Our Ref: 4046-G-L030 Rev A

Date: 31st July 2023

iD GeoEnvironmental Limited

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Mr Matt Davis
Story Homes
Story House
Lords Way
Kingmoor Business Park
Carlisle
CA6 4SL

Dear Mr Davis,

Phase 3A Edgehill Park - Remediation of Crownhole & Supplementary Treatment of Coal Mine Workings

Further to your instruction we are pleased to provide a discussion of the properties of anhydrite and the remediation measures recommended IDG Remediation Strategy Report reference 4046-G-R022 dated July 2021.

Anhydrite

Anhydrite or anhydrous calcium sulfate is a naturally occurring mineral with the chemical formula CaSO4. Anhydrite is typically deposited in sedimentary basins where large volumes of seawater have been evaporated. Anhydrite is typically encountered within bedrock comprising dolomitic limestone, mudstone and anhydrite stone which can be tens to hundreds of metres in thickness or as veins within hydrothermal deposits. Anhydrite is an anhydrous calcium sulfate with a composition of CaSO4. It is closely related to gypsum, which has a chemical composition of CaSO4.2H2O and under normal temperature, pressure and presence of groundwater, anhydrite transforms into gypsum.

The that mineral transition between Anhydrite and Gypsum ($CaS0_4.2H_20$) takes place according to the following reversible hydration-dehydration reaction, as a consequence of which there is a significant volume change:

$$CaSO_4 + 2H_2O \leftrightarrow CaSO_4.2H_2O$$

This reaction takes place at ambient temperature (i.e. <40 C) and atmospheric pressure, although at normal temperature and pressure the most stable mineral is Gypsum. Estimates of volume changes are based upon the molar values of calcium, sulphur and water. The degree of volume change is dependent upon the minerals crystalline structure and how water is retained within the rock pore spaces. Gypsification can result in a volume increase of up to 63%, whereas dehydration can result in a volume decrease of up to 39%., although volume changes in the field will be influenced by in-situ porosity, homogeneity of the rock mass and the groundwater regime. The degree of gypsification is also influenced by processing; for example anhydrite rock ground to dust will transform more rapidly than coarse gravel or cobbles.

The anhydrite stockpiled at Edgehill Park was probably mined from the Triassic St Bees Evaporite Formation bedrock immediately west of the site. The anhydrite is understood to have been obtained from a drift mine approximately 500m southwest of the Edgehill development. Marchon processed the anhydrite at the adjacent chemical works to manufacture sulphuric acid.

Background

A stockpile comprising approximately 20,000m^3 of anhydrite gravel and cobbles with traces of slag, brick, ash and clinker is present in the southwestern corner of Story Homes Edgehill Park development upon the hardstanding of a former tanker depot facility once operated by Marchon. Correspondence dated 10th February 2010 states that the Stockpile was excavated from beneath three former Marchon car parks to the north of Phase 3 during a previous phase of residential development and was placed in its current

location during 2010. Movement of the made ground was carried out in accordance with a Remediation Strategy prepared by Integra Consulting which was approved by Copeland Borough Council. Environment Agency correspondence reference EMMS05071 dated 21st March 2011 confirms that the Agency accepted a recommendation by McAuliffe Environmental that the stockpile did not comprise extractive waste.

Integra (2010) proposed that the Anhydrite be allowed to weather from anhydrite to gypsum (and consequently its anticipated volume expansion), prior to placement in POS. However, IDG assumed that Marchon had placed the Anhydrite bearing aggregate at its original location beneath a car park because the sulphate content was too low and the material was uneconomic to process. In such circumstances, the gypsification outcome is difficult to predict. IDG correspondence 4046-G-LR015 dated 22nd January 2021 presents the results of XRD & XRF laboratory analysis subsequently undertaken to establish the relative proportions of anhydrite, bassanite (hemihydrous anhydrite) and gypsum present to inform updated remediation proposals. The laboratory analysis shows that the stockpile contains a high proportion of calcium sulphate. Based upon the average proportions of Anhydrite and Bassanite combined within the five samples, the stockpile comprises approximately 50% Anhydrite with potential for gypsification and this volume has significant potential to expand or contract under the right conditions.

Remediation

The Anhydrite Stockpile has now stood for 10 years beyond the allocated 2 years it was predicted that weathering should take place to enable gypsification to occur prior to placement in POS. While there is localized evidence of gypsification, trial pits into the stockpile have not detected any widescale transformation. This absence of widescale gypsification is probably attributable to the coarse angular granular nature of the material and the stockpiles consequent high porosity and capacity to drain swiftly.

Based upon the above, the most appropriate placement location for the Stockpile is considered to be above the groundwater table and beneath a relatively impermeable clay barrier at a location where expansion/settlement does not impact upon any proposed/existing structures or future activities. Ideally this could be a screening mound structure, covered with low shrubs. However, the higher the mound, the greater the potential for expansion both vertically and laterally and for the mound sides to heave and destabilize at some point.

Section 6.3 of IDG Remediation Strategy reference 4046-G-R022 dated July 2022 provides further details of the above remediation proposal. Environment Agency email correspondence dated 10th February 2021 presented in Appendix A, confirms that the Anhydrite Stockpile may be re-used on site in accordance with a Materials Management Plan (MMP), which complies with the CL:AIRE Disposal of Waste Code of Practice (DoWCoP). A MMP is currently in process which will be submitted for approval in due course.

Supervision & Verification

Remediation of the anhydrite Stockpile will be supervised and verified in accordance with the Remediation Strategy.

We trust that the above recommendations are appropriate. Please do not hesitate to contact us if you have any questions.

Yours faithfully,

[redacted]

Nick Ward BSc. (Hons), FGS.
for and on behalf of
iD GEOENVIRONMENTAL LIMITED

Appendix A: EA Correspondence 10th February 2021

APPENDIX A

Nick Ward

From: Drewery, Sarah [redacted]
Sent: 10 February 2021 13:51
To: Nick Ward
Cc: McFarlin, Matthew; Bardsley, Peter; Locke, Liz
Subject: Anhydrite stockpile - Correspondence reference NO/2020/113153/01-LO1

Hi Nick,

As discussed earlier, as the original plan was for re-use on site under DoWCoP and the stockpiled material is site-derived we will not object to the use of DoWCoP on this occasion provided we agree with your amended remediation strategy and provided you comply fully with DoWCoP. It is unfortunate that it has been stockpiled for so long but re-use on site under an MMP would clearly be the best environmental option for the material.

Regards,

Sarah

Sarah Drewery | Senior Environment Officer, Cumbria & Lancashire Area
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