Highways England: A303 Amesbury to Berwick Down Project, Development Consent Order Application

Scheme Reference: TR010025

Summary of oral submissions at ISH 10:

Flood risk, groundwater protection, geology and land contamination

for

The Stonehenge Alliance
(Reference No. 2001870)

by

Dr. Kate Fielden and Dr George Reeves

Summary of oral submissions made at ISH 10 on behalf of the Stonehenge

Note. The following summaries are listed according to the Agenda items and in the order the items were taken at the hearing.

3. Flood risk and drainage

3.2. *Road drainage strategy*

3.2.i. *Are the pollution measures sufficient?*
3.2.i.a and b. The Alliance is concerned about untreated road drainage, potentially from a chemical spillage or other, passing across Blick Mead into the Avon SAC, with potential for damage to environmental material at Blick Mead and contamination of the SAC. Although this is the current situation, we consider that increased traffic together with the flyover and joining slip roads could make road accidents involving possible pollution events at this location more likely than at present. Highways England's proposals for culverts for untreated road drainage over the Blick Mead Site are inadequate to ensure no adverse effects on the SAC beyond reasonable scientific doubt. We share the concerns expressed by the EA and WC on the lack of explicit detail on the control of pollution from road drainage but do not consider, in respect of the SAC, that detailed design should be a matter for agreement with the EA/WC at a later stage or that reference is simply made in the DCO documentation to the need for additional measures beyond the DRMB requirements.
Nor do we consider this a matter to be agreed at a later date with the SoS (or the contractor) following the advice of the EA and others "further down the line"; rather, the Statement to inform the AA should state that, beyond reasonable scientific doubt, there would be certainty of no adverse impact on the SAC as a result of a chemical spill or similar incident which would require additional storage capacity for contaminated fluids (including water) over and above that required for DMRB standards owing to the sensitivity of the environment of the Scheme.

3.2.ii. It would seem sensible to have a manual as well as an automated, tunnel drainage system as a fallback position, e.g., in case of a power cut. The EA also made this suggestion. We strongly agree with Andy Rhind-Tutt that generators for pumps are needed in case of a power cut: this is a health and safety issue as well as a matter of preventing contamination. Such pumps would need to be located within, not outside the tunnel.

4. Contamination, including groundwater contamination

4.i and iii. *Whether controls as set out in DCO documentation are adequate and whether pre-commencement survey work is necessary*
With reference to MW-WAT6 and MW-WAT7, the Alliance considers that measures for protection of the SAC (already over-polluted) should include regular monitoring, on a daily basis, during construction and, perhaps on a less regular basis, for some time during operation of the Scheme. Regular monitoring is also needed *before work begins* to obtain baseline data for heavy rainfall periods and periods of dryer weather.

The video submitted by Andy Rhind-Tutt ("Additional Submission accepted at the discretion of the Examining Authority – Blick Mead Water Flows 12.8.19) gives a clear indication of the speed at which water flows through the aquifer and the potential for rapid contamination of the SAC/groundwater.

Presentation by Dr George Reeves to A303 Stonehenge Examination ISH10 on 29.8.19 (Made between Agenda items 6 and 7)

Introduction [*Slide 1*]
The presentation at the hearing did not cover all of the information in the notes supplied earlier with the presentation images. Rather than an academic exercise, this work has been an attempt to identify possible extreme groundwater conditions.
In my view, we are dealing with a uniquely difficult shallow Chalk bedrock tunnelling situation. That is in part due to the poor quality of the Chalk (referred to in my earlier submissions), especially in the western tunnel section where Phosphatic Chalk occurs, but also due to the complexity of Chalk hydrogeology, particularly in the Stonehenge Bottom area and the western and eastern chainages affected by the significant vertical fracture zones and, more importantly, by the higher permeabilities associated with what I term the Whitway Rock Horizon.

With great respect to Ms Ayliffe, I think that no other UK Chalk tunnelling project can be realistically compared to the A303 tunnel project. No other location has an important shallow, unconfined Chalk Aquifer with such complex hydrogeology, upon which a number of agricultural and private abstractors are solely dependent but, in addition, no other UK Chalk tunnels have an important set of archaeological features on the surface forming a World Heritage Site.

1. [*Slide 2*]. I have undertaken quite a lot of further work on the data supplied by Highways England, on relevant published and unpublished information, core images, maps etc. I will concentrate on my conclusions.

2. [*Slide 3*] In considering groundwater issues, I am of the opinion that a less permeable layer, equivalent to the Whitway (Stockbridge/Barrois Sponge Bed) Rock Horizon, is present within the Chalk Bedrock (the Upper Seaford Chalk).

3. [*Slide 4*] My further work included the study of plans and sections and I referred again (briefly) to the need for a 3D-model, pointing out that the three dimensions as well as a time dimension (especially for consideration of groundwater problems), are in my opinion very important. [*Slides 5 and 6*] I have prepared my own map of boreholes undertaken and studied the boreholes on the Geology of Britain website.

4. I have been asked why the Blick Mead and Amesbury Abbey springs occur where they are; what feeds (at around the same level OD) Springbottom Farm wells and springs, and the springs in Stonehenge Bottom; and what feeds the larger groundwater abstractors nearby. I read the AWM report by Travis Kelly (checked by Dr Jane Sladen) for Highways England and my interest was aroused by the complexity of the hydrogeology. I looked at the borehole data available to me and the Geological Map, Devizes sheet [*Slide 7*], where the Whitway/Stockbridge Rock horizon is well mapped. There is no mapping of it west of Amesbury due to the drift cover in the area.

5. Concerning the Whitway Rock Horizon at Stonehenge, the principal issue of significance arising from my investigations is that a less permeable layer equivalent to the harder, Whitway Rock is present from between 60 and 80m AOD, either continuously or intermittently along the tunnel route. I consider that it is more accurately described as "The Whitway Rock Horizon", coincident with the Barrois' Sponge Bed [*Slide 8*]. In the slide, on the left, it is shown as a circa 5m-thick layer of harder rock, approximately 5 metres below the junction of the Seaford and Newhaven Chalk. This 5m-thick harder layer, termed "porcellaneous limestone" has not been found definitively in the Stonehenge area. It has, however, apparently been looked for by Highways England's geologists.

Above this less permeable layer is a horizon of fissured/fractured Chalk Rock (the Upper zone of the Seaford Chalk) which acts as a faster eastward and southward conduit for groundwater flow and gives rise to the Amesbury Abbey/Blick Mead springs. There is no other explanation: they arise exactly at that horizon.

I am developing a (conceptual) "model" of the structural and hydrogeological properties of the Whitway Rock Horizon but am hampered by not having all the relevant data that we have asked Highways England to provide. Much of the supporting evidence that I have used comes from the 2001–2004 Highways Authority drilling campaigns.

6. The presence of the Whitway Rock Horizon was suspected by Highways England but coring in some boreholes was either not deep enough or it has been missed (in my opinion) owing to the difficulty of interpreting the drilling data, core box images and some borehole geophysical wireline responses. It is also intermittent in nature and is apparently not easy to identify, with consequent potential for lack of recognition in the cores. Its characteristics at Stonehenge are as listed in *Slide 9* but its presence has not been recognized, identified or modelled by Highways England.

7. [*Slide 10*] The geological cross-section produced by Highways England at Fig.2 in their Deadline 3 *Implications of 2018 Ground Investigations to the Groundwater Risk Assessment* (REP3-018) (reproduced below) is noteworthy. The section shows where the Whitway Rock was expected to be and the proposed tunnel line. The geology in Stonehenge Bottom is obviously extremely complicated, with massive vertical fractures. It is proposed to place the tunnel within or partly within the Whitway Rock and the horizon of high permeability above it. See levels in *Slide 13*: Boreholes R13 and R11, where I interpret the Whitway Rock Horizon to be at the tunnel soffit level as proposed.
The original section drawing was by Professor Mortimore in 2012 (I said 2017 by mistake), who is an acknowledged expert on Chalk geology and adviser to Highways England. We suggested that he might be asked to attend the Examination to help elucidate some of the problems of the unique chalk geology at Stonehenge, particularly re this Whitway Rock horizon.

8. In my view, the Whitway Rock Horizon is present, along with the horizon of highly permeable rock above it. More data is needed to confirm the position and properties of both horizons. [*Slide 11*] Some of the data, on the BGS GeoIndex Database, is subject to commercial confidence but Highways England has given me access to it [*Slide 12*].

9. *What are the implications of the situation I have identified?*

i) Tunnelling through the Whitway Rock Horizon and the highly permeable horizon above it would give rise to problems in groundwater movement: there could be considerable displacement, both during and after construction. Private and commercial/agricultural water supplies could be affected.

ii) De-watering on a large scale might be required because the modelling hasn't taken into account any possible influence of this zone.

iii) Problems with collapse and voids and events arising from vibration could be exacerbated.

iv. The fractured and waterlogged nature of the horizon above the Whitway Rock and the tunnel could require very considerable amounts of grouting to allow smooth progress of the TBM and ameliorate any potential effects on archaeological remains, especially if the TBM might be halted for any reason.

v. Grouting has implications for contamination which could be rapid through the zone of highly permeable Rock above the Whitway Rock.

vi. The location of the tunnel might need to be re-considered. Viability of tunnelling here at all is in question, in my opinion, given the sensitivity of the WHS.

10. In summary, therefore, there is convincing evidence of a sub-horizontal zone of elevated permeability in the upper 10 metres of the Seaford Chalk which is likely to adversely affect groundwater inflows to the proposed tunnelling, with possible considerable chance of delays and requirements for much additional grouting and groundwater control by dewatering, as demonstrated and described in the Groundwater Report, and especially where the Stonehenge Bottom pumping test is discussed.

Addendum

11. *Slide 13* shows the author's spreadsheet identifying the Whitway Rock Horizon from borehole information. This is "work in progress". I have now added the chainage and location of this horizon, locating it to the tunnel soffit level, in a new column on the right.

12. [*Slide 14*]. This image of a core sample (R20) shows, in my opinion, the heavily fractured zone above the location of the Whitway Rock, where it is more evident/developed in the western area of the Salisbury Geological Survey.

Cost implications

13. I consider there are serious cost implications possibly involved due to delays, cost over-runs and consequent considerable claims from contractors unless this area of information is examined further.

Postscript

In examining the detail of groundwater and lithological data relating to the Whitway Rock Horizon, it was noticed that Highways England had used a dated figure (Fig.2), attributed to Professor Mortimore in his 2012 Glossop Lecture (see reference and Fig.2 reproduced below). It remains uncertain if the AWM groundwater modellers have superimposed the correct profile of the proposed tunnel (as defined in the HEng A303 Amesbury to Berwick Down Project Documents APP-010 and APP-019 (Engineering Section Drawings) on their Figure 2.

The groundwater levels and postulated zone range of the Whitway Rock horizon are also problematic (see figure below) as explained in Dr Reeves' presentation to the hearing.

In view of a presumably much more recent (and radically different in its eastern part) section drawing of the geology across Stonehenge Bottom by Professor Mortimore et al. (2017, Fig.16a; reproduced for comparison at end of this submission), there is no obvious reason nor any explanation why Mortimore's 2012 section is used and represented in AWM Report No. TR010025 Document 8.23 – Implications of 2018 Ground Investigations to the Groundwater Risk Assessment (REP3-019) republished with tracked changes, dated 31.05.19):

In discussion following the presentation

Highways England said, re Dr Reeves' complaint about non-provision of requested data, notably 2018 ground investigation work, that this comprises c.4000 pagers of borehole information which it does not intend to submit to the Examination since it is not required for the ES. Highways England also said that it would be wholly inappropriate to release **that volume of material that hasn't been subject to analysis**. This is a matter of concern. Not only would Dr Reeves have been content to study 4,000 additional pages of data (having already studied some 5–6,000 pages earlier supplied by Highways England), but it is also very surprising to learn how much data remains to be analysed, especially since we have highlighted the inadequacy of information in the DCO application documentation on geology and groundwater in particular.

References

Highways England, AWM Report No. TR010025 Doc. REP3- 019) 8.23 – Implications of 2018 Ground Investigations to the Groundwater Risk Assessment (republished with tracked changes, dated 31.05.19).

R.N.Mortimore, "Making sense of Chalk: a total-rock approach to its Engineering Geology". The Eleventh Glossop Lecture, Geological Society Publications, 2012.

R.N. Mortimore, et al., "Stonehenge—a unique Late Cretaceous phosphatic Chalk geology: implications for sea-level, climate and tectonics and impact on engineering and archaeology", Proc. Geol. Assoc. (2017).

R. W. N. Soley, et al., *Modelling the hydrogeology and managed aquifer system of the Chalk across southern England*. Geological Society, London, Special Publications, v.364, 2012, pp.129-154.

Figure 2 "Chalk Stratigraphy with Tunnel and Chalk Rock Elevations (adapted from Mortimore (2012))" and used in Highways England Document REP3-019

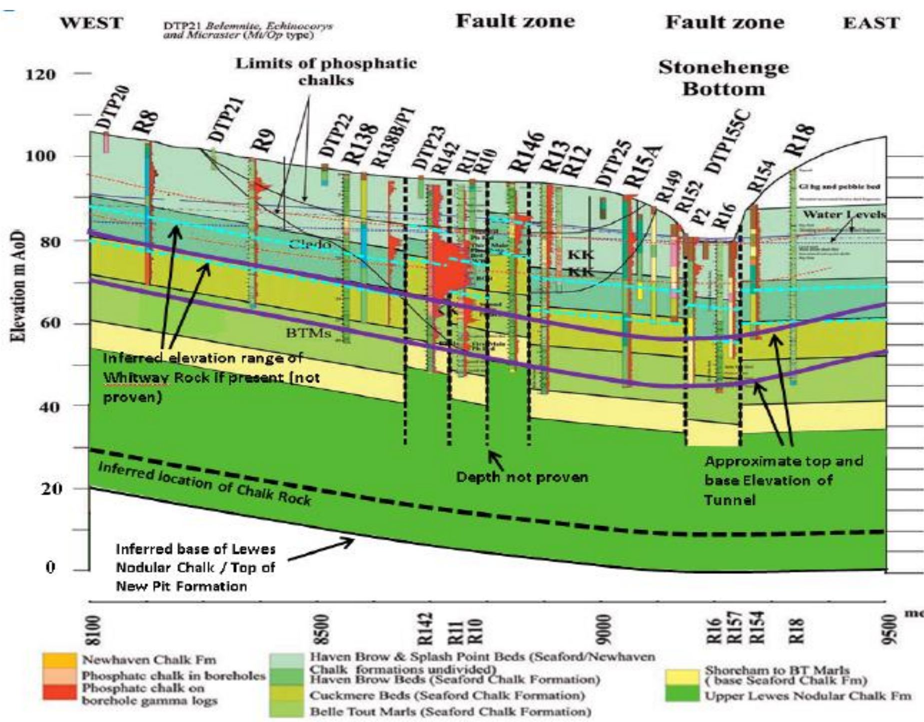

Fig.16a ("The control boreholes used to establish the stratigraphical position and thicknesses of the chalk beds and the phosphatic chalks. . .") from Mortimore et al. 2017, for comparison with 2012 section used by Highways England, above

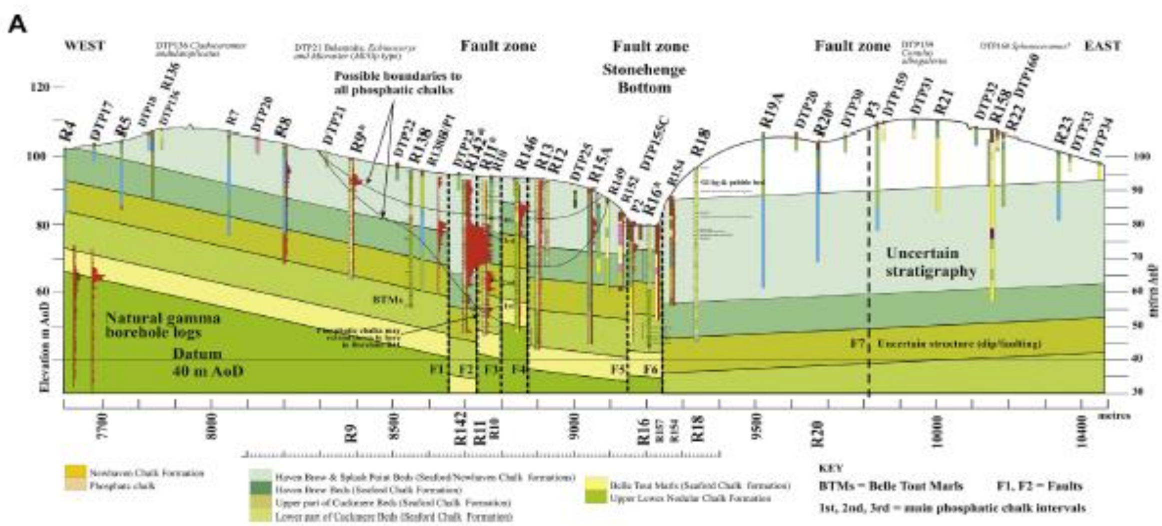

Fig. 16. (a) The control boreholes used to establish the stratigraphical position and thicknesses of the chalk beds and the phosphatic chalks. Fully-cored boreholes R9, R142, R11, R16 and R20 have been biostratigrpahically analysed for macro- and nannofossils and provide the controls for recognising bed displacements caused by faults and the stratigraphical position of the phosphatic-chalks. In addition, other boreholes with Natural Gamma geophysical logs (red spiky profiles), show where phosphatic-chalks are present. Mt = *Marsupites testudinarius*, Op = *Offaster pilula*. (b) Sedimentary model 1: A multichannel interpretation for the Stonehenge phosphatic chalks constructed from boreholes and trial pits showing the zones of north–south faulting defining the eastern limit of the channels (no phosphatic-chalks east of Stonehenge Bottom). The geological section shows the location of the two largest channels and 18 smaller ones in a complex fault zone (Modified from Mortimore, 2011, 2014). The thickest deposits are located in a down-faulted area between faults F1 and F2. Mt = *Marsupites testudinarius*, Op = *Offaster pilula*. (c) Sedimentary model 2: A single major channel interpretation for the Stonehenge phosphatic-chalks linking the thickest deposits with fewer smaller ones. The large channel incorporates phosphatic-chalk Event 3 (P3) in BHR11 and R142 and is presumed to incorporate the thick phosphatic-chalks in BHR12. Earlier phosphatic-chalk Events P1 and P2 and the later P4 event are represented by smaller channels. Mt = *Marsupites testudinarius*, Op = *Offaster pilula*.