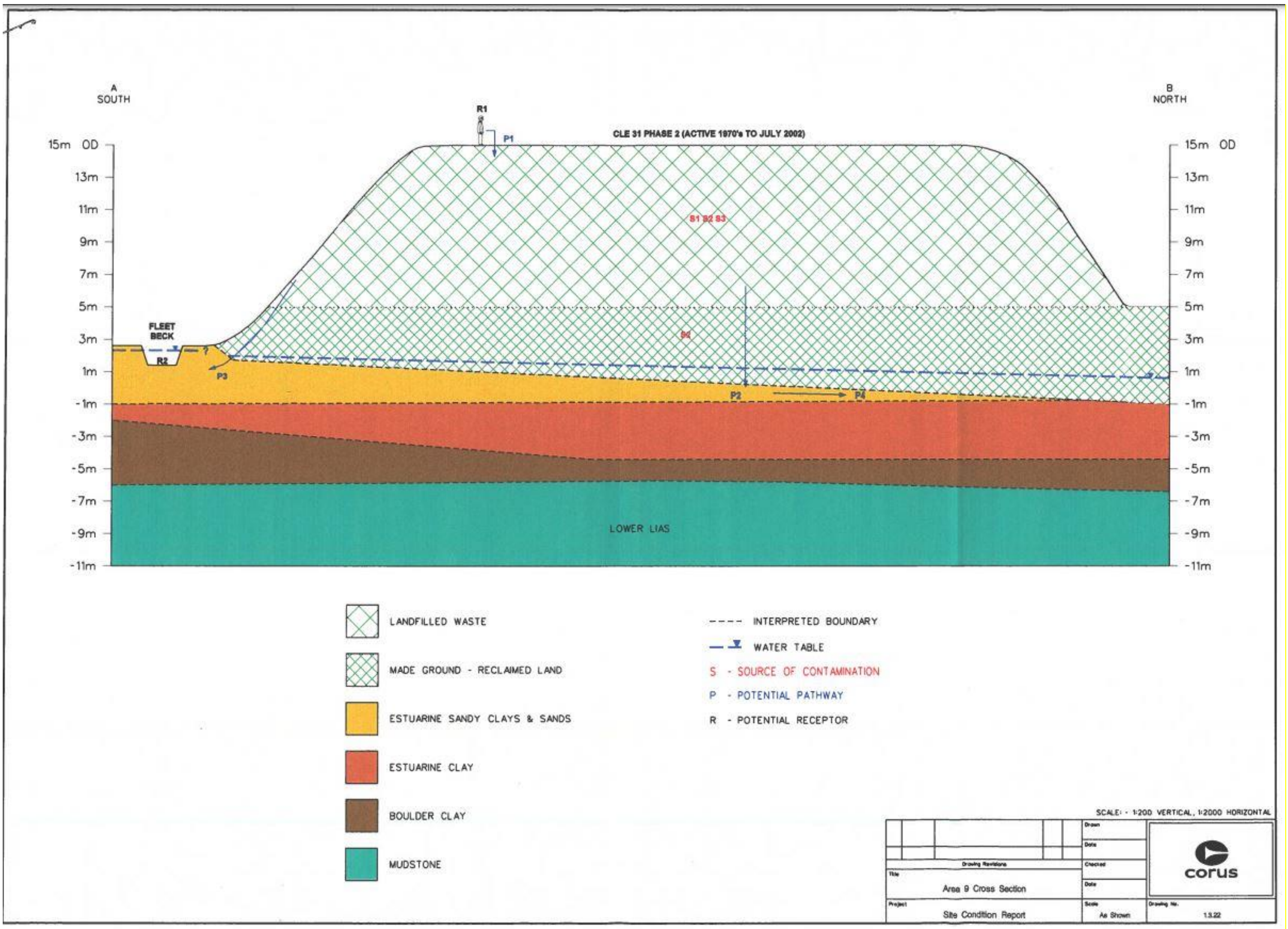

Figure 4 : Teeswork's schematic profile and conceptual model (AOD/OD scale for elevation reference)[1]

[1] It should be noted that there is a positive offset of 5 m between the elevation reference zero used for the geophysics (asl scale) and the reference zero used on the section in Figure 4 (OD scale). This means that an altitude of 15 m in OD scale is equivalent to an altitude of 20 m in asl scale.

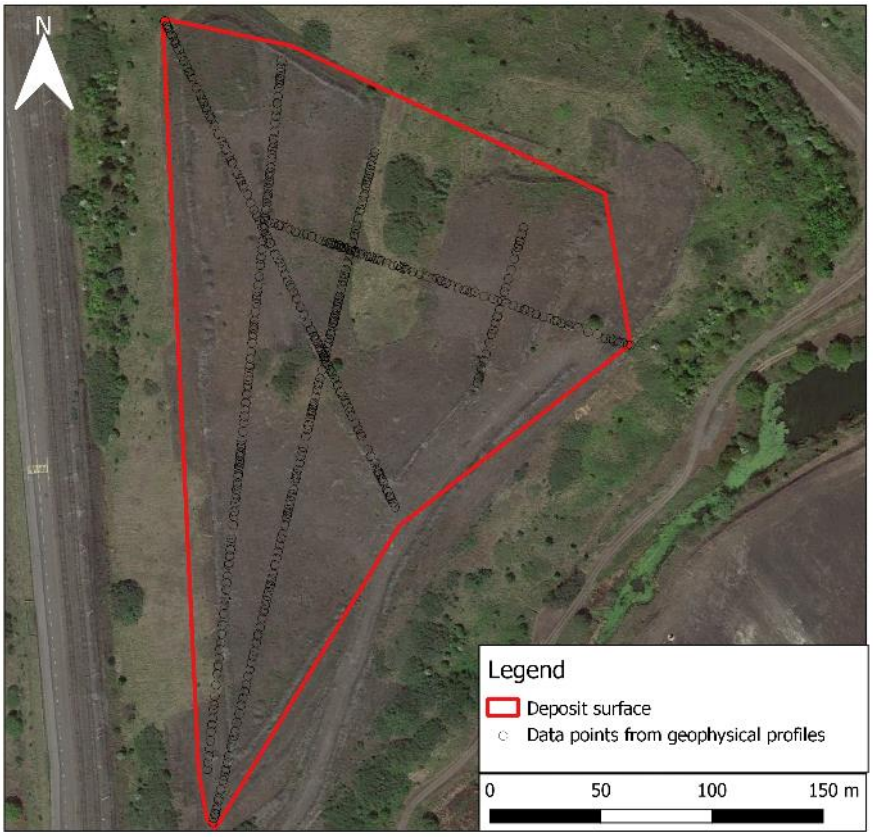

Figure 5: Data points collected from geophysical profiles. The full description of the geophysic's investigation plan and schedule for is available in Wagland et al. (2022)*.*

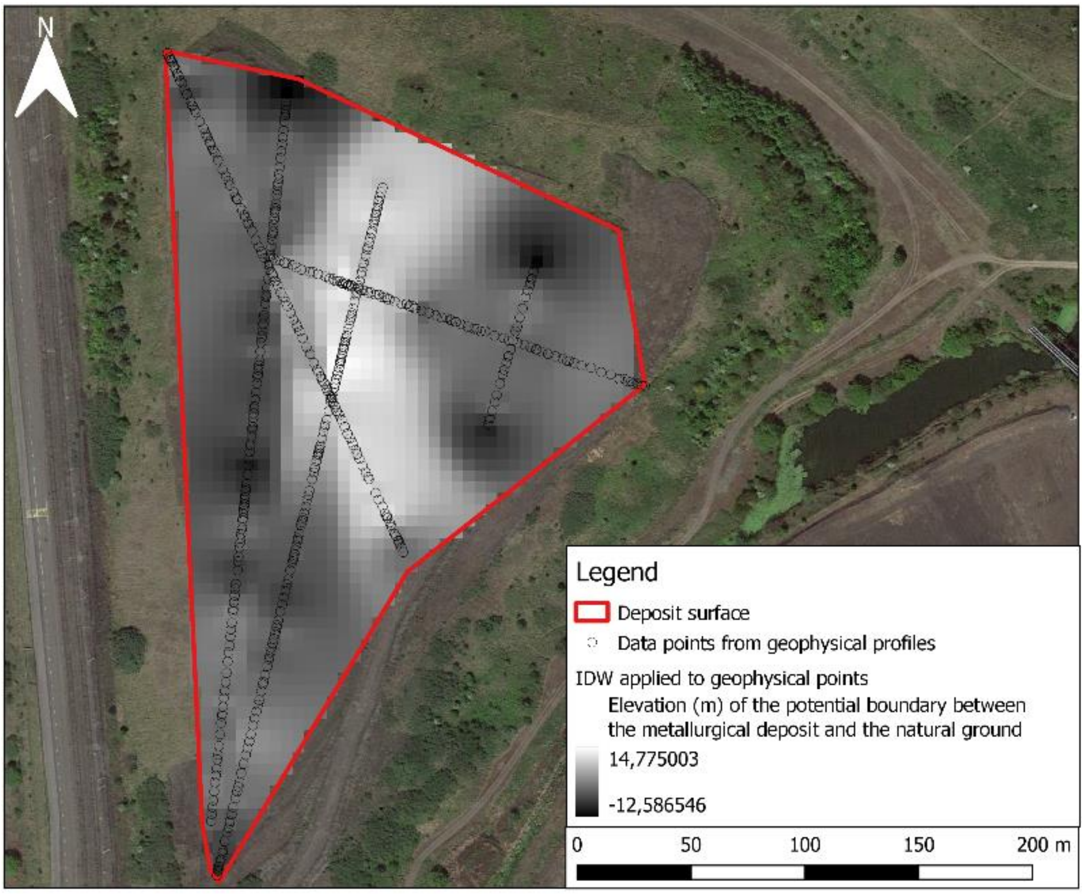

Figure 6 : Map delimiting the potential deposit surface (in red), based on geophysical information (elevation of the boundary between the deposit and natural ground)

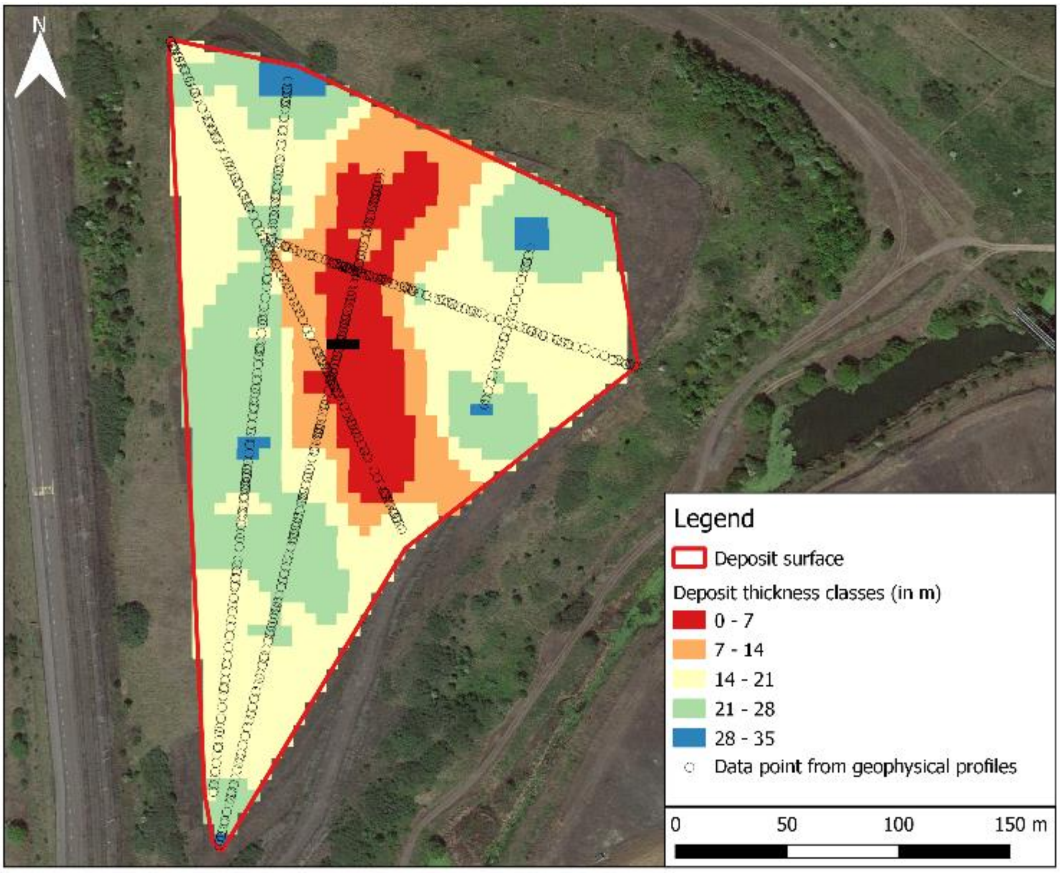

Figure 7: Deposit thickness classes

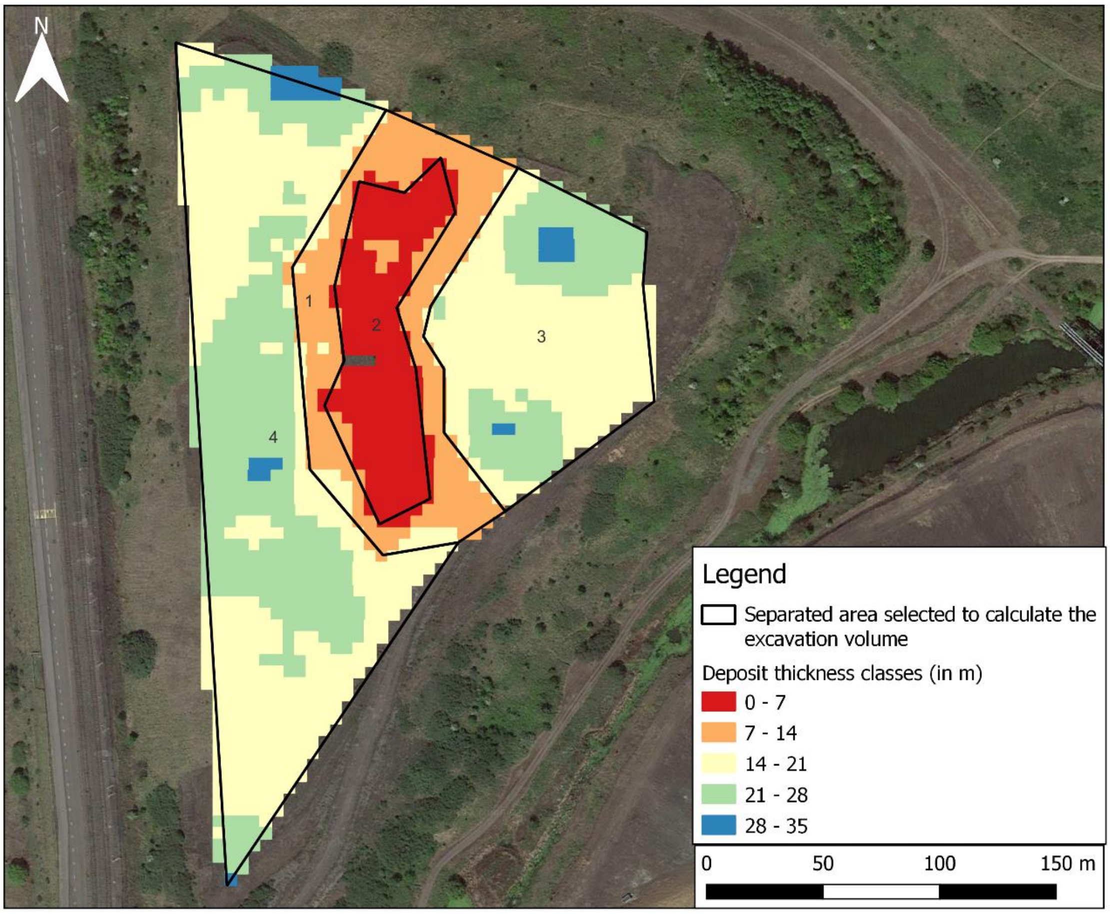

Figure 8: Separated area (numbered 1 to 4) delineated for the calculation of the excavation volume

3.2 Most relevant excavation methods and recommendations proposed, based on available information

Based on the information available, excavation of the estimated 461 446.5 m³ of the CLE31 portion of the Teeside site does not show any major challenges for excavation and civil engineering techniques. On the contrary, the conditions appear to be quite favourable, based on information from site visit, historical studies and the Teesworks' schematic section.

The characteristics of the site and deposit allows the use of conventional excavation machines (excavators, dump trucks, dumpers, bulldozers, etc). On the site though, numerous visual variations in the appearance of the slag are observed, which can significantly influence the excavation process. Slag of varying characteristics and levels of alteration can be seen, including instances where air pockets are concealed by hardened layers of slag (Figure 9). Some slag samples exhibit high porosity, others are ribbed, and the remaining ones are harder and display signs of cracking. These various visual characteristics can be seen on Figure 10. For these reasons, selective excavation does not seem appropriate in this case, and bulk excavation of the entire identified deposit will be chosen instead, with a strong emphasis of post-excavation sorting and preprocessing. This surface will therefore probably not pose any particular challenge and will be broken with conventional machines, eventually equipped with rippers.

Figure 9: Indurated slag layers resulting in the creation of air pockets

Figure 10: Range of slag characteristics observed on site: weathering type, porosity and veining

Based on the Teesworks scheme, it can be seen that the position of the water table is at least 1 to 4 m below the bottom of the deposit, which is very positive as it indicates that there will be no additional cost involved in the potential installation of drains to draw down the water table. The structure of the material seems to be a mix between gravel and laminated to disintegrated rock masses, with poor to very poor surface condition (highly weathered). This structure can probably be assimilated to an Osha classification of type B "unstable rock", which requires an initial verification of stability beforehand. During excavation, the necessary precautions must be taken to maintain a safe slope to ensure stability, preferably around $\alpha=h/L=4/10$ (~21,8°).

In order to be able to accurately design the pre-treatment and excavation process, more information is required and needs to be gathered beforehand. This information includes having an idea of the exact composition and characteristics of the slag, such as the bulk density, the metal/mineral composition, the grain size, the geotechnical characteristics, etc. Given the observed heterogeneity of slag on site, the most appropriate method for a metallurgical waste recovery project would therefore be to excavate the entire volume of metallurgical waste and invest more money in the design and operation of the pre-treatment facility to sort slag with similar properties. In comparison with the practical case of the DUFERCO pilot site, it can be considered that the pre-treatment of the Teeside site will probably require one to three additional separation stages, representing an extra cost by a factor 1,5 (estimated approximately between 18 and 40€/m³).

4 References

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