ARROW 14

Hydrogeological Assessment of Whitemoss Landfill on behalf of ARROW by:

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Notes on Geological Section, Stability Report and landfill liner thickness

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Geological Cross Section

Further to the DCO hearing, a hydrogeological cross section has been produced to inform the discussion regarding a groundwater discharge zone to the south of the application area, in the area of Brookdale Farm.

Hannah Fraser's report (HFCL, 2014) stated

> *4.2.33 Examination of the 1:25,000 OS map indicates that there is a marked contrast in the Brookdale Farm area with the proposal site in that there are several water features and wells marked. This corresponds to subcropping thin interbeds of sandstone and mudstone in the Coal Measures. Many of the water features around Bickerstaffe Moss and Rose Farm occur at an elevation of approximately 65 m OD; similar features around Brookdale Farm are at an elevation of between 55 m OD and 65 m OD.*
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> *4.2.34 It is considered likely that the surface water features to the south of the site are related to groundwater in sandstone bands discharging to ground as the sandstone bands subcrop against the falling topography in this area. The elevation broadly corresponds with the elevation of the water table in the southeastern portion of the proposal site. The area is considered to be a discharge zone for groundwater in the Coal Measures*

Potential impacts of dewatering to water features in this area have not been considered in the Environmental Statement. The applicant contends that there is a significant thickness of drift across the Coal Measures, which prevents connectivity with surface water features. However the British Geological Survey borehole record from the Brookdale Farm Borehole (which can be found in Wardell Armstrong's (2014) Mine Shaft Hazard Assessment) show drift cover to be only 6.5 m thick in this area, and to comprise predominantly soil, sand or gravel rather than boulder clay. This compares with, for example, 13 m of drift including 10.9 m of boulder clay at BHE40 on the site. Table 1 shows the geological succession proved in the Brookdale Farm borehole.

Table 1 Brookdale Farm borehole geological sequence

Brookdale Farm Borehole	Thickness (m)	Depth (m)
Sandy Topsoil	1	1
Sand brown	1.5	2.5
Red/brown boulder clay	2	4.5
Loose Gravel	1	5.5
Red/brown boulder clay	1	6.5
Coal Measures	1.5	8

Figure 1 shows the hydrogeological cross section. It can be seen that the combination of thin drift, sandstone subcrop and a topographical depression make it highly likely that groundwater discharges to surface in the vicinity of Brookdale Farm. The Environmental Statement is therefore deficient in not assessing impacts of dewatering and landfilling on the water features in this area.

Stability Report

Hannah Fraser's report (2014) raised issues concerning Basal Heave. The applicant's response was that the stability risk assessment report had adequately dealt with these issues.

A copy of MJCA's May 2014 'Stability Risk Assessment and Design review for the Western Landfill Area at Whitemoss Landfill Site' has been reviewed, to examine how basal heave issues have been assessed.

Table SRA5 presents the results of the stability analyses. The relevant parts of the table are reproduced here.

Extract from Table SRA5, MJCA, 2014.

Model Component	**Analysis**	**Calculations**	**Factor of Safety**	**Comment**
Basal sub-grade	Basal heave	N/A	Qualitative assessment undertaken in 2003 SRA demonstrated stability against basal heave. See Section 3.1.5 of the 2003 SRA presented in Appendix SRA1	Basal sub-grade conceptual models for the existing site assessed in the 2003 SRA and for the western landfill area are consistent with the exception of the presence of two shafts within the Phase B area of the western landfill area. The assessments of basal sub-grade stability undertaken in the 2003 SRA are therefore relevant to the western landfill area. See section5.2 of risk screening.
Basal lining system	Basal heave of the basal sub-grade affecting the basal liner	N/A	Qualitative assessment undertaken in the 2003 SRA demonstrated that instability of the basal sub-grade will not affect the basal liner. See section 3.3.3 of the 2003 SRA	The basal liner conceptual model for the western landfill area is consistent with that assessed in the 2003 SRA. The only exception is the extension of the basal liner up the intercell bunds proposed for the western landfill areas. This exception is assessed further in the current SRA. Otherwise the assessments undertaken in the 2003 SRA area relevant to the western landfill area. See section 4.2 of risk screening.

Appendix SRA1 containing the 2003 SRA has not been made available for review, however it is clear from Table SRA5 that no quantitative assessment of basal heave has been carried out.

Section 14.15.16 of the Environmental Statement nonetheless states that 'while the site is being constructed and during the filling of the phases, groundwater will be abstracted from the Coal Measures beneath the liner to prevent basal heave of the liner'.

The risk of basal heave is therefore recognised by the Environmental Statement, and it is unclear how a stability assessment could be carried out without quantitative assessment of waste densities and thicknesses. There remain, in our view, grave concerns regarding the potential for basal heave at the site.

Landfill Liner

The Stability Risk Assessment and Hydrogeological Risk Assessment refer to the basal lining system as being a 1m thick layer of clay with a maximum permeability of $1x\ 10^{-9}$ m/s. The ESID (Environmental Setting and Installation Design) report refers to a liner of at least 1 m thickness with a permeability of no more than $1x\ 10^{-9}$ m/s.

Wardell Armstrong's December 1997 '*Report on the suitability of the indigenous clay source for the use in lining works at Whitemoss Road South Landfill Site, Skelmersdale including procedures for compaction and post-placement quality control testing*' states that '*A further criterion is that the clay achieves a permeability of less than or equal to 1 x 10^{-9} metres per second after compaction and we are satisfied that this can sensibly be achieved between the moisture range of 11% to 17%*'. There is no indication in the report that the clay is required to be suitable to meet a lower permeability criterion.

Section 3.2 of Annex 1 of the landfill directive requires that

> *3.2 The geological barrier is determined by geological and hydrogeological conditions below and in the vicinity of a landfill site providing sufficient attenuation capacity to prevent a potential risk to soil and groundwater.*
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> *The landfill base and sides shall consist of a mineral layer which satisfies permeability and thickness requirements with a combined effect in terms of protection of soil, groundwater and surface water at least equivalent to the one resulting from the following requirements:*
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> - *Landfill for hazardous waste $K \leq 1,0 \times 10^{-9}$ m/s; thickness ≥ 5m*

A liner of 1m thickness and permeability of 1×10^{-9} m/s does not comply with the Landfill Directive; a liner at least 5 m thick is required if the permeability is to be 1×10^{-9} m/s. If a lower permeability can be achieved, the liner may be thinner than 5 m

in accordance with a calculation to show equivalent protection. There is no indication in the available reports that the site-won clay has been tested to demonstrate that a lower permeability than 1 x 10^{-9} m/scan be achieved, nor is there any indication that there is sufficient site won material available to provide a 5 m mineral layer across the entire base of the landfill. The applicant should provide explanation as to how the requirements of the landfill directive are going to be met, providing evidence as to the proposed thickness and permeability of the liner, and the suitability and availability of site won materials. The implications appropriate volumes of site-won material not being available are that insufficient material will be found at commercially viable rates or in a timely manner in accordance with the operational requirements of the facility.

Figure 1 Hydrogeological cross section