Notes of GARD visit to SESRO Clay Compaction Trial site 20th May 2025

Present:

Mike Greig	GARD
Chris Binnie	Consultant to GARD
John Lawson	Consultant to GARD
Dominic Molyneux	Binnie design team leader
Senior Geologist	Binnie
Mark Mathews	Thames Water (on secondment from Jacobs)
Liaison officer	Thames Water

Summary

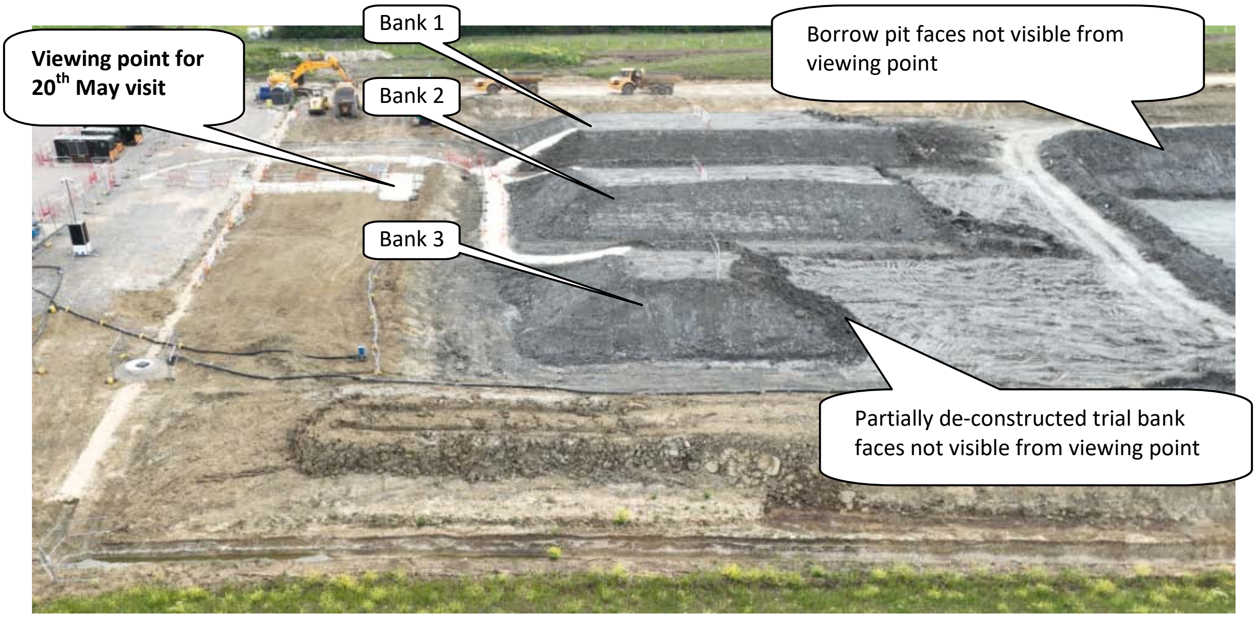
In summary, the site visit to the clay compaction trial was of limited value because we were not allowed access for close up inspection of the trial banks or borrow pit. Observations from the site appear to have shown considerable variations in the borrow pit material, apparently leading to a design change from a homogeneous clay embankment to a separate clay core and shoulders. On the day of the visit this apparent design change was denied by Thames Water and Binnie staff. However, Thames Water have subsequently confirmed the design change, but denied it was a consequence of findings from the compaction trial. The design change would probably have considerable impact on the cost of the embankment and the time needed to build it.

No detail was provided of geotechnical findings from the trial or how the findings would affect dam design. The value of the trial and the implications of its findings will not become apparent until a report on the trial and more detail of the changed embankment design are available, but Thames Water and Binnie staff were unable to say when this might be.

These notes report on what was seen at the Clay Compaction Trial site visit and record the post-visit comments of the GARD contingent

The visit was confined to the stakeholder viewing site for the Clay Compaction Trial (CCT) and there was no access allowed to the partly de-constructed trial banks or the borrow pit. We were told that it was not possible to enter the site to make a close inspection of the trial banks and borrow pit because earth moving plant was working on de-construction of the banks. We complained that the purpose of the CCT site inspection was mainly lost if it was not possible to see the site close up, particularly to observe the bonding of compacted layers in the faces of the partially deconstructed banks or the variation of materials in the faces of the borrow pit. Thames Water responded by saying that we were being treated the same as other stakeholder visitors. We pointed out that Thames Water knew we were visiting as GARD's professional advisers, not stakeholders, and that the close up access should have been made available to allow proper inspection.

Therefore, the trial banks were viewed from the location shown below (taken from GARD drone photography on 17th May 2025):



The restricted view of the trial can be seen on the photographs at the end of this note, taken from the viewing point shown in the photograph above.

It was explained that Bank 1 was constructed with clay from 1-3 m depth of the trial pit, Bank 2 from 3-7 m depth and Bank 3 from 7-10 m depth. We were told that the material in Bank 1, taken from the top 3 m of the borrow pit, was of a suitable moisture content for compaction to form an impermeable core. The material below 3 m depth was found to be relatively dry and difficult to compact, despite the wet weather in autumn/winter 2024/25. We were told that the variation of clay with depth would be taken into account in the construction planning and earthworks plant requirements.

We were told that the borrow pit had been extended from 10 to 14 m depth to see what material lay beneath, in case it was needed. The clay material found was said to be hard and to contain limestone nodules which sound as though the material would difficult to compact.

We could see the material that an excavator on Bank 2 (ie coming from 3 -7 m depth in the borrow pit) was tipping into a dump truck. From what we could see, this did not look well bonded, coming out as loose soil and occasional blocks of clay.

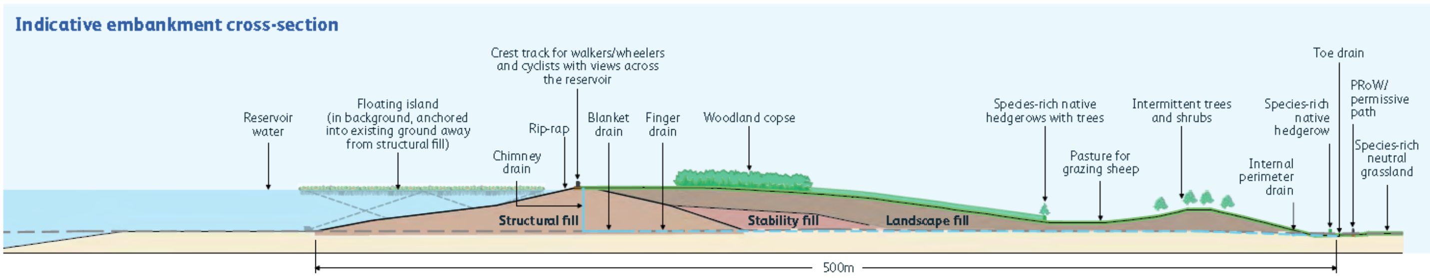
We were told that the clay in the borrow pit had been found to be different from that expected and that it got drier and stiffer with depth. This could mean the impermeable core clay would need significant discing to break up the lumps, watering to make it more pliable, then discing again to get the clay as uniform as possible, and then rolling in a way to get good bond between the layers.

We were told that that the layers of clay had been placed in several thicknesses varying from 15 cm to 40 cm thick to determine the optimum layer thickness – they are awaiting test results before deciding. From the limited visual evidence on site, there appeared doubt that the core would be sufficiently impermeable, even if placed in the thinner layers.

Whereas the documents provided to GARD previously had shown the design of the SESRO dam as a homogenous dam with some overlying landscaping fill, we pointed out that a recent NCE article had described the dam as having a clay core with supporting shoulders. We were told on site that the design had always assumed a clay core and supporting shoulders, but we were not provided any further information on the planned zoning of the earthfill or shown a cross-section. The design with a separate clay core and shoulders is not consistent with the following documents:

- The 2007 design report which made no mention of a clay core and showed the whole dam as “compacted clay fill”[1]
- Appendix 3 to Jacobs 2008 engineering report which showed an upstream zone and a downstream zone separated by a chimney drain – no sign of a clay core[2]
- SESRO Gate 2 concept design report and cross-section did not show a clay core[3]
- The ‘Technical brochure’ for the first pre-DCO consultation did not show a clay core and a cross-section showed a chimney drain located in the centre of the cross-section, where a clay core would be, if one had been planned (see diagram below)

The TW liaison officer asserted that it had been a separate clay core embankment design in the pre-DCO consultation in summer 2024. She did not change her view even when MG read the appropriate extract from the consultation document which made no mention of a separate clay core and shoulders and showed the cross-section below[4]:



This diagram shows a homogeneous ‘structural fill’ and a chimney drain located in the in the centre of the dam – where the clay core would be if the dam is designed with a clay core and separate shoulders.

Subsequently, in an email dated 10th June, commenting on the draft of the notes, Thames Water has said:

> *“The design change from a homogenous internal design for the reservoir embankment to a clay core and shoulders formed part of our design development following on from Gate 2. This detailed design change is not as a result of the CCT trial. An explanation of the clay core and shoulder design will be presented in our Gate 3 reports.”*

The Arup-Binnie JV was only appointed to the SESRO team in July 2024 and the Binnie personnel had therefore had no involvement in the dam design prior to that date. It is also worth noting that the

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[1] Upper Thames Major Resource Development, Stage 2 Preferred Scheme and Design Options Report, 2007, page 28 and Figure 5-2 on page 29

[2] Draft Jacobs Preliminary Design Report v4, Appendix 3, 2007, page 3-3 and Figure 3.1

[3] SESRO Gate 2 Concept Design Deport, 2022, page 2-6 and cross-sections on page 2-7

[4] SESRO first pre-DCO Consultation, Technical Brochure, June 2024, cross-section on page 46

plan for the Clay Compaction Trial had been finalised prior to the appointment of Binnie's and Binnie therefore inherited the trial as previously planned.

We were told that the borrow pit had been sampled geotechnically but, when we asked for copies of the results, this information was not available, but would be in due course.

We had said we had read that the trial bank of Havant Thicket reservoir had found difficulty in bonding the clay fill layers and that appreciable work was needed to wet the clay so the layers would bond adequately to make a homogenous core for the dam. Whilst that soil is reported to be London Clay, and is thus from a different geological formation, the Kimmeridge clay may respond in a similar way.

The stability of embankment dams is generally limited by the pore water pressure (PWP) build up in the foundation and lower layers of the embankment and the rate of PWP dissipation. Thus, for embankment dams formed of, and on, clay soils, PWP monitoring of a trial bank is vital for establishing the design criteria and, subsequently, during and after construction. We were told that no PWP gauges had been installed in the trial because the 3 m height of the banks was insufficient for meaningful pore pressure development and for monitoring its dissipation. In any case, the banks were being dismantled after only a few weeks after completion, making information on likely PWP dissipation less reliable.

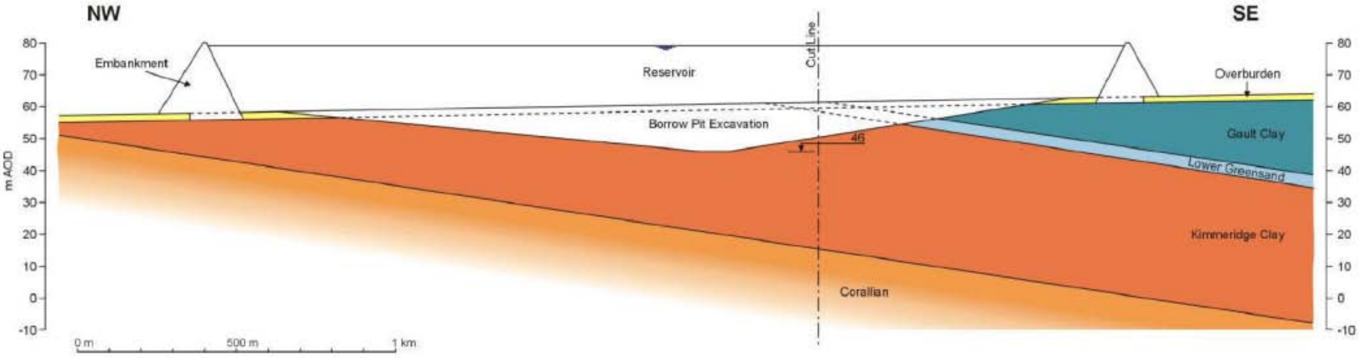
In the absence of a drawing of the revised cross section and basic geotechnical information from the CCT trial, we asked when such information would be provided, eg for the Gate 3 report later this year. Thames Water and the Binnie staff were unable to say when or if such information would be available. They seemed to suggest GARD did not need this information because dam safety would be assured by the appointment of the a Construction Engineer under the Reservoirs Act, and the appointed Construction Engineer was already involved in the clay compaction trial and design development through bi-weekly meetings. We commented that there was such an appointment on the last major UK embankment dam for Carsington Reservoir, but that still failed towards the end of construction, luckily with no loss of life. We were told that a Reservoir Advisory Panel had been appointed, but we were not told who was on that so we could not check the range of experience available.

Changing the design of the dam from a largely homogeneous bank to a clay core embankment dam has safety, cost and programme implications. Whilst the main body of the shoulders of the dam may become less critical, the core section becomes more critical as the core needs to become the main water retaining feature. Thus it needs to have low permeability with no gaps and no un-bonded layers. This requires careful control of moisture content to ensure all the clay has sufficient flexibility and does not arch through differential settlement. There are examples both in UK and overseas, where the construction has not been sufficient with the clay being put in too dry and stiff, leading to significant leakage, and potential failure. For a relatively hard clay soil, as would appear to be the case at SESRO, achieving a sufficiently pliable and uniform core can be difficult, time consuming, and expensive.

Two sites where these problems have occurred were Shek Pik dam in Hong Kong, circa 1963 and Balderhead dam in UK. At Balderhead there was arching across the core and they had to put in a new slurry trench core. Such a remedy would be very expensive for a 10 km bank such as at SESRO.

The variability of material encountered in the full scale borrow pit will be considerably more than the variability of the material encountered in the trial borrow pit. The ground level area of the trial borrow pit is about 1 hectare, whereas the ground level area of the full scale borrow pit will be about 6 km^2, 600 hectares. Thus, the full scale borrow pit will cover about six hundred times the area of the trial borrow pit area.

The dip slope of the geological layers at the borrow pit site means that, at a given depth of the borrow pit, different geological layers will be encountered in different areas of the pit, with potentially different geotechnical properties, as illustrated below[5]:



In addition to encountering Gault Clay and Greensand in some parts of the full scale borrow pit, at a given depth of the borrow pit, different layers within the Kimmeridge Clay will be encountered. The trial borrow pit seems to have revealed that there is considerable variation in geotechnical properties of different layers within the Kimmeridge Clay (as well as variation in moisture content). It appears that this variation, with some layers being found unsuitable for compaction into an impermeable layer, has led to the change from a homogeneous clay bank to a separate clay core and shoulders, although this is denied by TW and Binnie staff.

The change from a homogeneous clay bank to a separate clay core and more permeable shoulders will substantially complicate the construction of the embankment. For example, it seems likely that material suitable for the impermeable clay core will need to be stock-piled before being placed in the dam. Double-handling of this material is likely to lead to more complex earth moving operations and substantial cost increases and a longer earthworks construction programme.

Chris Binnie, John Lawson and Mike Greig
23rd May 2025

[5] Diagram from SESRO Design Concept report, Figure 2.1

General view from viewing point - Bank 1 on the left and Bank 2 on the right:

Photo of the Bank 2 being de-constructed: