

UPPER TRIBUNAL (LANDS CHAMBER)



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Case No: LCA/290/2010

TRIBUNALS, COURTS AND ENFORCEMENT ACT 2007

COMPENSATION – mining subsidence – preliminary issues – whether damage to Wentworth Woodhouse “subsidence damage” – Coal Mining Subsidence Act 1991

IN THE MATTER OF A NOTICE OF REFERENCE

BETWEEN:

(1) PAUL HENRY RICHARD JAMES
NEWBOLD (deceased)

(2) MARCUS CLIFFORD THOMAS JOHN
NEWBOLD

(3) GILES RAYMAN WILLIAMSON JAMES
NEWBOLD

Claimants

and

THE COAL AUTHORITY

Respondent

Re: Wentworth Woodhouse, Wentworth,
South Yorkshire

Hearing dates: 4-6, 11-15, 25, 27-29 April and 3-4 May 2016
(Closing submissions in writing: 31 May 2016)

Martin Rodger QC, Deputy President and Paul Francis FRICS

Royal Courts of Justice, London WC2A 2LL

Michael Barnes QC and *Eian Caws* instructed by David Cooper & Co, solicitors, for the claimants
Dominique Rawley QC, instructed by DLA Piper, solicitors, for the respondent

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The following case is referred to in this decision:

Newbold v The Coal Authority [2013] EWCA Civ 584

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Introduction

1. This reference concerns Wentworth Woodhouse, one of the greatest private houses in Great Britain. It was built in the second quarter of the 18th century in open country a few miles from Rotherham. Its façade is one of the longest of any house in Europe and its interiors the finest of any Georgian stately home. The house and its associated structures are now in a state of deterioration which the claimants attribute to subsidence caused by the effects of coal mining for which, in their reference to the Tribunal, they seek compensation “likely to be in excess of £100m”.

2. Beneath the house and its landscaped park lie the productive seams of the South Yorkshire coalfield which had been mined in the area at surface outcrops from the early middle-ages. The Fitzwilliam family, whose ancestors had owned Wentworth Woodhouse since the time of the Normans, were mining coal reserves on their estates by 1750. The invention of Newcomen’s steam powered engine allowed deeper mine shafts to be sunk in the 18th and 19th centuries to meet the insatiable demand created by the industrial revolution and by the increasing use of coal to power ships, railways and factories. By the 1920s deep seams were being exploited under the park and close to or under the buildings and structures at Wentworth Woodhouse. The 1947 nationalisation of the coal industry brought intensified mining beneath the park and formal gardens which continued until the 1960s, by which time the mines in the immediate vicinity were exhausted or uneconomic.

3. Wentworth Woodhouse is now owned by the claimants, who are brothers. They acquired the house and grounds through a family company in 1999. One of the original claimants was Mr Paul Newbold, who has died since the making of the reference.

4. The respondent, the Coal Authority, was established by the Coal Industry Act 1994 in succession to the British Coal Corporation (formerly the National Coal Board), and is the body responsible for meeting claims under the Coal Mining Subsidence Act 1991 for compensation for damage caused by mining subsidence. These proceedings were commenced by notice of reference given on 22 December 2009 under section 40(1) of the 1991 Act. The reference had been preceded by the service of two damage notices under section 3 of the Act, the first given on 31 January 2007 and the second on 3 August 2009. The Coal Authority initially resisted the claims on the grounds that the damage notices did not comply with the statutory requirements, so the Tribunal directed that the validity of the notices be determined as a preliminary issue. On 23 May 2013, the Court of Appeal confirmed the Tribunal's earlier determination that both notices were valid: *Newbold v The Coal Authority* [2013] EWCA Civ 584.

5. The issue now for consideration is whether any of the deterioration in four separate parts of the buildings and structures at Wentworth Woodhouse is "subsidence damage" within the meaning of section 1(1) of the 1991 Act, such that the cost of its remediation will fall on the Coal Authority. The four areas selected for consideration are (1) a line through the east front of the north wing of the mansion following the area putatively influenced by the Wentworth fault; (2) the north tower of the mansion and the adjacent north quadrant; (3) the south terrace wall; and (4) the camellia house. On 1 May 2014 the Tribunal directed the trial of preliminary issues to identify whether, in relation to those four specific areas, coal mining has caused any subsidence damage. The evidence and the arguments before us went rather further, the real debate being not simply whether subsidence damage had occurred at any time (which in many instances was not contentious), but whether such damage was the result of a renewed phase of ground movement occurring since the 1990s, long after conventional expectations would have ruled out historic mining as a cause of damage.

6. The claimants contend that the great majority of the damage at Wentworth Woodhouse is at least likely to have been caused by ground movement attributable to mining. The primary trigger for this movement is suggested to be the collapse of old mine workings as a result of their inundation by rising ground water following the general cessation of pumping in the South Yorkshire coalfield in the 1990s. The Coal Authority asserts the contrary: that ground movement caused by mining ended many decades ago and that Wentworth Woodhouse is largely stable, with the damage visible in the four selected areas being either historic or attributable to a variety of other causes, including neglect and decay.

Representation and witnesses

7. At the hearing of the preliminary issues Mr Michael Barnes QC and Mr Eian Caws of counsel appeared for the claimants, instructed by David Cooper & Co, solicitors. Mr Giles Newbold, one of the claimants, Mr David Scholey MICE, a Chartered Civil Engineer with Arup,

Mr Tom McWilliams, Estate Manager at Wentworth Woodhouse and Mr David Pearson, who farms the Home Farm as tenant of the Fitzwilliam Wentworth Estate, gave factual evidence. Expert evidence in respect of mining and ground engineering matters was given by Mr Peter Stevenson B Eng C Eng MICE C Geol FGS, and structural engineering evidence was given by Dr Gregor Beattie PhD, M Eng C Eng, both of Arup.

8. Ms Dominique Rawley QC appeared for the Coal Authority, instructed by DLA Piper, solicitors. She called Mr Lee Cammack, the Coal Authority's Project Manager responsible for public safety and subsidence claims in Yorkshire and Nottinghamshire, who gave evidence of fact. Expert evidence on mining and subsidence matters was given by Mr David Wilshaw FRICS IEng FIMMM MQB of Wardell Armstrong and structural engineering evidence by Mr Clive Richardson BSc (Hons) C Eng FICE FStructE IHBC of AECOM (formerly URS).

9. We are grateful to all those who participated in the reference for their very considerable efforts and their assistance to us in determining these preliminary issues.

Statutory provisions

10. Section 2(1) of the 1991 Act imposes a duty, originally on the British Coal Corporation but now on the Coal Authority, to take remedial action in respect of "subsidence damage" to any property. Subsidence damage is defined by section 1(1) of the Act and means "any damage to land, or to structures or works on, in or over land, caused by the withdrawal of support from land in connection with lawful coal mining operations." By section 1(2) any alteration to the level or gradient of land which does not affect its fitness for the use for which it might reasonably have been expected to be put to, is not to be regarded as damage for this purpose.

11. By section 2(2) the Coal Authority's statutory duty is to take remedial action in respect of subsidence damage to any property either by the execution of remedial works, or by the making of payments in respect of remedial work carried out by another person, or by the making of a payment in respect of the depreciation in the value of the damaged property. Each of these potential courses of remedial action is governed by detailed provisions of the Act which it is not necessary to consider at this stage of the reference.

12. The duty to take remedial action arises only if a notice is given to the Coal Authority, referred to as a damage notice, stating that the damage has occurred and containing further prescribed information (section 3(1)-(2)). The person who gives a damage notice is referred to in the Act as 'the claimant', an expression extended to include any successor in title of that person (section 3(6)).

13. A damage notice must be given within six years of the first date on which any person entitled to give the notice had the knowledge required to found a claim in respect of the damage (section 3(3)-(5)).

14. Section 4(1) of the Act requires that, as soon as practicable after receiving a damage notice, the Coal Authority must inform the claimant whether or not they agree that they have a remedial obligation in respect of the damage specified in the damage notice. In this case, after an interval of six months for investigation, the Coal Authority responded to the damage notice given by the claimants in January 2007 denying that they had any such obligation.

15. Any question arising under the Act is required by section 40(1) to be referred to the Upper Tribunal for determination. Under section 44(2) a reference must be made either within three years of the date on which the Coal Authority are in breach of their remedial obligation, or within the time for serving a damage notice, whichever expires last.

16. There are substantial issues between the parties in this reference on limitation but they do not form part of the preliminary issues to be determined at this stage, so it is unnecessary to refer further to the relevant statutory provisions.

17. It is relevant also to refer at this stage to the provisions of the Act dealing with the burden of proof on the question whether any damage is subsidence damage. Section 40(2) of the Act allocates that burden between the parties as follows:

“Where in any proceedings under this Act the question arises whether any damage to property is subsidence damage, and it is shown that the nature of the damage and the circumstances are such as to indicate that the damage may be subsidence damage, the onus shall be on the Coal Authority to show that the damage is not subsidence damage.”

18. The burden of proving that damage has occurred is on the claimants. Mr Barnes QC submitted on behalf of the claimants that the onus was on them also to establish, by reference to the nature of the damage and other circumstances, that the damage “may be subsidence damage” i.e. that it may have been caused by the withdrawal of support from land in connection with mining operations. He suggested that in this case that burden was relatively light, and that once it was discharged the onus would shift to the Coal Authority to establish on the balance of probabilities that the damage under consideration was not subsidence damage but had some cause other than the withdrawal of support from land in connection with mining operations. For the Coal Authority Ms Rawley QC emphasised that before the Coal Authority was required to prove anything, it was for the claimants to prove the mechanism of damage for which they contended, that it had occurred, and to identify the items of damage which had been caused by that mechanism. We return to this issue at paragraph 326 below.

19. There is a legal issue between the parties on whether the mechanism of damage which the claimants say has afflicted Wentworth Woodhouse in the relatively recent past is such that the damage is “subsidence damage” within the meaning of the 1991 Act, but we will return to that issue at the conclusion of this decision.

Historical background

20. The Wentworth family lived at Wentworth in the West Riding of Yorkshire for almost a thousand years, from the 11th to the 20th centuries. In 1640 Charles I bestowed the title of Earl of Strafford on one of the family's most controversial ancestors, his adviser and favourite, Thomas Wentworth, but the King proved powerless to resist Parliament's demand for Strafford's attainder and execution in 1641. The Earl's direct descendants produced no male heir and his extensive estates in the West Riding and in Ireland eventually passed in 1695 to an infant cousin, Thomas Watson-Wentworth, who was created Marquess of Rockingham by George II in 1746 in gratitude for his support of the Hanoverian regime.

21. The building of the west front of the house was commenced by the 1st Marquess in 1725 on the footprint of Strafford's Jacobean mansion, and was completed in 1735. By that time the erection of the vast east front had already begun and it was structurally complete by 1742. After the death of the 1st Marquess in 1750, the palatial interiors were completed by his son Charles, the 2nd Marquess of Rockingham, a supporter of the constitutional rights of the American colonists and George III's Prime Minister in two short-lived administrations from 1765-66 and for a further three months in 1782. A Whig grandee, a noted sportsman and a patron of both art and science, Rockingham installed an 80 ft telescope on the roof of the house and in 1779 completed the construction of the largest stable block in England in its grounds. His horse Whistlejacket won him a record purse over four miles at York in 1759. For more than 200 years Stubbs' magnificent portrait of the rearing thoroughbred, painted in honour of that victory, was displayed in the Whistlejacket Room at Wentworth Woodhouse before finding a second home in the National Gallery in 1997.

22. The house with all its contents passed on the death of the 2nd Marquess in 1782 to his nephew, William Fitzwilliam, 4th Earl Fitzwilliam. In 1790 Fitzwilliam commissioned Humphry Repton, one of Georgian England's most celebrated landscape gardeners, to redesign the park and lay out the formal gardens.

23. Underpinning it all lay coal. The spectacular wealth required to complete and inhabit Wentworth Woodhouse and its landscaped park was generated from the middle of the 18th century by iron works, by the manufacture of china and by progressive agriculture on a home farm of 2,000 acres and tenanted estates in Yorkshire and Ireland, but increasingly in the 19th and 20th centuries by the mining of coal from around and beneath the estate. The Earls Fitzwilliam were not only landowners but mine owners whose collieries at Elsecar and New Stubbins made them amongst the richest families in Victorian and Edwardian England. It was from those same Fitzwilliam pits that seams of coal encircling the house were worked for the family's profit until 1 January 1947, when nationalisation vested the coal mining industry in public ownership. With nationalisation came retribution, or so it seemed, as the historic park and gardens were brutally mined by open cast techniques and the beleaguered house was threatened with requisition.

24. In 1948 Peter Fitzwilliam, the 8th Earl, was killed in a flying accident with his lover, Kathleen “Kick” Kennedy, sister of JFK. He left no male heir and the title and estate passed to a distant, childless cousin of great age. On his death the destination of the Earldom and all that went with it was settled by the High Court in a dispute over the legitimacy of the elder of two yet further distant Fitzwilliam cousins.

25. In 1950, after open cast mining had laid waste to the park and gardens, Wentworth Woodhouse entered perhaps the most prosaic phase of its history. Rotherham Borough Council took a lease for a term of 200 years of the greater part of the house, the stable block and the grounds to provide a home for the Lady Mabel College of Physical Education, named in honour of the 7th Earl Fitzwilliam’s aunt. The College operated at Wentworth Woodhouse until the lease was surrendered following the death of the 10th and last Earl Fitzwilliam in 1986. The Fitzwilliam estate, including the park, the home farm and the village of Wentworth, had by then already passed to an independent preservation trust (the Fitzwilliam Wentworth Amenity Trust), but the house and its immediate grounds and stables were acquired in 1988 by the pharmaceutical entrepreneur Professor Wensley Haydon-Baillie. The failure of his fortune saw the principal buildings repossessed by Swiss mortgagees who disposed of them in May 1999 to the claimants, Paul, Marcus and Giles Newbold. Their father, Clifford Newbold, was a distinguished architect who aspired to restore Wentworth Woodhouse to its former splendour. Clifford Newbold died at the age of 88 on 29 April 2015 having succeeded in 2012 in opening the house to the public for the first time.

An overview of the buildings and structures at Wentworth Woodhouse

26. The house itself is 180 metres long and 50 metres wide and has almost 400 rooms. Pevsner’s description gives a sense of its grandeur and introduces some of the features of significance in these preliminary issues:

“Wentworth Woodhouse is two eighteenth century houses merging with one another. Incorporated in the earlier of the two are the few remains of an earlier house of c.1630. The two eighteenth century houses can never be seen together. One faces West, the other East - their centres are nearly, though not entirely in line. There is considerable difference in level between them, which amounts almost to a full storey. The differences in character are even more startling. The West front of c.1725-30 is gay and profusely decorated, the East front begun c.1734 is staid, reserved and correct. It is also exceedingly ambitious - with its 600 ft. the longest front of any English country house ...

The East front consists of a principal block of nineteen bays, with lower eleven-bay wings connected by convex quadrants to higher, square angle pavilions with square domed roofs and lanterns. The main house is clearly derived from Wanstead in Essex: rusticated ground floor, piano nobile, and in addition, in the nine-bay centre of the block, another half-storey, and a portico of six giant Corinthian columns.

The wings were originally only one and a half storeys high, and had plain broad five-bay pediments. These were altered by John Carr from 1782-4. Due to him are the giant

Doric columns and the three-bay pediments. The height of the quadrants was also raised. The angle pavilions however are original.

The whole of this majestic if not imaginative East front is a screen to hide the complex and irregular ranges behind.

A large quadrangular stable block, on a scale to emulate the house, was added by John Carr in 1768.

The stone and glass Camellia House was built at some distance from the house, to the South West, in the early nineteenth century. Attached to the back of this is a summer house of earlier date.”

27. Pevsner therefore identifies the east front of the house with the complex and irregular structures behind, the square pavilions (or towers) which stand at the northern and southern ends of the east front, and the 19th century camellia house in the garden. The scale of the stable block attracts his attention, but he makes no mention here of the south terrace wall, the fourth of the specific areas of interest which are the subject of these preliminary issues and which have been explored in the evidence. We will describe those features in more detail when we come to consider the extent to which they have been damaged.

The lie of the land

28. The house and the former mining village of Wentworth situated about 2km to the northwest are located along a west to east trending ridge on the south side of a hill. The mansion itself has a north south alignment so that while the land rises gently from the west façade it slopes down to the east and more steeply to the south. As the length of the house runs across the general slope of the land it obstructs the path of surface or sub-surface water running down the slope, as does the terrace wall on the southern side of the site.

29. The stable block is to the north west of the house at a distance of about 400 metres. The camellia house lies at a similar distance in the formal gardens, which are to the west and south of the house. These are bounded on the south by a terrace retained by a 400 metre terrace wall constructed in 1735; the sloping ground below the terrace is approximately 3 or 4 metres lower than the level of the terrace itself. To the north of the gardens, between the mansion and the stable block, runs a ha-ha wall.

30. The general geology of the district is of the middle coal measures: relatively thin beds of coal formed about 350 million years ago interspersed with sandstone, shale and clay in repetitive sequences or strata. There are thirteen named coal seams within approximately 350m depth beneath the site, of which seven have been mined.

31. A geological fault, referred to as the Wentworth (or Elsecar) Fault, runs on a north west to south east alignment through the centre of the site and passes beneath the mansion and stable

block. The fault downthrows to the south by 40 metres (i.e. the geological strata to the south of the fault zone have sheared and dropped so that they are now 40 metres below the same strata to the north of the zone). The experts agree that where geological faults are present these can be re-activated by mining activity resulting in localised ground movements and damage significantly greater than the general subsidence profile which would be expected in their absence. The claimants also contend that reactivation of a fault can occur as a result of the recovery of groundwater long after the cessation of mining.

An overview of mining techniques

32. Four principal methods of mining have been employed in the vicinity of Wentworth Woodhouse. They are opencast working, pillar and stall working, longwall working and room and pillar working. We include here a brief description of those methods.

33. “Opencast” working is, as its name suggests, the extraction of coal directly from the surface of the land. This method does not involve the sinking of mineshafts, which are required for the mining of deep seams by the other techniques.

34. “Pillar and stall” working is the oldest method of underground working. Coal is removed from the seam in a grid pattern leaving pillars of coal in situ to prop up the roof and the rock or overburden which lies between the seam and the surface. When mining is completed what is left of the seam are the open areas from which the coal has been removed and a series of pillars of un-worked coal which continue to provide support to the roof and the overburden.

35. “Longwall” working is the most common modern method of extraction. A main pathway or heading is created from the bottom of the mine shaft from which, at right angles, two parallel tunnels are dug into the coal seam. A wall of coal is then progressively extracted from the seam between the two parallel tunnels by mechanical methods, and the cut coal is carried away through the tunnels. At the working face the roof is held up by hydraulic jacks but as extraction progresses these jacks are advanced and the roof of the mined area is left unsupported and deliberately allowed to collapse. The collapsed area is referred to as the “goaf”.

36. A key feature of the longwall method of working is that it involves the removal of all or nearly all of the coal in the seam (hence it is referred to as “total extraction”) making it the most productive and efficient deep mining technique. Modern mechanised longwall mining, such as has been used at least since the 1960s, employs a wide working face or panel of up to 350 metres. A similar approach was used before mechanisation, but “old” longwall working in the 1920s progressed using narrower panels down to about 40 metres in width.

37. The “old” longwall technique was employed before the advent of hydraulic props and mechanisation and relied on the manual extraction of coal. At the working face the roof rocks were supported by timber props which would have been removed to allow for the collapse of the roof areas as the face moved forward, and re-used as the seam progressed. Direct access to

the face may have been via a single tunnel as illustrated in a construction industry publication we were shown (CIREA SP32 of 1984).

38. Generally in longwall mining the wider the extracted panel of coal the more comprehensive will be the collapse of the roof. The collapse of the strata overlaying the worked seam causes the migration of movement to the surface, resulting in subsidence. It is agreed between the experts that where longwall techniques have been adopted this movement at the surface will normally occur either immediately or shortly after the withdrawal of support by extraction of the coal.

39. The area at the surface which is liable to be affected by subsidence as a result of longwall mining is not confined to the area lying immediately above the underground working but extends for a distance surrounding the worked out area. The extent of this zone of influence can be predicted by a simple calculation: the boundary of the area liable to be affected to any extent is within an angle of draw of 35 degrees from the worked face (which corresponds to 0.7 x depth of working); experience nevertheless demonstrates that damage from mining induced movement is generally confined within a more restricted area, described by an angle of draw of 26 degrees (corresponding to 0.5 x depth of working). Thus a longwall seam worked at a depth of 100 metres might usually be expected to cause damage at the surface in an area extending for 50 metres beyond the point immediately above the limit of the worked face, but that area could extend to up to 70 metres.

40. The fourth method of mining employs the “room and pillar” technique. This is akin to pillar and stall working in that it does not involve total extraction of all of the coal in the seam but leaves un-worked pillars as support for the roof as mining progresses. Using the room and pillar technique a greater proportion of the coal is extracted from the seam by mining long “rooms” rather than the smaller “stalls” found when the pillar and stall method is used. The long rooms or passageways in which the mining takes place are about 20 metres wide and the pillars which separate them from each other are continuous walls or ribs comprised of the un-worked coal. The extent to which the roof of the mined seam would collapse when the room and pillar technique was used was a matter of controversy between the experts to which we will return later.

Predicting subsidence: the Subsidence Engineers Handbook and Mulpan

41. The extensive history of mining in Great Britain has allowed mining engineers to acquire considerable experience of the effects of underground mining on surface structures. The severity and extent of these effects differ depending on the depth of the seam, its thickness, the dimensions of the coal panel worked, the angle of the seam and other matters. By the 1960s practical experience permitted the development of an empirical model for estimating mining subsidence, published in 1966 as the Subsidence Engineers Handbook (“SEH”). This model did not purport to be a comprehensive predictive or diagnostic tool for all situations and was limited in its application to comparatively simple mine layouts.

42. We were shown extracts from the 1966 and 1975 editions of the SEH. By 1975 the model was underpinned by between 150 and 200 case studies of subsidence which had been caused by longwall mining, from which predictive tables and charts were compiled. Only two of the case studies involved mining in panels narrower than 50 metres and most were for very much larger panels; the narrowest longwall panel included in the studies was about 40 metres wide, of which there was a single example, while at least 98% of the panels studied exceeded 100 metres.

43. In the 1980s the data collected in the SEH was used to create a computerised software package known as “Mulpan”. As well as predicting subsidence Mulpan includes an assessment of “strain” or the effect of lateral (rather than vertical) ground movement, but less reliance seems to be placed on this measure. Mulpan has become a standard tool used by the Coal Authority in assessing claims for compensation; an assessment was commissioned by the Authority in response to the claimants’ first damage notice in January 2007 and another was requested by Mr Wilshaw when he was first instructed.

44. Mulpan was regarded by both geotechnical experts as a reliable basis for the general estimation of movement in the vicinity of Wentworth Woodhouse occurring at or about the time of mining using longwall methods. It should be appreciated that the Mulpan programme, like the SEH before it, is not a tool for measuring subsidence which has occurred, but rather for predicting whether, and to what extent, subsidence attributable to mining ought to have occurred. Armed with this prediction it is then possible to assess whether subsidence actually evidenced on the ground is likely to be mining related, or must have had some alternative cause.

45. Although based on sound mining principles and experience these mathematical methods of predicting the surface effects of deep mining are acknowledged to have their limitations. In particular as Mulpan is based on case studies of longwall mining it does not purport to predict movement as a result of opencast or partial extraction techniques; nor does it predict the effect of mining induced fault reactivation. In addition as the case studies on which Mulpan is based date from the 1980s and earlier, the programme could not take account of any large scale regional ground movements such as are said by the claimants to have occurred in South Yorkshire since the cessation of deep mining in the 1990s.

Mining in the vicinity of Wentworth Woodhouse

46. Extensive coal mining to depths in excess of 300 metres took place in the general locality of Wentworth Woodhouse between 1923 and 1979, with the last mining in the immediate vicinity ending in 1964. Seven different coal seams were mined from different collieries, in part by the opencast method and in part by a variety of deep mining techniques. The location and progress of the workings is shown in detail on seam abandonment plans prepared by the NCB or its predecessors and now held by the Coal Authority. These have enabled the main details of the relevant workings to be substantially agreed.

47. In order of their descending depth below the surface the seven worked seams mined in the immediate vicinity and their different modes of working are summarised in the following table:

Seam	Dates of working	depth below ground level	Seam height	Mining technique
Barnsley	1947-1948	Up to 22m	2m	Opencast
	1951-1953	Up to 30m		Pillar and stall
Swallow Wood	1961-1964	60-67m	1.2m	Longwall
Lidgett	1963-1964	75-95m	1.51m	Longwall
Top Fenton	1950-1962	210-215m	0.8m	Longwall
Parkgate	1923-1925 1935-1959	205-270m	1.5m	Longwall and room and pillar
Thornccliffe	1946-1948	230-235m	0.8m	Longwall
Silkstone	1961-1963	296-310m	1m	Longwall

48. It is relevant to say a little more about two of these seams, the Barnsley seam, which is the closest to the surface of all seven worked seams, and the Parkgate seam, which is considerably deeper and was the only seam worked in the immediate vicinity of Wentworth Woodhouse before nationalisation in 1947.

The Barnsley seam

49. The Barnsley seam is the shallowest seam worked in the Wentworth area, and is found only on the south side of the Wentworth Fault. It outcropped close to the surface immediately south of the terrace wall and from April 1946 until August 1948 coal was extracted from it by opencast mining in the area to the front of the camellia house and on both sides of the terrace wall (though not beneath it) as well as in the formal gardens to within about 150 metres of the west front of the main house. The recently nationalised NCB is said to have been given personal instructions by Emmanuel Shinwell, the Minister of Fuel and Power, to dig “up to the back door” of the house; as a result the formal gardens became part of what was reputed to be the largest open cast mine in Britain. We were able to view aerial photographs of the open cast workings during our site visit.

50. The opencast workings were restored by 1948 but extraction from the Barnsley seam resumed in 1951. This time the workings were below ground at a depth of about 30 metres (although they may have been shallower in the vicinity of the camellia house), and the pillar and stall technique was employed. The subsequent abandonment plan shows a densely chequered warren of tunnels extending in some places to within about 50 metres of the west front of the mansion. The workings encroached much more closely on the camellia house, entirely

surrounding it so that it appears on the abandonment plan as if marooned on a tiny island of solid ground. Moving north the Barnsley workings extended almost to the wall of the stable block, where they encountered the line of the Wentworth fault and abruptly ceased.

The Parkgate seam

51. The Parkgate seam is critical to the claimant's case and lies beneath the site at a much greater depth than the Barnsley seam. It was mined to the north of the Wentworth fault using both the longwall and the room and pillar techniques at a depth of 200 metres below the surface and to the south of the fault at a depth of 240 metres. The abandonment plan shows three or four distinct phases of the workings.

52. Mining of the Parkgate seam advanced from the Elsecar colliery some miles to the north east of Wentworth. In 1922 and 1923 the longwall method was used to extract coal from the seam to the north and north east of the stable block and of the mansion itself to within about 150 metres of the north tower. It is assumed that longwall mining was halted at that distance from the house out of concern by Earl Fitzwilliam to protect his family home.

53. In 1924 the more conservative room and pillar method was employed to mine the Parkgate seam in an area directly beneath the entirety of the stable block and to the west and north-west of the mansion, coming to within about 100 metres of the northern end of the west wing. A chevron pattern was adopted under the stable block and the abandonment plan shows the workings angling towards the mansion in long chambers dug from central access tunnels.

54. In 1925 a similar pattern of working took place to the east of the mansion below the gardens, with the same arrangement of alternating areas of extraction and support running to within about 100 metres of the east front; these workings terminated in a short section of much narrower intercommunicating tunnels. The dimensions of the worked panels were very similar below the stable block and to the east of the mansion, the panels being about 20 to 22 metres wide and progressing in long rooms separated from each other by solid blocks of coal of the same dimensions; the length of these rooms varied and was not the subject of specific evidence, but appears from the abandonment plans to have been as little as 60 to 80 metres in some locations and as much as 300 metres in others.

55. Finally, between 1927 and 1939 the Parkgate seam was worked to the south and south west of the mansion, immediately beneath the terrace wall and the camellia house. These workings were by the pillar and stall method below the camellia house and approaching the western end of the terrace wall, but predominantly by the room and pillar technique towards the eastern end of the wall.

56. Once again it is assumed that the adoption of these more conservative, partial extraction techniques in the mining of the Parkgate seam closest to the mansion was intended to preserve it from damage.

57. Three further important features of the Parkgate seam should be noted. First, to the east of the mansion it lies directly above the later workings in the Thorncliffe (1946) and Silkstone (1962) seams (both mined by the longwall technique). The Thorncliffe seam is only about 25 metres below Parkgate, but Silkstone is much deeper. Secondly, the abandonment plans show a section through the seam indicating that above and below the coal itself there were strata of “inf. coal” (which we take to mean “inferior coal”), “clod” and “dirt”, referred to elsewhere as “top softs” and “bottom softs” or as “seatearth”. It was explained that this is softer rock which includes remnants of the soil and organic matter which once supported the vegetation from which the coal strata were created. Thirdly, and significantly for the claimants’ case, the Parkgate seam was the only seam worked directly beneath the stable block.

58. The impact of the Wentworth fault on the workings has been a continuing subject of concern. We were shown correspondence in 1960 between agents for the Fitzwilliam Estate and the National Coal Board. Concern about ongoing movement prompted Mr Bedford, the Area Land and Minerals Officer for the Board, to comment that: “The amount of movement is surprising and I agree that the Parkgate pillars were inadequate and the recent Barnsley workings have set up movement on the fault plain (sic) which may continue for some considerable time”. It is not clear whether the inadequate Parkgate pillars were those created in the areas worked by the pillar and stall technique or by the earlier room and pillar workings.

Un-mined areas

59. No mining took place at any time directly beneath the mansion itself (nor beneath the adjacent village of Wentworth). The Fitzwilliam family had been the principal beneficiaries of mining under their estate, but the change from aristocratic to public ownership in 1947 brought intensified activity in the immediate vicinity and led to the complete encirclement of their magnificent home both at the surface and underground. When the abandonment plans are consolidated they show Wentworth Woodhouse surrounded on all sides by mine workings, in and under the garden, and beneath the terrace wall, the camellia house and the stable block, but not below the mansion which alone sits on an island of solid ground.

Record of historic mining subsidence claims

60. A series of claims for compensation for damage to Wentworth Woodhouse caused by mining subsidence have been made in the past by the Fitzwilliams and by the local authority on behalf of the Lady Mabel College. A large number of these claims were met by the Coal Authority’s predecessors. The relevant records of claims and associated correspondence are now held by the Coal Authority and the frequency of these has been analysed by Arup on behalf of the claimants. Although the general chronology of claims is relied on by both parties and is not in dispute, care must be taken not to equate correspondence concerning damage claims with evidence of recent damage, as it is clear to us from perusing the correspondence that some claims were dealt with at a leisurely pace and generated correspondence over a considerable period.

61. The earliest claim made to the National Coal Board appears to have been in 1950 and there were regular claims and related correspondence continued throughout the period in which the College operated from Wentworth Woodhouse. From the mid-1950s until the mid-1970s correspondence in relation to the mansion and the stable block intensified, with claims being recorded in each location. After a lull between about 1975 and 1982, first a trickle and then a spate of further exchanges took place concerning the mansion in the mid to late 1980s. Damage claims in relation to the stable block reduced after about 1974, but correspondence continued over about the next 15 years.

62. Masonry ornaments and monumental baskets of fruit on the roof of the camellia house were removed as a precaution in 1961 when very bad cracks first began to appear in the building. Claims in respect of damage to that building were concentrated in the early to mid-1960s, with eight claims in about seven years. Four further claims or items of correspondence concerning the condition of the building were received during the 1980s, the last in 1987.

63. Damage claims were also submitted in respect of the terrace wall, the first in September 1961; gaps created in the wall were fenced off in 1963 when subsidence at the wall was said still to be active; a further formal notice was given in 1976 and correspondence continued until 1986. Claims were also made in relation to the grounds and structures within them between the mid-1960s and the mid-1980s.

64. In general it appears that these historic claims for compensation were not contentious and were settled amicably between the NCB and the West Riding County Council or the Wentworth Estate. Not insubstantial sums were frequently paid out. Details of the last claims settled by agreement were provided by Mr Cammack. £12,000 was paid towards works of repair to damaged brickwork and stonework in the mansion between 1984 and 1988, and a further £3,000 was spent in September 1985 on repairs to an underground tunnel or cellar beneath the building. A payment of £2,316 was made as a contribution towards the repair of damage in the College gymnasium, located in the stable block, in September 1987. £2,329 was paid as a contribution towards the repair of the ha-ha wall, also in 1987.

65. In July 1986 a claim in relation to the camellia house was made by the Wentworth Estate, whose agent was "certain that recent damage has occurred". A joint inspection revealed the camellia house to be in a bad state of repair and dilapidated with evidence of vandalism. Nevertheless, the claim was subsequently rejected on the grounds that no recent mine workings had taken place in the vicinity of the property which could have been responsible for the damage.

66. No further payments have been made for damage at Wentworth Woodhouse since 1988, and Professor Haydon-Baillie (no stranger to litigation) appears to have submitted no claims during the period of his ownership from 1988 to 1999.

67. The absence of later claims may have been unexpected. The NCB had certainly anticipated further liability, despite the absence of recent mining activity in the area. In December 1986 its

area estates manager for South Yorkshire estimated a repair liability of £46,000 for the house and a further £20,000 for the stable block, an assessment which appears to have been accepted by the Board's Deputy Accountant. A file note in June 1987 referred to recent movement apparent on the east elevation with large courses of stone displaced and a stone fractured. Internal correspondence in 1987 acknowledged that liability for damage to the main structure could not be finalised because of "continued slight movement along the fault line". A review in 1988 recorded that "this property sits on a nest of geological faults and was damaged in 1986; movement does occur from time to time."

68. Mr Cammack also told us that there are over 680 domestic and 50 commercial properties within a 2 km (1.2 mile) radius of Wentworth Woodhouse. Since 1990 claims have been made for compensation for damage to ten properties within that area. Two of these claims were settled by a payment from the Coal Authority in the early 1990s (both relating to a fissure which opened in the same area of woodland). Eight further claims (five of which related to built structures) were rejected. Since 1996 the only claims in the locality received by the Coal Authority have been the claims in relation to the damage to Wentworth Woodhouse which are the subject of this reference, and a claim by Yorkshire Water (advised by Arup) in respect of damage to the Hooper Reservoir which was rejected by the Coal Authority in 1999 and was not pursued. The purpose of this part of Mr Cammack's evidence was obviously to invite the inference that an absence of damage claims meant an absence of ground movement. In that regard it is relevant to note, however, that a high proportion of the 730 properties within Mr Cammack's chosen radius of Wentworth Woodhouse are likely to be in the village of Wentworth itself, beneath which no mining took place.

Damage

69. The large scale extraction of coal by underground mining using total extraction methods invariably results in ground movement and often in surface deformation. Three varieties of ground movement were identified as relevant to Wentworth Woodhouse: subsidence, which is the vertical lowering of the surface of the ground; strain, which is differential horizontal displacement of the ground; and tilt, which is differential vertical displacement. There is no dispute that considerable damage has occurred to Wentworth Woodhouse in the past as a result of ground movement caused by mining, and the buildings all bear signs of substantial works of repair carried out in about the 1960s. The last recorded repair following an accepted subsidence claim was in 1988. The current dispute concerns damage of more recent origin.

70. Comprehensive surveys of the fabric of the structures at Wentworth Woodhouse may be required at a later date but it was agreed by the parties that at this stage in the claim it was necessary and proportionate to establish only whether or not there has been ongoing subsidence which might have been caused by mining. To enable that to be done further investigations have been concentrated on four specific locations rather than across the buildings and estate as a whole. The areas under scrutiny have been:

1. The north tower including the north quadrant on the east front of the mansion

2. A line of damage through the east front of the mansion, the north wing and an internal courtyard known as Basin Court which is said by the claimants to follow the line of the Wentworth fault
3. The south terrace wall
4. The camellia house

We will now briefly describe each of these areas and identify the damage which the structural engineers agree is present, and which we were able to observe on our site visit. We refrain at this stage from attributing this damage to any particular cause, on which there is very much less agreement. We omit from our description a number of areas of damage which the engineers agree are not attributable to mining subsidence.

The north tower and quadrant

71. At either end of the east front of the house stand identical square towers (the “pavilions” of Pevsner’s description), each of four storeys with walls about 8 metres long, topped by a four sided convex slate roof itself surmounted by a timber lantern. The towers are connected to the wings of the mansion by masonry quadrants (curved walls). Each tower has pairs of windows on the ground, first and second floors on the east side. The façades on three sides are of ashlar stone blocks with a brick backing or inner skin, while the west face is two skins of brick.

72. The north tower has undergone a series of alterations in the 19th and 20th centuries which we will describe in greater detail later. These involved additions, modifications and removals of walls, staircases, floors and roof beams and the introduction in the 1920s of substantial steel beams in the roof space. Open parapet gutters run within the roof space and these have caused damage by overflowing. The timber beam supporting the attic floor has deteriorated and now sags dangerously; it is supported from the floor below (the second floor) by a pair of acro-props resting on a timber structure designed to spread the load from above.

73. The quadrant wall is a curved stone structure of three storeys, with a corridor behind, and its own shallow and lightweight lean-to roof. It links the north tower with the north wing of the east façade. Within the quadrant a timber staircase leads to the upper floor of the tower; the quadrant wall leans out and a gap exists between the staircase and the wall.

74. The structural engineers agreed that there are seven individual items of damage in the north tower and quadrant which require to be considered (on the grounds that they are said by the claimants to be related to mining subsidence). These can be further classified into four types of damage: the “lean” or rotational settlement of the quadrant wall, of as much as 200mm in the middle of the wall; vertical cracks in the masonry on a number of elevations, particularly the east; cracks in walls and ceilings visible inside the tower; and finally a “lean” or distortion of the tower itself.

The line of damage through the east front and the north wing

75. The geological fault which runs diagonally beneath the mansion with a more or less southeast to northwest alignment has already been described. It is agreed that there is a line of damage to the structure of the mansion running from a point approximately midway along the east front wall of the north wing (to the north of the central portico), through the rear wall of this wing and in the cellars below Basin Court. The line of damage continues through the dividing wall separating the original west front from a later west wing addition (comprising ground floor rooms G56 to 58, and principal floor rooms P41 and 42) and is evident on the west side of the building on the external wall of this extension.

76. The damage, categorised under eight headings, includes past cracking and movement in a cellar passageway (room B20) which required the rebuilding of sections of the passage walls in 1985; differential settlement which has caused extensive cracking to brickwork and ashlar stone facings of the external walls on the east and west fronts; particularly severe cracking around window openings and heads on the east façade; cracking and some leaning or bulging of the walls enclosing Basin Court; various floors and door frames out of true; and areas of cracking and deformation to wall plaster and ceilings.

77. The claimants assert that the line of damage follows the line of the fault and that movement in the fault resulting from former mining operations is responsible for the damage. The Coal Authority says that the actual line of the fault could be as much 20 metres to the south of the line of damage, and that apart from some long since repaired damage which had been accepted as mining related, the principal cause of the damage is likely to be settlement and subsidence from collapsed or damaged culverts or areas of soft ground.

The south terrace wall

78. A grand terrace was constructed in 1735 to enclose the formal gardens at Wentworth Woodhouse on their southern side. It is retained by a stone wall running from a point adjoining the south tower of the mansion. The wall first heads south for 80 metres, then west along the entire length of the gardens before returning north to end beyond the Camellia House. The south facing section of the terrace wall is one of the structures we have been asked to consider in detail.

79. The south terrace wall is 440 metres long. In the east it abuts a massive rotunda or circular platform providing views across the park; in the centre a solid bastion projects onto the adjoining farm land; towards the western end the wall is pierced by a gate. A terrace walk runs above the wall for almost its whole length ending close to the gate at a circular folly built in the style of an Ionic temple.

80. The wall varies in height along its length. It is 3 metres high at its western end but about 5 metres where it adjoins the rotunda in the east. It is divided into 25 bays, separated by stone buttresses (there is a divergence of view on whether the buttresses are part of the original design or later additions).

81. Bay 8 has recently collapsed to the ground in two places.

82. There are agreed to be nine areas or types of damage which have affected the terrace wall. Some of these are not contentious. It is agreed, for example, that the drop in the wall by about 2 metres towards its eastern end is likely to have occurred in the 1960s as a result of longwall mining in the Thorncliffe seam. It is agreed that repairs to a 40 metre stretch of the wall in the area around the gate at the western end were undertaken in about 1966 and are still satisfactory. There remain five contentious items of damage: the wall leans forwards by varying amounts in different locations; its face is bulging and cracked; the surface of the ground immediately behind the wall has sunk in places; the head of the wall is out of alignment; and there is cracking in the face of the wall (distinct from that associated with areas of bulging).

The camellia house

83. This imposing detached conservatory building is situated in the formal gardens about 450 metres to the west of the mansion. It was constructed in the Georgian style in the early 19th century with a high stone-faced south frontage incorporating virtually full height windows and surmounted by stone bottle balustrading. It has timber and glazed roofs. The flank and rear walls are of brick, and the building abuts at the rear onto earlier single-storey brick and stone outbuildings with slate pitched roofs. The whole structure is a Grade II* listed building.

84. That the building had been seriously affected in the past by mining subsidence, causing a tilt in the south wall of some 800mm, is not in dispute. It remains in issue whether further deterioration that has plainly occurred, including the collapse of the timber and glazed roofs and the partial collapse of the internal spine wall, is attributable to more recent ground movement or has been caused solely by lack of maintenance, vandalism and decay.

85. Whatever the cause of its current sorry condition the camellia house is now unsafe to enter.

The general condition of the structures before 1999

86. During the tenure of the County Council between 1951 and 1986, and while under the ownership of Professor Haydon-Baillie, Wentworth Woodhouse seems to have been in decline.

87. Mr Pearson has farmed the Home Farm at Wentworth, which includes the fields lying immediately below the terrace wall, since 1975. He had a poor recollection of dates, but told us that in about that year a contractor (whom he assumed was engaged by the Coal Board) had rebuilt or repaired half of the terrace wall in the same area as has suffered recent collapses. We think it likely that Mr Pearson's recollection was of the work undertaken by J. Utley & Sons to the eastern section of the wall in 1982 at the expense of the NCB. Mr Pearson also told us that he had noticed, over the years, distinct changes in the contours of his field below the terrace

wall, and that settlement had broken the land drains causing ponding to occur. He believed the wall itself undulates more than it did, which suggested to him that it is still settling.

88. A report prepared in September 1976 by Donald Insall and Associates found the house itself to be “in a progressive state of decline” which was attributed not to neglect, as “normal maintenance has clearly been vigilant”, but rather to “the natural and long term ageing and behaviour of old materials”. The authors expressed the view that “All old buildings decline to a critical condition periodically in their history, and this building is reaching one of those points.” The principal areas of concern were the roofs of the mansion and the north tower, the means of disposal of water from them, the conservation of stonework and the repair and repointing of brickwork. A major programme of repairs was recommended.

89. It is not clear to us how much, if any, of the major work identified by Donald Insall was undertaken or who would have been responsible for carrying it out. A report for the Fitzwilliam Estate in 1987 (at about the time of the surrender of the College lease) referred to some areas of roof covering having been repaired but described most materials as having been in position for many years; on the east front some stone work had also been replaced at window heads. A later report prepared by English Heritage in November 1998 records that little work had been done in the previous 10 years; most of the problems associated with the building’s fabric were of long standing but there was said to have been a noticeable deterioration in that period. Although the overall condition of the property was described as fair, some parts, and in particular the roofs, were in poor condition.

90. In April 1999, shortly before Wentworth Woodhouse was sold to the claimants, a further condition survey was undertaken by Martin Stancliffe, Architects, on behalf of the Fitzwilliam Wentworth Amenity Trust.

91. The architects’ report warned that the roof of the house needed to be re-covered in many places, but expressed much less concern about the consequences of mining. Appended to the report was the report of a firm of structural engineers, Gifford & Partners, dated March 1999, compiled following a visual survey undertaken over several visits in the preceding month. This recorded evidence of previous repairs, stepped cracking and fractured stonework on the east façade, and evidence of previous settlement at the north end of the façade, but the overall conclusion was that the mansion appeared to be in reasonable structural condition and that much of the cracking which had been observed was either minor in nature or unlikely to be due to recent movement. Isolated instances of bulging were observed on the terrace wall but this too was found generally to be in good condition. The stable block was described as being in reasonable overall structural condition but with evidence of slightly more serious cracking which was not thought to be due to recent movement. The exception to this generally encouraging picture was the camellia house, the structure of which was found to be in poor condition and requiring extensive works. Making due allowance for “necessary small scale remedial work” the conclusion of Martin Stancliffe was that “the massiveness of the structure and the lack of any recent dramatic main structural defects point to a structure in good order and one which can be repaired with confidence.”

92. Mr Giles Newbold told us that when he first saw the house in 1999 there was some evidence of cracking and defects to parts of the structure, but these were no more than he would have expected in a building of such great age, and he insisted that it was not in a seriously dilapidated state. That recollection is broadly consistent with the Martin Stancliffe report.

93. Before the sale was completed the Trust shared the conclusions of their architect's report with the claimants who commissioned no other survey for themselves. They did obtain a standard mining report from the Coal Authority (paying a fee of £34.00) which related to the mansion, the stable block and the camellia house but not the terrace wall. The report included a statement which is now acknowledged by Mr Cammack on behalf of the Coal Authority to have been untrue (although that is immaterial for the purpose of this reference) to the effect that the Authority's records "do not disclose any damage notice or claim having been given, made or pursued since 1 January 1984". There had in fact been a number of claims in or after 1984 but their non-disclosure was explained by Mr Cammack as being attributable to the practice in the NCB's historic records of referring to the house as the Lady Mabel College, which, understandably, was not the designation used in the claimants' request for a mining report.

94. Mr Cammack also accepted as incorrect a statement in the report that the records showed no "*fault or other line of weakness at the surface as having affected the stability of the property*". From correspondence in 1987 the NCB clearly had knowledge of damage to the structure of the north wing and along the line of the fault and considered that slight movement was ongoing in that location; it also then estimated that its own liability for the cost of further repairs to the mansion could be up to £50,000. That correspondence appears either not to have been available, or not to have been considered by those who produced the mining report.

95. We were told by Mr Giles Newbold that his family would not have purchased Wentworth Woodhouse had they known about the mining related issues that have subsequently come to light.

Signs of movement

96. On completion of their acquisition the Newbolds quickly began the task of restoring Wentworth Woodhouse, which was referred to as a "retirement project" for Clifford Newbold. Work was carried out to some parts of the roofs (which cover an area of between one and a half and two acres), the electric wiring and other services were upgraded and an alarm system was installed. The driveways were repaired and general restoration works commenced.

97. Mr Tom McWilliams was employed by the claimants in 2000, initially as caretaker and then as estate manager with a brief to engage skilled local tradesmen to undertake remedial work. Mr McWilliams was resident in the north tower and gave evidence that he had observed cracks in the internal walls and ceilings of that building. The effect of his evidence was that the cracking had continued to the present day and worsened. Props had later to be installed in an upper floor of the tower to support the ceiling and roof timbers above as that part of the structure was considered to be at risk of collapse. He also observed movement of newly laid

slates on the roof of the north tower and damage by water penetration to newly decorated areas in the suite known as Clifford's Lodgings where the roof had been re-slatted and re-leaded in 2001.

98. Within a relatively short time of their arrival at Wentworth Woodhouse the Newbold family therefore came to suspect that movement was occurring and all non-essential restoration work was halted. Mr Giles Newbold told us that doors started to jam in the Pillared Hall, the Long Gallery and the King George IV suite, plaster cracks opened up in various internal walls and plaster mouldings fell from some ceilings (including on one occasion in 2008 or 2009 when a large piece of plaster fell onto the pillow of Paul Newbold's bed). He also said that the main driveway, which had been resurfaced, began to show signs of settlement. The floors of several rooms in the mansion started to slope. He considered that there was ongoing damage including the collapse of part of the terrace wall and continuing tilting to the wall of the camellia house.

99. The general gist of Mr Newbold's evidence was corroborated by the account of recent movement given by one of the Newbolds to Mr Scholey in September 2005 and recorded by him in Arup's August 2006 desk study (although nothing was noted as having been said about newly sloping floors).

100. We were told that in 2005 Clifford Newbold, Giles Newbold's father, had been awakened from sleep by "a massive bang" which he feared was caused by a beam slipping somewhere in the building. That unsettling experience finally prompted Mr Newbold to seek external advice and in July 2005 he instructed Hinchcliffe Chartered Surveyors to prepare a mining report. The report, which is a short document dated 8 August 2005 advised that the last subsidence damage had occurred more than 30 years previously and concluded that any new claim would be out of time or would be defeated on the basis that historic repairs had already been undertaken. Any damage of more recent origin would be attributed to other causes.

101. Mr Newbold said that when Mr Hinchcliffe was pressed with evidence of recent and ongoing damage he suggested that further investigation was needed, although that advice is not recorded in the report. Mr Hinchcliffe recommended that a larger firm be appointed because some of what was going on with the building appeared unusual.

102. At the end of August 2005 the Newbolds therefore instructed Arup. A first visit by Mr Scholey on 9 September was followed in January 2006 by a second, to observe areas of recent damage. He informed us that on his initial walk around the buildings he had considered that the most likely cause of the widespread problems that he observed was ground movement. The geotechnical desk study produced by his colleagues in August 2006 ("the 2006 desk study") recorded that Mr Newbold's instructions had been prompted by "concerns over recently observed movement." In particular Mr Scholey was told about and observed for himself, internal and external cracks, including around the north tower and along the east front, many of which he described as being clean and having sharp edges indicating that they were recent. He was also alerted to what was said to be recent settlement of roads within the grounds and settlement of the ground behind the terrace wall.

103. In his oral evidence Mr Scholey said that on his various visits to Wentworth Woodhouse he had personally observed ongoing damage including forward dislocation of the terrace wall at the buttress between panels 5 and 6 and the collapse of panel 8 in 2015. He had noted the collapse of the spine wall in the camellia house and further damage to its roof structures. He corroborated the evidence of Mr McWilliams concerning the north tower, where he had seen an increase in the number and severity of cracks on the internal face of the south, east and particularly the north external walls at ground and first floor level, and on internal walls around door openings. He drew particular attention to two localised external fractures in the ashlar stonework on the east wall of the tower; whilst the original date of the failure was not known, these cracks have sharp edges and clean, fresh stone faces which indicated to Mr Scholey that they had occurred recently and since his detailed inspection in 2006. The cracking at high level to the north end of the east wall of Basin Court, noted in 2006 also appeared to him to have increased in intensity at lower levels since then.

104. Internally, Mr Scholey had observed further cracking in the decorative vaulted plaster ceiling in the first floor library in the northern section of the east wing, where a small area of plaster had fallen away. The existence of plaster dust on the carpet indicated that the movement was very recent. Finally, Mr Scholey confirmed that a timber wedge that had been driven into a crack in the stonework of the external wall beneath one of the windows on the east front of the library has become loose, indicating further opening up of the bed joint.

105. The 2006 desk study suggested that the recent damage to the structures and settlement within the grounds was indeed due to mining subsidence attributable to one or more potential causes, namely: reactivation of the Wentworth fault; inundation settlement of the previously worked coal seams and of the geological fault due to rising minewater; and settlement of mine workings due to recent groundwater abstraction (a hypothesis not subsequently pursued).

106. The 2006 desk study was followed up between October and December 2006 with a comprehensive room by room visual survey by Mr Scholey and other Arup engineers, resulting in a July 2007 report recording cracks and defects in the structures (“The Arup 2007 Survey”). Mr Scholey had also recommended level monitoring, verticality surveys and intrusive site investigations to determine the ground conditions deep beneath the buildings; it was hoped that these would substantiate the hypothesis of mining subsidence and provide material to support a claim. With the exception of crack monitoring none of these investigations were undertaken at that time.

The current claim

107. On 1 February 2007 the claimants gave a damage notice to the Coal Authority; a second notice, intended to make good defects alleged by the Coal Authority in the first and to update the allegations of damage, was given on 3 August 2009. Each notice asserted in general terms that damage had been caused to Wentworth Woodhouse and its associated structures.

108. The two damage notices differed materially only in relation to the damage specified. The 2007 notice contained the following statements in response to questions 8 (date when damage was first recognised) and 9 (brief description of damage):

“8. By the present owners 2005.

9. Evidence of recent cracking and movement to the main house and stableblock building, settlement and disturbance of walls, settlement of grounds and roads, including recently re-levelled road surfaces.”

The 2009 notice stated:

“8. 2009. (Damage notice dated 2007 detailed damage noticed from 2005).

9. Movement of the north tower has displaced roof timbers, further damage to ceiling plasterwork, further movement and damage to terrace wall and cracking to the underground drainage system.”

109. The claims were taken seriously by the Coal Authority and a significant number of meetings took place with the claimants in 2008 and 2009, at least one of which was attended by its Chief Executive. The two damage notices were eventually rejected by the Coal Authority (on 24 December 2008 and 14 September 2009) on the grounds that any damage to the property which had occurred was not caused by coal mining operations and so was not subsidence damage under the Act.

110. The Coal Authority’s position was informed by advice from three sources. The first was a Mulpan analysis commissioned by the Authority. Secondly, a report was obtained from White Young Green, a large engineering consultancy, who recommended investigations for which the Coal Authority budgeted £250,000. For reasons which are unclear these investigations were not carried out. Finally, a draft report was prepared in February 2009 by Alan Baxter & Associates LLP, a firm of structural engineers who had conducted limited initial inspections of the property on 9 April and 29 May 2008. This report contains much useful background information about the history of Wentworth Woodhouse and its architecture on which we have relied, but it did not purport to be more than an initial opinion on possible explanations for apparent movements in the buildings and walls.

111. Drawing on the Mulpan analysis the Alan Baxter report concluded that the effects of mining on the mansion had been very small, that the effects on the stable block and the camellia house were minor (despite significant overall settlement) and that the significant deformations of the south terrace wall were historic. It postulated that most of the recent movements and distortions found in the mansion and the north tower could be explained by factors unrelated to mining, including: differential settlement of parts of the building relative to others because of variable ground conditions and foundation depths on either side of the fault, and different stages of construction; local settlement caused by collapsed culverts and drains beneath the mansion; the decay of timber built into external walls; and movements resulting from seasonal thermal and moisture changes. The report found no signs of recent mining related movement.

112. Following the wholesale rejection of their claim the claimants referred it to the Tribunal.

113. After the Court of Appeal had confirmed the validity of the damage notices in May 2013 it was suggested by the claimants that, rather than expend what would undoubtedly amount to hundreds of thousands of pounds on the preparation of a comprehensive schedule of condition for the whole of the property, only four selected parts of the property should be examined in detail. The Coal Authority agreed, and on 1 May 2014 the Tribunal ordered the claimants to serve a schedule setting out each item of damage alleged to exist, and each item alleged to have been caused by coal mining subsidence, in relation to the four chosen areas. The order made it clear that both parties reserved their positions on whether these areas were representative, but they were obviously selected on the basis that a ruling on the cause of damage apparent in those areas would be of general assistance to the parties.

114. In January and July 2014 Arup engineers inspected the four areas specifically to identify if there were any further signs of movement or damage since their 2007 report. The resulting report, dated 25 July 2014 (“the Arup 2014 report”), presented extracts from the 2007 Arup Survey Report and observations relating to further movement said to have been apparent on the 2014 re-inspections. The report included detailed room data sheets for all of the relevant areas and a series of annotated photographs.

115. The Coal Authority’s response dated 3 November 2014 followed inspections carried out by its experts on 17 and 18 September 2014. It pointed out that the Arup report was little more than a condition schedule which did not distinguish between damage said to be caused by mining and other damage. Indeed, it implied that all of the recorded damage was caused by mining subsidence which clearly was not the case. In contrast, the overall conclusion of the Coal Authority’s advice was that, with the exception of the tilting to the south wall of the camellia house, the vast majority of the damage that had occurred could be explained without reference to mining.

116. Helpfully, the Coal Authority experts also compiled the first iteration of a Scott schedule, recording the results of the visual inspections by both parties’ engineers. By February 2016 this schedule had been updated and expanded to summarise the structural engineering experts’ views on each of the items in dispute.

117. Further investigations were carried out on behalf of the Coal Authority by two specialist contractors (to a brief prepared in March 2015 by Mr Richardson after input from Arup). Obsurvus Ltd, a Doncaster based firm of Land and Hydrographic Surveyors, undertook a series of independent level monitoring, verticality and crack movement checks, and NAL Plant Ltd dug trial pits and opened up floors and ceilings in the north tower under the direction of Mr Richardson. Additional investigations were later proposed but never carried into effect, including drainage surveys, the extension of some trial pits and the provision of safe access to the camellia house. Access to the cellars under the mansion was also requested, but this proved difficult due to the presence of asbestos and was only achieved at a late stage of the experts’ investigations.

The expert evidence in outline

118. It was agreed that the Coal Authority's factual and expert evidence should be served first, with the claimants' evidence to follow 6 months later. A further short period was allowed for supplemental reports, although eventually the expert evidence emerged in a series of exchanges up to and during the final hearing. We provide an outline of the expert evidence below, before considering the important points in greater detail.

119. Four experts gave evidence. The two structural engineers and the two mining experts each helpfully produced statements of agreed facts and issues.

Structural engineering

120. Mr Clive Richardson of URS/AECOM is a structural engineer specialising in the survey, repair and development of structures in historic environments; he is accredited in the conservation of historic structures and from 1992 to 2014 was Engineer to the Dean and Chapter of Westminster Abbey and he remains Engineer Emeritus following his retirement from that appointment. He has had no practical experience of mining subsidence and, on the basis of Mr Wilshaw's advice, adopted the proposition that mining subsidence should have ceased at Wentworth Woodhouse many years ago.

121. Mr Richardson's first report, dated April 2015, was an initial critique of Arup's July 2014 report and adopted a surprisingly combative tone. It concluded that other than at the camellia house there was no evidence of significant damage due to mining and that the vast majority of the alleged defects could be attributed to other causes. Mr Richardson ruled out fault reactivation as a potential cause of the damage along the line through the north wing of the mansion on the basis of Mr Wilshaw's view on the likely position of the fault, and thought it probable that the same damage was attributable to the presence of a culvert or drain beneath the structure which may have leaked or collapsed along its length. The damage to the south terrace wall and such as there was to the north tower and the adjacent quadrant wall were in the nature of those structures given their age and design.

122. Mr Richardson produced a second report in February 2016 following further inspections (including of the cellars), the completion of the additional investigative works agreed with Arup, and the first 6 months level monitoring statistics from Obsurvus. In response to the reports of Dr Beattie and Mr Stevenson he maintained his original views: the damage to the terrace wall was predominantly due to non-mining causes present since its construction in 1735; the damage to the north tower and quadrant was due to a combination of specific non-mining causes; the camellia house was derelict, but exhibited no ongoing movement; and the most likely cause of localised damage along the putative line of the fault through the north wing of the mansion was associated with the presence of underground culverts or drains.

123. In response to a third report by Mr Stevenson on 18 March 2016, and following a further inspection of 23 rooms in the mansion including along the alleged line of the fault, and

consideration of Arup's crack monitoring results, Mr Richardson issued a third report. This reiterated that there was no evidence of any structural movement having occurred within the mansion since 2001 and proposed that the crack patterns on the east front walls on both sides of the main portico were historic and were not in any event consistent with subsidence caused by movement in the fault line. The most likely cause of the settlement that had occurred historically was the collapse of ancient culverts which run under the building and none of the recent movement and partial collapse of the terrace wall was mining related.

124. For the claimants, evidence concerning the damage to the buildings was given by Dr Gregor Beattie, a structural engineer with 24 years' experience who heads Arup's Advanced Engineering and Infrastructure Teams on both new projects and historic buildings. He was first appointed in November 2015 and carried out detailed inspections at that time. His first report, dated 11 December 2015, concluded that ground movement is still occurring and causing ongoing damage to the structures in all four of the areas specifically investigated, and elsewhere within the buildings and structures on the estate. Whilst he accepted that there could be factors other than mining involved, such as damage to drains and culverts, poor maintenance and general decay, it was his view that the line of movement through the mansion in particular loosely follows the predicted fault line and is likely to be mining related.

125. Dr Beattie's first addendum report dated 6 February 2016 followed further inspections and monitoring, and responded specifically to the Scott Schedule prepared by Mr Richardson and to Mr Stevenson's report on ground movement. He considered that all of the latest evidence supported his initial conclusions. The observed structural damage was compatible with mining subsidence and the views of Mr Stevenson on what was likely to be occurring below the surface of the ground pointed to the conclusion that the damage was indeed due to mining and could be expected to continue.

Mining engineering

126. The conclusions of the structural engineers on both sides were heavily predicated on the opinions of the mining experts on the nature and sequence of events likely to have occurred at depths of up to 320 metres below the ground following the cessation of mining in the area in the 1960s.

127. For the Coal Authority, Mr David Wilshaw is a qualified mine surveyor and a technical director of Wardell Armstrong, specialising in mining subsidence. He has 44 years' experience in the industry, 17 of which were spent with the National Coal Board.

128. Mr Peter Stevenson, who gave evidence for the claimants, is an engineering geologist and geotechnical engineer with a particular background in ground engineering. During a long career with Arup, for whom he is now a consultant, he has dealt with major projects worldwide while, more locally, he has advised on risks to the HS2 high-speed rail project associated with former mine workings.

129. The mining experts agreed that subsidence attributable to the immediate consequences of longwall mining at Wentworth Woodhouse would generally have been completed by the mid-1960s, within a few years of the final coal extraction from the seams in the vicinity of the house, although they may have continued until the mid-1970s in the area of the fault. The damage said by the claimants to have occurred since their acquisition of the house in 1999 cannot therefore be accounted for by reference to conventional mechanisms of mining induced subsidence. Through the evidence of Mr Stevenson the claimants therefore presented a case on the causation of damage which has not previously been relied on in mining subsidence claims, and which builds on recent research on the occurrence and consequences of mine water rebound following the general cessation of mining in the United Kingdom.

130. Mr Wilshaw inspected the property on behalf of the Coal Authority in September 2014 and before producing his first report on 29 April 2015 he had access to the Arup 2006 desk study, the 2009 draft report from Alan Baxter Associates, the Arup 2014 report, coal mining abandonment plans for the area, the Scott Schedule and a draft report of the initial investigations undertaken at Mr Richardson's suggestion early in 2015. He based his analysis substantially on the Mulpan subsidence prediction model and also referred to the Subsidence Engineers' Handbook of 1975, and to various geological and topographical maps, theses and relevant publications.

131. Mr Wilshaw's overall conclusion, from which he did not resile in two addendum reports (of 29 February and 24 April 2016), was that whilst there was unarguably evidence of past subsidence damage caused by mining activities in all four locations, and of reactivation of the Wentworth fault, any movement was of long standing and would have ceased very shortly after the cessation of mining and certainly by the early to mid-1970s. More recent settlement could not be the result of returning mine water as suggested by Arup because, in his opinion, the inundation of the former mine workings would have occurred shortly after the completion of mining operations in the vicinity and the recovery of water could reasonably be expected to have been complete by the mid-1970s. He did not believe reliance could be placed upon evidence derived from remote mine water monitoring stations and in his view the abandonment plans for the mines in the immediate vicinity of Wentworth Woodhouse gave a more reliable picture of the potential for rapid mine water recovery. It followed that none of the damage identified as current was consistent with mining subsidence, mine water rebound or fault reactivation. Mr Wilshaw was also unable to reconcile the reported damage in the mansion with the conjectured position of the known fault line, and considered that the damage to the north tower was significantly in excess of that which could be attributed to the modest ground movements predicted by the Mulpan programme at that location. Whilst the extensive and historic movement of the camellia house and the terrace wall were at least in part mining related, Mr Wilshaw did not believe that any recent movement was caused by mining.

132. For the claimants, Mr Stevenson's original report of 28 October 2015 did not respond to Mr Wilshaw's first report (we assume he had not seen or been asked to comment on it) but sought to provide a comprehensive assessment of the issues before the Tribunal by drawing on a very wide evidence base. This included the studies and reports by Arup and other experts; monitoring of three Ordnance Survey benchmarks on the site; InSAR satellite mapping results provided by NPA Fugro Ltd; crack monitoring data; a CCTV drainage survey undertaken in

2009; surface and foul water drainage records and maps; mine water recovery records from four monitoring stations at distances of between 1.8 and 3.4 km from the mansion; the Mulpan analyses; the mining related claims history; a visual assessment of the structural damage patterns and the accounts of movement contained in the witness statements of the factual witnesses.

133. Mr Stevenson also drew extensively on published technical papers and case histories of delayed ground movement due to groundwater recovery in abandoned coal fields. This literature is of relatively recent origin as the phenomenon it describes is the result of the cessation of deep mining in the UK by the 1990s. The papers referred to included studies of the South Wales, Leicestershire, North Staffordshire and Northumberland and Durham coalfields published between 1997 and 2013.

134. Mr Stevenson's thesis was that the original ground movement attributable to historic longwall coal extraction had ceased by the late 1960s, but that a new phase of ground movement has occurred between (probably) the late 1980s and the present day, which appears to be ongoing. This delayed phase of ground movement was directly related to the recovery of mine water in abandoned mine workings and to the general rebound of groundwater which had formerly been controlled by intensive pumping during the era of deep mining. The technical literature demonstrated that the return of mine water following the cessation of pumping has resulted in a generalised regional uplift in the ground in former mining areas. Mr Stevenson postulated that over the same period and for the same reasons, the presence of rising water has caused reactivation of the geological fault beneath Wentworth Woodhouse and the sporadic collapse of the remaining pillars and supports holding up the roof of the room and pillar workings in the old Parkgate coal seam. By this mechanism continuing ground movement had been experienced across the site, as could be demonstrated most clearly, he considered, by data relating to the stable block.

135. On 5 February 2016 Mr Stevenson produced a supplemental report responding to Mr Wilshaw's first report and Mr Cammack's witness statement of January 2016. He considered the Mulpan programme on which Mr Wilshaw relied as unsuited to determining the magnitude of ground movements from the Parkgate seam (the relevant parts of which were not worked by the longwall method). He noted that the relevance of the Parkgate workings to the subsidence at the camellia house was not discussed by Mr Wilshaw – a major omission in his view, as subsidence and damage across the estate during the 1980s occurred within the zones of influence of the Parkgate workings and could not be considered coincidental.

136. On 5 February 2016 Mr Stevenson also contributed a detailed commentary on mining subsidence causation and other matters which was appended to Dr Beattie's supplemental report of the same date. Dr Beattie placed reliance on this commentary and effectively adopted Mr Stevenson's views as his own.

137. Mr Wilshaw's first addendum report responded to Mr Stevenson's initial report and to his response to Mr Wilshaw. It took account of new information as by this time Mr Wilshaw had undertaken an inspection of the basement cellars in the mansion, and had received monitoring

results from Obsurvus for the period since June 2015. Mr Wilshaw dismissed the remote mine water monitoring data relied on by Mr Stevenson as there were many factors that could affect levels of recovery and no hydro-connectivity had been proven to exist between the four monitoring sites and Wentworth Woodhouse. He also considered the OS benchmark values for the first time and, after drawing attention to their potential for inaccuracy, accepted that they might be a more reliable indicator of the extent of past subsidence at the mansion than the Mulpan programme on which he had based his own conclusions. Despite this apparent concession Mr Wilshaw remained of the opinion expressed in his first report. He pointed to the absence of recent damage in part of the basement corridors, allegedly on the fault line and which had been rebuilt in 1985, together with the evidence from the InSAR, Met and Obsurvus monitoring which he considered supported the views that had been expressed in his initial report.

138. As a response to the claimants' case Mr Wilshaw's first addendum report was somewhat selective. In particular he did not address the evidence of Mr Stevenson on the principle of mine water rebound or the mechanism of the failure of roof support in the Parkgate seam which are important to the claimants' case.

139. On 18 March 2016, Mr Stevenson responded to the first addendum report of Mr Wilshaw, and to the supplementary report of Mr Richardson. He provided further detailed consideration of the proposed line of the fault and a commentary on the most recent crack monitoring by Obsurvus.

140. So stood Mr Stevenson's written evidence at the start of the hearing, but he was not finished yet. In response to statements made by Ms Rawley QC in her opening remarks (which Mr Stevenson considered to be both novel and incorrect) he produced two further short papers. On 18 April his fourth report concerned the assumed methods of mining in the Parkgate seam, a subject which had not previously been obviously contentious, while his fifth (though dated 15 April) concerned the InSAR satellite mapping data and explained the differences between himself and Mr Wilshaw on that topic.

141. On 24 April 2016, after 8 days of the hearing and immediately before Mr Stevenson was due to begin giving his oral evidence, Mr Wilshaw produced a further report responding specifically to Mr Stevenson's opinions on the precise methodology of mine working in the Parkgate seam, on modes of failure, pillar stability and subsidence estimation, and on the conclusions which could or could not be drawn from the InSAR data series. The late arrival of this substantially new material necessitated an adjournment of the hearing for two days.

142. On 26 April 2016, Mr Stevenson produced a short response to Mr Wilshaw's latest report providing further analysis of different methods of mining and their consequences, and a rebuttal of Mr Wilshaw's views on the probable mode of roof collapse and pillar stability in the Parkgate seam.

143. Finally, and in response to evidence given by Mr Wilshaw for the first time in cross examination about the potential illegality of his postulated method of working in the Parkgate seam, Mr Stevenson provided a supplementary note on 4 May 2016, after the completion of the oral evidence, which Ms Rawley was content to admit without challenge.

Observations on the expert witnesses

144. At this stage we will make some general observations on the experts. Each was extremely well qualified and we are grateful to them all for the very considerable assistance they have provided to the Tribunal.

145. Of the mining experts Mr Wilshaw had the greater practical experience, but his focus was narrower than might have been expected. His initial report relied almost entirely on the Mulpan programme, although he acknowledged its limitations. He appears not to have looked for corroborative or contrary evidence (the Ordnance Survey bench mark records, or the InSAR data). As additional evidence became available he appeared to make no critical reappraisal of his original assessment that mining related subsidence could only occur within, at most, a few years of the cessation of mining.

146. At the start of his involvement Mr Wilshaw was not assisted by limitations in the material made available to him. In particular, when he wrote his first report he does not appear to have been shown the full historic claims records kept by the Coal Authority. Nor did he make reference to these records in his second and third reports, even though by then he had seen the evidence of both Mr Cammack and Mr Stevenson. The records demonstrate that as late as 1988 a different view to Mr Wilshaw's had been taken by the NCB's engineers and accountants on continuing mining related ground movement. These views were worthy of proper consideration which they did not receive from Mr Wilshaw.

147. Mr Wilshaw did not refer to the technical literature and empirical studies describing the occurrence and consequences of mine water rebound and regional uplift which were relied on by Mr Stevenson in his first report. He appreciated the significance of this material for the claimants' case but he did not offer an opinion of his own on its relevance until he was cross-examined. His treatment of the literature was then superficial and dismissive.

148. Mr Wilshaw's evidence on the mechanism of failure of the pillars in the Parkgate seam arrived very late, on day 9 of the hearing. The subject had not originally seemed contentious and the need to address this element of the claimants' case may not have been appreciated until a late stage, but by the time its significance was appreciated Mr Wilshaw was placed in a difficult position. He had to rely either on suggestions by others or on his own eleventh hour researches into technical material with some of which he may not have been entirely familiar. His calculations on pillar strength were prepared by a colleague and Mr Wilshaw was unable comfortably to explain or defend them when cross-examined.

149. In summary, Mr Wilshaw has considerable experience and undoubted expertise, but we found him to be generally unresponsive and unwilling to take seriously the alternative views on which the claimants' case rested. Those alternative views appeared to us to deserve greater respect than Mr Wilshaw was prepared to give them.

150. Mr Stevenson was a persuasive and at times almost evangelical witness, whose command of the subject matter was impressive. He was thoughtful and careful in his written material and in his answers to questions. For example, he was rightly cautious in treating the very subtle variances in the InSAR and benchmark data as significant on their own, and provided explicit health warnings to the Tribunal over the margins of error appropriate to the readings.

151. His evidence gave the impression of having been prepared under pressure of time. That is not a criticism of Mr Stevenson, who was asked to assimilate a very large volume of material in a very short period. He told us that he produced his first report, which runs to 110 pages, within six weeks of first being instructed. To a large extent he stood on the shoulders of his Arup colleagues, who had covered much of the same ground in their 2006 desk study (which was produced eleven months after being commissioned).

152. It was also apparent to us that Mr Stevenson's analysis evolved significantly as he was writing his original report. We suspect that he had not had the luxury of being able properly to assess the many different strands of the evidence before committing himself to a conclusion favourable to the claimants. Some strands, superficially supportive of the claimants' case (such as the benchmark data) assumed prominence, while others (such as the effect of the undermining of the Parkgate seam) were given less attention than they appeared to us to demand.

153. By the time Mr Stevenson was asked to form a view of the probable causes of damage to the structures at Wentworth Woodhouse these proceedings had been underway for more than five years and had already been the subject of major hearings in the Tribunal and the Court of Appeal. The claim had been commenced on the basis of advice from Arup, Mr Stevenson's own firm for most of his professional career. The same can be said of Dr Beattie, who has been with Arup for 18 years and whose first involvement at Wentworth Woodhouse was a site visit in November 2015. We do not underestimate the difficulty of making a wholly objective assessment of the evidence likely to be experienced in such circumstances by even the most independently minded expert.

154. Mr Richardson's evidence was thorough and authoritative and his experience of diagnosing damage to historic buildings appears second to none. He acknowledged that he had no specific experience of damage caused by mining subsidence. He was therefore dependent on the views of Mr Wilshaw on certain important aspects of the case, for example the potential for the Wentworth fault to have caused damage along the line suggested by the claimants. To that extent his freedom to form his own views risked being restricted and his independence compromised. The same was true of Dr Beattie, who was invited to assume that the damage either was or was likely to have been caused by mining. Mr Richardson nevertheless provided reasons of his own why he considered that mining was not the cause of recent damage, and that

other explanations were more likely. Thus, although the scope of his evidence was somewhat curtailed by his instructions, we were nevertheless greatly assisted by his views.

155. Dr Beattie was an experienced, thoughtful and careful witness, but his contribution appears to have been hampered by his instructions. His initial report was simply a resume of previous Arup studies while his second more substantial contribution deferred to a surprising degree to the views of Mr Stevenson on matters which we would have thought were more comfortably within his own expertise, such as the potential mechanisms of failure of the south terrace wall. In other respects his written evidence was at a high level of generality which failed to distinguish usefully between historic and more recent, relevant, damage and deterioration. Once again we think this was probably a reflection of his brief, as it was obvious from his oral evidence that he had a very thorough command of the subject matter of the dispute and was extremely well qualified to assist the Tribunal.

Mine water rebound

156. As we have outlined, Mr Stevenson attributed the ground movement and structural damage reported at Wentworth Woodhouse since 1999 to the collapse of previously stable workings, especially in the Parkgate seam, and the reactivation of the geological fault beneath the mansion, in each case as a result of several phases of significant mine water rebound since the general cessation of mining in the 1980s and 1990s.

157. It was common ground that rising mine water can disturb old mine workings and result in ground movement, subsidence and structural damage, although the severity of these residual effects was in dispute. The timing of mine water rebound in the locality of Wentworth Woodhouse was also very much in issue.

Mine water rebound in the South Yorkshire Coalfield

158. The expressions “mine water” and “groundwater” have been used interchangeably in the evidence. At some points a distinction was introduced between water present within the voids, tunnels and shafts of disused workings themselves and liable to be polluted, termed mine water, and groundwater, meaning the water naturally present in the spaces, cavities and pores within soil and rock.

159. When a mine is worked below the natural level of the water table it is necessary to remove water from the workings and the area around them in order to prevent these from flooding. This is done by redirecting the water to other underground workings or pumping it to the surface. This process continued for centuries while active mining took place in British coalfields. When such pumping ceases water is liable to return over a period of time to its previous level. The restoration of water to its former level in the ground after the cessation of pumping is referred to as “mine water rebound.”

160. In 2005 a report entitled *An Overview of Minewater Rebound in the South Yorkshire Coalfield* was published by the Environment Agency. Its authors, Sean Burke and John Barber, acknowledged the assistance they had received from the Coal Authority in providing data on mine water levels. It has not been suggested that the account they gave of the management of mine water levels in South Yorkshire was materially inaccurate.

161. The coal bearing strata of the South Yorkshire coalfield dip to the east, so that the shallower reserves are in the west and the deeper in the east. Mining was originally undertaken using drifts or shallow pits where the productive Barnsley seam outcrops at the surface between Sheffield and the area west of Barnsley. With the industrial revolution, steam powered pumps enabled access to deeper coal reserves and between 1795 and 1840 three steam pumps were installed to serve the Fitzwilliam's own collieries in the neighbourhood of Wentworth Woodhouse.

162. The progressive closure of exhausted or uneconomic shallow mines in the west threatened the recovery of mine water levels and necessitated more coordinated action to protect the new, deeper "down-dip" workings to the east from inundation. In 1918 the owners of 15 threatened collieries formed the South Yorkshire Pumping Association which agreed to take over the Fitzwilliam pumping stations and drainage system. In 1929 the Association achieved official recognition as a mine drainage committee under the Mining Industry Act 1920 and remained responsible for mine water management until nationalisation in 1947.

163. The South Yorkshire mine drainage scheme made use of new and existing pumps in a network of strategic pumping stations. Some of these locations are now used as monitoring stations, at which the level of mine water is measured, but the closure of 73 collieries in the 1980s and 1990s rendered the pumping network largely redundant. By 1985 only 19 pumping stations on the perimeter of the coalfield were still functioning, while by 2005 only Maltby, Rossington and Car House pumping stations remained in operation to protect the last few deep pits in the east (all of which have since been closed).

164. As a result of the cessation of most pumping Burke and Barber reported in 2005 that mine water levels had recovered significantly; levels in the shallow collieries in the west which included those around Wentworth had almost fully recovered and presented a risk to river water quality.

Hydrological connectivity

165. The South Yorkshire coalfield contains large areas of connected underground workings, with networks of open roadways through which water may pass freely and other areas of collapsed goaf or fractured ground where transmission will occur at a slower pace. These connections effectively create large "ponds" undergoing generally simultaneous mine water rebound. The boundaries of the ponds are defined in some locations by geological faults. The rate of rebound across the whole coalfield is dependent on the extent of connectivity between

these ponds. It is clear from the studies relied on by Mr Stevenson that recovery of mine water to its former pre-mining levels is a slow process, taking many years or decades to complete.

166. Mr Stevenson produced a hydrogeological map of the area around Wentworth prepared by his firm in 1998 (presumably in connection with its investigation of damage to the Hooper Reservoir, a little to the north east of the estate). Its main focus is on the area to the north of the Wentworth fault, towards the reservoir. It indicates that the dip of the worked strata is towards the east and that drainage generally takes place from west to east.

167. The abandonment plans for the worked coal seams show various vertical shafts connecting different mining horizons. There are also known to be tunnels connecting workings on each side of the fault line. In the early 1960s two such tunnels were driven between workings in the Lidgett and Swallow Wood seams on opposite sides of the fault at a depth of between 60m and 95m below the surface. These run between the mansion and the stable block and connect longwall workings extending beneath the formal gardens on the west side of the mansion with similar workings to the south, directly below the terrace wall.

Mine water rebound data

168. The recovery of mine water has been monitored by the Coal Authority since 1989 at four locations in relatively close proximity to Wentworth Woodhouse, and the data was in evidence before us. Each of the locations is a disused shaft or pumping station. These lie to the south west (Thorpe Hesley, for which data is available from 1992 to 2013), to the west (Skiers Spring – 1992 to 2015), to the east (Warren House – 2001 to 2015), and to the north (Hemmingfield – 1995 to 2013). Each pumping station is at a distance from the mansion of between 1.8km and 3.4km.

169. Mine water levels have risen at each of these monitoring points, in some cases very significantly, since the collection of data began. Levels are expressed in metres AOD (meaning “above ordnance datum” or above sea level).

170. The greatest increase has been recorded at Skiers Spring to the west, where mine water has recovered from -130m AOD in 1992 to 50m AOD in 2015, a rise of 180m over a period of 23 years. The most rapid part of this increase, of about 160m, occurred between 1992 and 2001.

171. At Thorpe Hesley to the south west recovery was also rapid from 1992 to 2001 before levelling out. During that period the mine water had rebounded by approximately 100m from a starting point of -60m AOD. By the end of 1994 the levels of water measured at Thorpe Hesley and Skiers Spring were more or less equal and thereafter they rose, and occasionally fell back slightly, in tandem.

172. The availability of data from the Hemingfield shaft begins in 1995, by which time mine water had already risen to approximately 10 to 20m AOD. After 1997 water levels were broadly similar to those at Thorpe Hesley and Skiers Spring. At the Warren House shaft the available data was first collected in 2001, at which time mine water levels were recorded as being significantly lower than at the stations to the north and west. At about the end of 2005 mine water began to recover steeply, by 60m in 12 months, and by early 2007 it had reached similar levels to those measured at the other three locations. During the period of this rapid rebound the levels of water in at least two of the other three shafts also moved distinctly upwards.

173. Mr Stevenson plotted the approximate levels of five of the coal seams on a chart showing the rising mine water at the four measuring stations. This demonstrated that the deepest seam, Silkstone, would already have been flooded by the time the data set began in 1992, as would the Thorncliffe and Parkgate seams above it. Precisely when the water level reached the Parkgate workings is not established. The data is not inconsistent with that having occurred either in the late 1980s or early 1990s as Mr Stevenson believed, or in the 1970s as Mr Wilshaw thought. The shallower Lidgett and Swallow Wood seams appear to have been reached by about the millennium.

Rebound and connectivity in the vicinity of Wentworth Woodhouse

174. Basing himself on the data from the Coal Authority's four measuring stations, Mr Stevenson postulated three distinct phases of mine water recovery. The first phase had begun before 1992 when records first become available, and lasted until 2003, and was most clearly demonstrated by the Thorpe Hesley and Skiers Spring data, which showed a rise in ground water levels of in excess of 160m. The second intermediate phase, from late 2005 to 2007, was apparent in all four locations but most pronounced at Warren House which caught up with a rise of 60m. Mr Stevenson also detected a third lesser phase of recovery, from late 2011 to 2015 with an additional rise of about 20m which may be continuing.

175. Although the data was incomplete, the pattern of convergence of water levels in all four locations indicated to Mr Stevenson that drainage was indeed occurring towards the east, from higher water levels in the west, and that there was a high degree of connectivity across the area. He considered that the data reflected a reduction in the former complexity of drainage paths across the district as mine water pumping gradually ceased and water levels rose above the levels of the worked out coal seams.

176. Mr Wilshaw took a different view. He considered that hydrological connectivity was not demonstrated across the district as a whole and that the data collected from shafts as close as between 1.8km and 3.4km could not be relied on as indicating the probable extent of mine water recovery in the locality of the damaged structures. Pumping in the Thorncliffe seam would have ceased on its abandonment in 1967 and Mr Wilshaw thought that by shortly after that date mine water recovery would have begun at Wentworth Woodhouse. He considered that pumping in the Lidgett seam would have ended between the cessation of mining in 1964 and the final abandonment of the seam in 1973. He based his opinion on his extensive experience of local

variances in mine water recovery, which prompted him to rely on site specific information, and also on the abandonment plans on which some areas were described as “water logged” and which showed a substantial amount of water management being undertaken (including the pumping of water down to the Parkgate seam from the Lidgett seam).

177. Mr Wilshaw therefore considered that mine water recovery had begun in the deepest seams during the 1960s and would have progressed rapidly to completion by about the mid-1970s. As a result any residual ground movement caused by the inundation of abandoned workings would have been complete by the late 1970s.

178. While we acknowledge the difficulties of assessment in the light of incomplete information, we have no doubt that the evidence of Mr Stevenson is to be preferred on this aspect of the case.

179. Mr Wilshaw’s original evidence took no account of the mine water monitoring data collected by the Coal Authority itself (although it was available to him and he mentioned its existence in his first report). His view appears to us to be entirely inconsistent with the pattern of convergence of water levels in all four monitoring locations. We find it impossible to accept that the records of ground water derived from shafts in such close proximity and surrounding Wentworth Woodhouse are irrelevant, or that a high degree of connectivity is not demonstrated across the site for the reasons relied on by Mr Stevenson. Mr Wilshaw’s indifference to this data was surprising and it did not seem to us that, when he did consider it, he did so with an open mind.

180. Mr Wilshaw’s chronology is also inconsistent with the general picture presented by the 2005 Environment Agency report which, despite its regional focus, contains no indication that significant mine water recovery had commenced by the late 1960s when mining continued across South Yorkshire. A similar Environment Agency report published in 1999 implied that mine water rebound was a relatively recent phenomenon in South Yorkshire, describing it as “underway”.

181. Mr Wilshaw’s view does not explain how deeper workings in the same seams of coal to the east would be protected from flooding if the shallower exhausted mines had been allowed to flood decades earlier. The Parkgate seam was worked until 1985 at Cortonwood colliery only a few miles to the northeast, where it is 200m deeper than at Wentworth, and water would naturally have migrated down dip towards it if allowed to rebound entirely in the abandoned workings. Several drainage connections and tunnels between Cortonwood and the workings from Elsecar are shown on the Arup hydrogeological map.

182. We also regard it as significant that Mr Wilshaw’s evidence that pumping in the immediate locality of Wentworth Woodhouse would have ceased shortly after the end of mining in each seam was conjectural. No NCB pumping records or other factual evidence concerning the management of mine water and the cessation of strategic pumping was adduced by the Coal Authority to assist us in understanding the monitoring data it made available. It is clear from the

2005 report that such records must then have been available but Mr Wilshaw had no access to them.

Regional uplift

183. The occurrence and effect of mine water rebound is not localised. In a 2008 paper published by the British Geological Survey (*Longwall mining-induced fault reactivation and delayed subsidence ground movement* by L.J. Donnelly) there was said then to exist sufficient borehole monitoring and observation evidence to conclude that there was a general condition of regional recovery of the ground water levels in the British coalfields.

184. One consequence of this general recovery of ground water levels has been a gradual rise or uplift in the surface of the ground over former coalfields. A 2006 study of the Staffordshire coalfield using InSAR satellite ground monitoring data for the period 1992 to 2004 observed that continuing subsidence was apparent in the southern area of the coalfield, where mining had ended in 1998, while in the northern area, where mining had ceased much earlier, a general uplift of the ground was detectable. A similar study of the Northumberland coalfield from 1995 to 2008 (*Monitoring post-closure large scale surface deformation in mining areas* by C. Banton and others) showed a similar pattern in the early years of monitoring (with discrete areas of subsidence in districts where mining had most recently ceased, but areas of uplift elsewhere) but a more general uplift towards the end of the study period. When uplift rates were compared to mine water monitoring levels a relationship was demonstrated. On average the surface of the ground in affected areas underwent uplift by 0.7mm for every 1m rise in mine water levels.

185. Mr Stevenson explained the mechanical processes by which recovering water levels may cause additional movement after the cessation of mining, including a general uplifting of the surface of the ground. His explanation was not contested by Mr Wilshaw. The saturation of the ground due to a rise in groundwater levels increases the pore pressure within the rock mass. The water acts to resist the compressive effect of external pressure and pushes the grains of the rock apart. The result is a weakening of the rock and a change in the stresses within the rock mass. Where the rock mass, or overburden, has already been fractured and broken due to collapses caused by successive phases of long wall mining, additional residual settlement may occur.

186. The study of regional changes in ground levels makes use of the satellite mapping technology known as interferometric synthetic aperture radar or InSAR, to which we have already alluded. This technique is designed to record differences over time in the levels of points on a hard structure such as the roof of a building. Electromagnetic waves are projected on to the surface of the earth by the InSAR satellite orbiting at 780km and are reflected back to the satellite from hard surfaces. The orbit of the satellite brings it over the same point once in about every thirty-five days when the same monitoring process is repeated. On each occasion on which the satellite passes overhead the phasing of the wavelength returning to the satellite is measured. By comparing the measurements returned from the same points on a structure

(referred to as persistent scatter points, or PSP) a relatively precise measurement is able to be made of the level of those points at different times.

187. By taking measurements on a wide spread of hard surfaces across a large area the InSAR technique can also assist in understanding regional changes in surface levels, as well as assessing movement in individual structures.

188. InSAR data is available for an area of 25 km² centred on Wentworth Woodhouse. The data for all hard structures in that region was presented in a colour coded form on an aerial photograph of the region (a “motion map”) on which areas of subsidence were shown in red and areas of uplift, or vertical movement, in blue, with areas of minimal movement (of +0.5 to -0.5mm per year) in green. As Wentworth Woodhouse sits in the centre of its own very extensive park, in which there are relatively few significant buildings other than the house and the stable block, the motion map centred on the house is largely an expanse of uninformative grey, with zones of colour confined to the centre and extremities. The 25 km² region shown on the map was categorised by NPA (the firm which processed the data) into four “motion domains”. Significant uplift was indicated in the north-west, possibly extending to the south of Wentworth Woodhouse; significant subsidence extended northwards from the stables; a mixture of stable and subsiding data points existed to the south-west; and a mixture of stable and uplifting data points were displayed to the south-east.

189. None of the studies we were shown on the effects of mine water rebound in inducing regional uplift in abandoned coalfields was specifically directed at South Yorkshire, but the phenomenon is demonstrated across each of the former mining areas which have been studied, most recently in South Wales. It is also suggested by the InSAR motion map which indicates a significant general area of uplift to the north-west of the estate.

190. Although the ground in a former mining region may undergo a general uplift, the pattern is not always uniform. Banton’s Northumberland study examined the InSAR data at a local level and detected a correlation between variances in ground movement patterns and the boundaries of geological faults. An area undergoing uplift on one side of a fault line might be adjacent to an area experiencing residual subsidence on the other side of the same fault.

191. The existence of a generalised state of uplift in the level of the surface caused by returning groundwater may also exist alongside a more localised experience of subsidence caused by specific changes in the supporting ground which may themselves be related to rising water levels. For example, the recovery of water may set up episodic movements around a fault line, or cause the collapse of previously stable workings, whilst at the same time inducing greater buoyancy in the overburden. Measured over a period of time the combined effect of vertical movements in opposite directions will result in a net movement, which may be either up or down. The result may be net subsidence or net uplift, or even, if the opposite movements are of comparable magnitude, an impression of net stability. It was just such a state of apparent net stability which Mr Stevenson considered existed at Wentworth Woodhouse.

192. In his written evidence Mr Wilshaw did not express a view on the topic of regional uplift which features significantly in Mr Stephenson's analysis. In her closing submissions Miss Rawley acknowledged that the phenomenon is well known. In cross examination Mr Wilshaw agreed in principle that regional uplift could occur and probably was occurring in South Yorkshire. At the terrace wall and the camellia house, for which no InSAR data was available but which had been undermined, and at the stable block, which had been undermined and where subsidence had occurred, Mr Wilshaw considered that uplift could also have occurred. But he categorically ruled out the possibility of uplift having occurred at the mansion itself because it had not been directly undermined.

193. We found Mr Wilshaw's evidence on this aspect of the case unpersuasive, and not just because it was articulated for the first time in cross examination. His initial hypothesis that the general phenomenon of regional uplift categorically could not affect a property which had not directly been undermined was not derived from or supported by any of the technical papers on the subject. In its initial form it did not long survive examination before being modified to acknowledge that structures within the zone of influence of underground workings might also be affected by regional uplift. In either of its forms Mr Wilshaw's hypothesis seemed to us difficult to reconcile with what we understood to be the uncontested proposition that a general (and not localised) reduction in the water table was essential to permit deep mining and that on its cessation a generalised recovery of the former ground water levels would have occurred.

194. Nevertheless, it is striking that the InSAR motion map for the wider area around Wentworth Woodhouse for the period 1992 to 2001 shows no evidence of generalised uplift in the village of Wentworth which, like the mansion, had not been directly undermined. Some structures further to the west and south west are shown strongly in blue, indicating an average annual motion rate of 5mm upwards; the stable block and surrounding areas are bright red, indicating subsidence; but the village itself, and the mansion, both of which were protected from underground workings in their immediate vicinity, are shown in green, suggesting little or no net movement.

195. One troubling aspect of the evidence on regional uplift is that Mr Wilshaw's hypothesis (that a structure which had not been directly undermined would be left unaffected by it), did not form part of his written material and was therefore not put distinctly to Mr Stevenson in cross examination. Nevertheless, in answer to questions about the InSAR motion map for the 1990s Mr Stevenson interpreted the colour gradients from red, to green to blue as indicating a situation at the mansion and the village in which the regional uplift apparent further west and east was counteracted by localised settlement within the angle of draw of the most proximate workings; this was the opposite of Mr Wilshaw's modified hypothesis which considered that greater uplift would be experienced where mining had been most intense. When he was asked about the significance of the mansion sitting on an island of un-mined ground Mr Stevenson explained that he regarded the average annual rate of movement of the mansion up or down as of less significance than the effect of strain on those parts of the structures within the angle of draw of the workings.

196. The only InSAR data presented in the form of a regional motion map was for the period 1992 to 2001 and so covers most of the first phase of rapid mine water recovery which Mr Stevenson considered to have taken place. No comparable mapping of the data collected after 2001 was available. We consider that the earlier data shows a state of subsidence to have existed in the area of the stable block during the 1990s; away from that epicentre the mansion and Wentworth village exhibit no net subsidence over the same period; rippling further out, to the west and north west, but also apparent on the few structures providing readings to the south and east, areas of distinct uplift in the surface of the ground are encountered; beyond these, further to the south and east, in areas where Mr Stevenson told us geological conditions were different, a condition of net stability is again apparent.

197. We therefore consider that this regional picture is consistent with Mr Stevenson's hypothesis (from which Mr Wilshaw did not generally dissent) that a state of regional uplift is likely to exist in this part of South Yorkshire and that the apparent stability at the mansion must be understood in that context. We find that on average there was little or no net subsidence at the mansion between 1992 and 2001, but that the stable block, which had been undermined only by the Parkgate seam, was sinking, while other structures in the district at a little distance to the north-west were rising as the general level of the ground uplifted. The more localised 2001 to 2010 data (to which we will come later), although not presented in the same way, does not suggest any net change at the mansion. It cannot be ruled out that during this period the mansion was experiencing both the effects of this general uplift in the district and the effects of subsidence of the ground in its more immediate vicinity, with these movements combining to give a misleading impression of net stability. But equally, from the InSAR data alone, it cannot be excluded that, in common with the areas to the south, the mansion was generally stable and experiencing no vertical movement.

198. We agree with the submission of Ms Rawley QC on behalf of the Coal Authority that it would be surprising if the mansion had moved vertically down, while the district had risen by an equal amount, so that real movement was disguised and difficult to measure. But Mr Stevenson attributed the relatively recent damage at the mansion more to the effect of lateral movement in the ground within the angle of draw of the adjoining workings to the east and north (strain) rather than to vertical movement (subsidence) which is indicated at the stable block.

199. Mr Stevenson was persuasive that the totality of the evidence should be read as he suggests and we give weight to his expertise. As he emphasised, however, the detection of regional ground movements is simply one amongst a number of observations and data sets which must be assessed in their totality before a final conclusion can be reached on the cause of damage.

Fault reactivation

200. A second potential consequence of the recovery of water levels in the ground as result of the cessation of pumping is the reactivation of geological faults, such as the Wentworth fault which runs beneath the mansion.

201. For over 150 years instances have been observed and documented in the UK and elsewhere of the reactivation of faults in areas undergoing subsidence during and immediately after the extraction phase of longwall coal mining. The duration of such fault reactivation is generally thought to extend for up to two years after mining has concluded, and it can cause severe damage to built structures and landscape. More recently, however, in parts of the abandoned coalfields of the UK relatively smaller ground movements have been observed in the vicinity of fault outcrops many years after mining has ceased. A number of recent case studies point towards a connection between groundwater or mine water rebound and these post-mining ground movements around fault outcrops.

202. Although often described in the studies we have seen as “not fully understood”, the putative mechanism of groundwater related fault reactivation is the increase in pore water pressure within the rock in a fault zone which, it is thought, can lower the effective stress across the fault and lead to an increased chance of the ground on either side of the fault line slipping or shearing. One study of a geological fault intersecting a disused military airfield in the Lancashire coalfield identified spasmodic ground movements related to pulses of very high pore water pressure rather than a gradual or continuous process of further movement. Documented features associated with these ground movements include subsidence, and the formation of fissures, humps, steps or scarps in the ground in the vicinity of faults.

203. The precise duration of such movements associated with delayed fault reactivation is impossible to determine but these have been observed in the South Wales coalfield 10 years after the cessation of mining, while in north Staffordshire subtle movements have continued for over 15 years since mining ceased. In the Northumberland village of Ryhope, where the local colliery closed in 1966, rapid subsidence of as much as 21mm per year was experienced between 1995 and 2000. In Donnelly’s 2008 paper it was noted that most faults which had reactivated were now stable.

204. Somewhat surprisingly, given the availability of this body of technical literature, Mr Wilshaw said in his written evidence that he was not aware of the recovery of mine water ever causing further movement of a geological fault. He did not refer to the literature, but listed a number of faults in North Staffordshire where no movement had been experienced during the mine water recovery period. That state of knowledge, combined with his understanding of the chronology of pumping in the district, contributed to his assessment that any settlement attributable to the inundation of the worked seams would have been complete at Wentworth Woodhouse by the late 1970s.

205. We prefer Mr Stevenson’s view about the potential for the recovery of ground water in the vicinity of the fault to have caused its reactivation, which derives support from the technical literature. If reactivation did occur it would be liable to cause damage along the fault line in the mansion, such as was observed to have occurred in the cellar passageway rebuilt in 1985.

The claimants’ case on the causation of damage

206. The Claimants' primary case on the causation of damage to the structures at Wentworth Woodhouse is based on assumptions made about the mode of mining in the Parkgate seam and the subsequent behaviour of the abandoned workings at a depth of about 200 metres below the surface. As we have already described, this seam was mined in the 1920s immediately beneath the stable block, to the north and east of the mansion, and beneath the terrace wall and the camellia house. The mining was by relatively cautious partial extraction methods, mostly the room and pillar technique, except beneath the camellia house where the even more conservative pillar and stall approach was used. As previously described, relatively narrow panels of coal were removed leaving pillars separating each of the long rooms mined into the seam; the excavated rooms and the remaining pillars were each about 20 to 22 metres wide. Mr Stevenson surmised that these methods would have caused no collapse, or certainly no total collapse, of the roof of the workings at the time of mining and that any resulting subsidence at the surface at that time would have been moderate or minimal.

207. When they were abandoned, the Parkgate workings would therefore have been a series of largely open voids, separated by supporting pillars, with some loosely compacted debris in areas where the roof had weakened and some rocks had fallen. Above these rock falls natural arches would have formed at a distance of not more than about 20 metres which would have continued to support the overburden. Because they did not collapse to any substantial degree during or immediately after the active mining phase, these Parkgate workings would have retained the capacity for further collapse in future if either the passage of time or some specific set of circumstances precipitated a change in their condition.

208. Mr Stevenson considered that a significant change did occur deep below ground as a result of the successive phases of mine water rebound, beginning by the early 1990s, as we have already discussed. The effect of the inundation of the Parkgate seam would have been to weaken the roof rocks and the remaining pillars of coal. As the incoming water filled the interstitial pores within the coal and the rock the capacity of the coal pillars to resist the downwards pressure of the overburden would have been reduced and failure of the pillars would have become likely. The supporting pillars would have been pushed down into the softer seatearth beneath them. The result would have been roof collapse which caused subsidence and strain in the ground immediately above the workings and within a wider zone of influence at surface level.

209. Mr Stevenson believed that this process is likely to have occurred over the last twenty five years or so in the Parkgate workings beneath the stable block and the terrace wall and close to the mansion. The process of collapse and subsidence of the ground due to gradual mine water rebound is likely to have been sporadic and much more prolonged than the immediate controlled collapse of the roof where the longwall mining technique is employed. The inundation of water would have caused the coal and rock to become increasingly weaker and the supports to fail at unpredictable intervals.

210. Thus, Mr Stevenson considered that, unlike in areas worked by longwall methods, the complete convergence of the worked out stratum was delayed in the Parkgate seam and

occurred progressively from the 1990s onwards, rather than having been completed many decades earlier.

211. It is fair to say, as Ms Rawley QC submitted in closing, that Mr Stevenson's thinking on the mechanisms, extent and timing of the collapse of the Parkgate workings evolved through his various reports. Nevertheless, he always posited that, after the extraction phase, the Parkgate seam retained the capacity to cause further vertical or horizontal movement of the ground at the surface and that such movement was precipitated by mine water rebound. He also considered that regional uplift was occurring in and around the Wentworth Woodhouse estate. A general increase in the level of the ground above and in the vicinity of previous mining, as has been shown to have occurred in other abandoned coalfields, led to upwards ground movement at the surface and further strain in the ground. As with the weakening of roof rocks and underground pillar supports, the process of uplift is believed by Mr Stevenson to have been gradual, continuing over a substantial period of time and to have contributed towards the physical damage in the structures which is now apparent.

212. A secondary element of the claimants' case, also related to mine water rebound but not so heavily dependent on the condition of the Parkgate seam, is that damage was caused along the line of the fault which had been reactivated long after the cessation of mining.

Mode of working in the Parkgate seam

213. Both experts were subject to detailed cross-examination on the probable mode of working of the Parkgate seam to the east of the mansion in the pre-mechanised working conditions of the 1920s. This is an important topic but it was one which emerged in detail only at a late stage of the exchange of evidence, and on which each expert gave new evidence from the witness box. It is a subject on which it is naturally impossible for either expert to give evidence based on personal experience, and neither professed any special expertise in the history of mine working in the 1920s. We were shown the Coal Mines Act 1911 which, by section 50(1), required that the roof under which any work of getting coal was carried on was to be "systematically and adequately supported". But we were shown no historic study of mining techniques in the 1920s and no contemporary manual of mining engineering (which must surely have existed and be available). Each expert had a detailed theory of how the seam is likely to have been worked, but much of the evidence amounted only to informed speculation.

214. The rival positions of the experts were as follows.

215. Mr Stevenson postulated that across the 20-22 metre width of the coal faces in the Parkgate room and pillar workings the roof would have been well supported by pit props to protect the miners (between four and six in the room) from the risk of a collapse. As the face advanced some of those props might be removed to be reused further forward, but some would remain in position to provide a degree of continuing support. Access to the panel would be by routes which were themselves well supported and protected from collapse by timber props. The essential feature of this mode of working was that the roof of the mine would not totally

collapse as the panel advanced during mining and would be left supported to some extent by the pillars of coal and props when the miners moved on to another panel. A partial collapse or deformation of the roof at the time of mining was possible, Mr Stevenson considered, but where it occurred a natural arch would form at a relatively short distance above the previous level of the roof, and there would be no “convergence” or wholesale collapse of the roof to the floor.

216. Mr Wilshaw envisaged the workings differently. His arrangement was modelled on longwall workings and involved the formation of two parallel roadways down the sides of the room as it was dug out. These provided separate means of access and escape (which was a requirement of mining regulations where more than ten miners were working in a location, which Mr Wilshaw considered would be the case in each Parkgate room) and also enabled fresh air to circulate to the working face of the panel. The roadways would have been propped and protected by the creation of stone “packs” separating them from the central area, but that central section of the room would not have been protected from collapse, except at the coal face itself. Mr Wilshaw considered that the roadways and the stone packs would each have been about 2 metres wide, making 8 metres of supported area in total, there being two roadways and two packs, and leaving a 12 to 14 metre span of unsupported roof down the centre of the room. The packs were formed of rough stone retained on both sides by timber shuttering and would be constructed by hand from stone available within the mine itself.

217. As with longwall mining, the principle on which Mr Wilshaw’s system operated was that the central part of the roof of the room would collapse substantially to the floor as work progressed. The effects of the collapse would be experienced at the surface within a relatively short time of the coal being extracted. Consistently with this hypothesis Mr Wilshaw had originally included the Parkgate seam in his Mulpan assessment of the extent of subsidence at the surface.

218. We could see the logic of both systems and the drawbacks which each expert pointed out in the model proposed by the other. The quantity of props required by Mr Stevenson’s system was considerable, and the means by which fresh air would reach the miners at the coal face was not apparent. In Mr Wilshaw’s scheme a huge quantity of stone and timber shuttering would be required, far more than in any longwall system because of the number of individual rooms requiring protection; Mr Wilshaw also assumed an improbably large number of miners would be working at the face and elsewhere in the room; this cast doubt on his reliance on the need to comply with statutory requirements for separate access and egress, which had been the original justification for his assumed arrangements.

219. Despite the uncertainties left by the expert evidence, we have concluded that Mr Stevenson’s hypothesis on the mode of working in the Parkgate seam is more likely to be correct.

220. Our principal reason is that, as we understand it, the main purpose of adopting a conservative style of mining in the vicinity of the mansion was to protect the largest house in England, the ancestral seat of the mine owners themselves, from damage caused by surface

subsidence. Longwall techniques were employed in other parts of the Parkgate seam beneath the Park at or about the same time, but no risks appear to have been taken with the mansion itself (or with the neighbouring village of Wentworth where, we assume, the miners lived in houses provided by the Earl). The stable block, terrace wall and camellia house were afforded somewhat less protection but we cannot believe that mining was undertaken beneath those structures in the expectation that they would experience significant subsidence in its immediate aftermath. The camellia house is a delicate structure and the stables were the largest in private ownership in England. We are confident that the room and pillar, and pillar and stall, workings which were undertaken in the 1920s and 1930s would have been designed on the assumption that significant subsidence could be avoided by the use of those partial extraction techniques.

221. There is a second reason to favour Mr Stevenson's approach, but we are cautious about placing too much reliance on it. It is that the InSAR data provides evidence of subsidence having occurred in the 1990s at the stable block, which was directly undermined only by the Parkgate seam. Data for four locations on the stable block indicated a pronounced net downward movement of about 100mm between 1992 and 2006, followed by a lesser reduction of about 10mm from 2006 to 2008. The benchmark data suggested a comparable degree of subsidence between 1963 and 2008 (although the last mining directly below the stables was in the 1920s). Mr Wilshaw agreed that the InSAR data indicated that the stable block had undergone further subsidence and acknowledged that in the absence of any alternative cause this was suggestive of a further settlement of the overburden into the Parkgate seam after 1992.

222. There may be three reasons why subsidence was still possible at the stable block in the 1990s, so long after the cessation of mining in the Parkgate seam. The first is supportive of Mr Stevenson's hypothesis and is that at the time they were abandoned the roof of the workings was substantially intact and the rooms remained largely open, rather than being filled by compacted goaf, so that the potential for further convergence still existed. Alternatively, the further settlement may have been attributable to ground movement along the line of the Wentworth fault running through the southern side of the stable block which may have been reactivated by rising mine water, rather than to any recent convergence of the worked out seam. Thirdly, the settlement may have had some other explanation, unrelated to mining, which has not yet been identified because the main focus of the investigation has been on the specific areas elsewhere.

223. We give little weight to the third of these potential explanations. It has been apparent to the Coal Authority since it received Mr Stevenson's first report that he drew inferences about the behaviour of the Parkgate seam from his study of the stable block; the opportunity was always available to the Coal Authority to rebut those inferences by investigating that structure in greater detail to identify any alternative explanations for subsidence. It has chosen instead to ignore it. The level of the stable block benchmark (to which we will come) also provides an independent corroboration of the picture provided by the InSAR data.

224. We also doubt the second explanation. It was not suggested either by Mr Wilshaw or by Mr Stevenson, nor would it account for the subsidence recorded at the stable block benchmark,

which is well away from the line of the fault on the north side of this very large building (only two of the InSAR scatter points appear to be on the southern side of the building).

225. Our relative lack of knowledge of the stable block discourages us from forming conclusions which are wholly dependent on findings about its condition and behaviour; it does, however provide support for our primary conclusion. We therefore consider that in the absence of an alternative explanation, as Mr Wilshaw agreed, the evidence of marked subsidence at the stable block during the 1990s is indicative of a further settlement of the overburden into the Parkgate seam at that time. For that to have been possible it is much more likely that the Parkgate seam was worked in the manner described by Mr Stevenson, and that it had not experienced the more or less total collapse at the time of working in the 1920s which was contemplated by Mr Wilshaw.

226. We have therefore concluded, agreeing with Mr Stevenson's hypothesis, that at the time the Parkgate seam was worked and abandoned in the 1920s and 1930s the roof would not have converged with the floor and there would have remained the potential for a later collapse to cause further damage at the surface. But that finding is not enough by itself to justify the conclusion that the Parkgate seam retained its potential for further collapse as late as the 1990s when Mr Stevenson's first and most rapid phase of mine water recovery was underway. It is first necessary to consider what is likely to have occurred in the seam between the 1930s and the 1990s.

The behaviour of the Parkgate seam after its abandonment

227. The mine water recovery data suggests that the Parkgate workings to the south of the fault, including beneath the terrace wall, would have been fully submerged by the late 1980s while those to the north of the fault would have been inundated by 1992 or 1993. It is the condition of the workings at that time which is most material, and not the condition in which they had been left 50 to 70 years earlier. Something may have occurred to precipitate the collapse of the workings long before they became inundated by rising water. The Coal Authority argued that the single greatest flaw in Mr Stevenson's theory was that it overlooked the impact on the Parkgate workings of the mining of other seams immediately beneath them which it considers would have had a devastating impact on Parkgate stability.

228. The table at paragraph 47 above records the relative depths of the seven seams of coal mined at Wentworth, and by overlaying the seam abandonment plans the relationship between the various seams can be understood. Directly under the Parkgate seam, to the north-east and east of the mansion and at a total depth of about 250 metres (and so only about 25 metres below Parkgate) lies the Thorncliffe seam which was worked in 1948. In 1963-64 the Silkstone seam (at about 300 metres in depth) was also worked in substantially the same location. Mining beneath the terrace wall was undertaken in the Parkgate seam in 1939 and later in the Thorncliffe seam below it. Only beneath the stable block were the workings in the Parkgate seam not directly undermined by later workings; in that general area the Thorncliffe and Silkstone seams infringed on the area directly below Parkgate only to a modest extent, to the north of the stable block at a distance of about 60 metres in the Thorncliffe seam and about 100

metres in the Silkstone. The stable block Parkgate workings were thus within the angle of draw of the lower seams but not within the area most likely to be directly affected.

229. Both the Thorncliffe and the Silkstone seams were worked by the modern total extraction longwall method of mining. A much longer coal face was held up by hydraulic jacks during mining, but as the face advanced the jacks were deliberately removed, progressively bringing about a controlled total collapse of the roof. The space formerly occupied by the stratum of coal and its associated softer layers, all of which had been extracted, was now occupied by the goaf.

230. Mr Stevenson devoted a section of his first report to a discussion of engineering geological principles. He explained that the effect of mining is to change the stress regime within the rock mass above the workings, eventually achieving a state of equilibrium and locking in a new pattern of stresses. The compressive stresses created around the edges of the supporting pillars in the Parkgate seam would have been very high, due to the downward pressure of the overburden at such significant depths (over 200 metres). Mr Stevenson also referred to a standard mining industry publication (CIRIA SP32) which suggested that a ratio of pillar width to depth of seam of greater than 0.1 was advisable to maintain stability. He calculated that in the Parkgate seam the average pillar width of 20 metres at depths of the order of 215 metres or more failed to provide this level of protection, and described all of the Parkgate pillars as susceptible to crushing.

231. In his original report Mr Stevenson suggested two specific events which might have disturbed the equilibrium achieved at the time of mining, namely the saturation of the workings by rising mine water (possibly many decades later) or the undermining of the pillars by later longwall workings as occurred in the 1960s. Either of those events could cause significant changes to the stress regime which was “only just in equilibrium”. In his report of 24 April 2016 Mr Stevenson also said of the Parkgate pillars that “these pillars would have been severely fractured and broken” because of “the totally collapsing roof rocks above the underlying Thorncliffe workings”. Elsewhere he referred to the two seams having become hydrologically linked because mining in the Thorncliffe seam “would have caused some degree of collapse of the roof rocks between the two sets of workings”.

232. Despite having identified the workings in the Thorncliffe seam as a potential cause of the failure of the Parkgate pillars, Mr Stevenson devoted very much less attention to them than to the consequences of mine water rebound. This was surprising, as the impression he gave in parts of his evidence was that he saw the Parkgate pillars as having been distinctly vulnerable. He acknowledged that the Parkgate workings were relatively large for an unsupported room and pillar mine (hence his assumption of permanent timber propping) and demonstrated that the pillars failed the CIRIA stability calculation. There seemed to be a consensus that, at best, the Parkgate pillars were on the edge of stability.

233. It was therefore striking that, after citing a lengthy passage from CIRIA SP32 describing the mechanisms of pillar failure, Mr Stevenson drew attention (in a side note) to only two

phases in which such damage might have occurred in the Parkgate seam, namely at the time of the initial working and when the pillars were subject to saturation from the 1980s onwards. The same CIRIA passage on the crushing of pillars also noted that “problems are exacerbated when there are a number of workings of different ages at adjacent levels”, but Mr Stevenson did not draw attention to the significance of that observation.

234. Indeed, at times in his report Mr Stevenson appeared to lose sight altogether of the interaction between the workings in the adjacent Parkgate and Thorncliffe seams. He considered that “the [Parkgate] workings partially crushed to an equilibrium when first worked in the dry in the 1920s ... then stayed in equilibrium until the 1980s because they stayed more or less dry.” That analysis does not appear to accommodate the effect of the Thorncliffe and Silkstone longwall mining in the 1940s and 1960s at all.

235. Elsewhere Mr Stevenson described the effect of the Thorncliffe longwall workings as having significantly weakened the rock mass within and around the pillars of coal left in the Parkgate workings. He considered that this would have left them susceptible to subsequent triggers, including the effect of rebounding mine water. What Mr Stevenson did not satisfactorily explain is how, having regard to the extreme compressive stresses around the pillars, and his views on the marginal adequacy of those pillars, the roof of the Parkgate workings east of the mansion could have remained supported to any significant extent once the ground beneath the pillars dropped vertically downwards as, 25 or 30 metres below, the Thorncliffe workings were allowed to collapse.

236. Mr Stevenson relied on his analysis of ground movement at the stable block as providing significant assistance in understanding the behaviour of the Parkgate workings. But the most important difference between the workings beneath the stable block and those elsewhere, in particular to the east and north east of the mansion, was the much more immediate impact of the Thorncliffe and Silkstone workings. The contrast between the subsidence suggested by the InSAR data as having occurred at the stable block and the absence of such evidence of subsidence at the Mansion was attributed by Mr Stevenson to the masking effect of regional uplift, concealing the more modest subsidence which he believed to have occurred in areas where the Parkgate seam was not directly beneath the affected structures. He did not really analyse the alternative explanation, namely that there was no recent Parkgate related subsidence at the mansion because those workings had already converged long before becoming inundated, leaving little scope for further significant movement in the 1990s and later.

237. In his closing submissions Mr Barnes QC invited us to find that two significant events or series of events were likely to have destroyed the equilibrium of the Parkgate workings and to have caused roof collapse. The second of these was inundation as a result of minewater rebound; the first, which Mr Barnes described as “the less important in terms of immediate collapse”, was the working of the Thorncliffe and Silkstone seams below Parkgate. Having considered the totality of Mr Stevenson’s evidence we do not think it justifies Mr Barnes’ suggestion about the relative significance of undermining and inundation. We agree with the Coal Authority’s case that the more significant mechanism of collapse of the Parkgate workings is likely to have been the longwall mining undertaken in the Thorncliffe seam in 1948.

238. Nevertheless, we do not rule out the possibility that despite their earlier collapse some further disturbance of the Parkgate seam around the mansion, and of the fractured overburden above it, may have occurred as a result of mine water rebound. We can envisage that after undermining had caused the collapse of the workings the goaf in the Parkgate seam may not have been as thoroughly compacted as in a fully collapsed longwall mine. The pillars themselves would have fractured, but they would have continued to separate areas of goaf and are unlikely to have disintegrated entirely. The rock above the workings would also have fractured and we consider it possible that a state of equilibrium may have been achieved after the mining of the Thorncliffe seam which left some room for further settlement in and above the older Parkgate workings.

239. Mr Stevenson's belief that further disturbance would have remained possible even after undermining had severely fractured and broken the Parkgate pillars was supported by at least one of the studies on which he relied. A 1996 paper on *Groundwater Rebound in the Leicestershire Coalfield* gives an account of recent subsidence near Swannington where ancient workings were undermined by modern mining in the 1950s and 1960s; recent subsidence scars moving progressively along the surface of open ground were attributed by the authors to the continuing collapse of a 19th century pillar at a depth of about 140 metres below ground level following the cessation of pumping in the late 1980s and the subsequent rebounding of groundwater. The surface scarring occurred in precisely the location predicted by subsidence mechanics theory having regard to the mapped location of the pillar. This conclusion was reached despite the damage which must have been caused to the pillar when it was undermined at least 30 years earlier.

240. The many studies of groundwater rebound which we were shown emphasise the complexity of the interactions between adjoining seams and the difficulty of predicting the progressive effect of subsequent working beneath the supporting pillars separating adjoining rooms. It was apparent to us from the expert evidence we heard that a reliable understanding of the behaviour of the workings at Wentworth Woodhouse is very difficult to achieve and that there is ample room for well qualified experts to take very different views on what is more likely to have occurred. Our conclusion that the Parkgate workings are likely substantially to have collapsed long before their inundation by rebounding mine water, but that they may have retained some potential to trigger sporadic and unpredictable mining related ground movement for much longer, adopts elements of the views of both experts. Our acceptance of a residual possibility of further movement leaves intact the claimant's theoretical case on the mechanism of damage. It remains to be seen whether that theoretical case is made good by evidence of movement actually having occurred.

The measurement of ground movement

241. In the following sections of our decision we will review the different strands of evidence on the extent of movement in the structures at Wentworth Woodhouse. These comprised the Ordnance Survey benchmarks, Mulpan data, InSAR data, crack monitoring data, and verticality studies.

Ordnance Survey Benchmarks

242. A ‘benchmark’ is a chiselled horizontal mark made in a stone or brick structure, into which an angle iron can be placed to form a “bench” for a levelling rod, to ensure accurate repositioning of the rod each time a level reading is taken. Immediately beneath the horizontal line an arrowhead is usually chiselled to make locating the mark easier.

243. Benchmarks are used in surveying as a permanent reference feature to record the exact elevation of a point on a building or other permanent structure (such as a triangulation or ‘trig’ point) above or below ordnance datum (“AOD”). From 1844 to 1921 the datum point against which all height measurements were judged by the Ordnance Survey was located on St John’s Church, Liverpool. From 1921 to the present day, the datum point has been the tide gauge bolt on the pier at Newlyn in Cornwall. The Ordnance Survey have converted the figures from the historic datum to the modern version and have made the results available on their website, with a health warning that they are “only given as a guide and cannot be given exactly, but can be given with sufficient accuracy for most practical purposes of one decimal place of a foot.”

244. The Newlyn chart datum is the level of the lowest recorded astronomical tide, and the measurements taken at a benchmark thus records the precise height above mean sea level. The height of a benchmark is measured relative to the heights of nearby benchmarks in a network extending from a fundamental benchmark, which is a point with a precisely known relationship to the level datum of the area.

245. Mr Stevenson and Mr Wilshaw agreed in their joint statement that level surveys of the benchmarks at Wentworth Woodhouse provided an indication of ground movement at the location of the benchmark. They also agreed that benchmark data has limitations and that caution needs to be applied in its use.

The data

246. There are three Ordnance Survey benchmarks at Wentworth Woodhouse. One is located on the plinth at the base of the wall of the east front of the north wing of the mansion; the second is on the east end of the ha-ha wall which runs between the north tower and the stable block; and the third is on the wall at the north-west corner of the stable block. The fundamental benchmark to which they are all related is about 1km away at the Hooper Reservoir.

247. It was common ground that the stable block benchmark was in reasonable condition, and could be read without difficulty. The benchmarks on the ha-ha wall, and particularly on the east front of the mansion itself, are badly weathered, calling into question the reliability of measurements taken from them.

248. Successive editions of OS maps between 1892 and 1993 (and a survey in 1963) show levels for the three Wentworth Woodhouse benchmarks recorded on 7 occasions (1892, 1903,

1930, 1957, 1963, 1983 and 1993). The readings for 1892 and 1903 were converted by Mr Harbord of Arup from the published OS data to allow comparisons following the change of datum point from Liverpool to Newlyn in 1921. The quoted levels for the period 1892 to 1957 are given to the nearest 10mm, with a margin of error of +/-10mm, while the 1963 survey provides figures to the nearest millimetre.

249. Mr Stevenson questioned the reliability of the benchmark readings for 1983 and 1993, which were consistently higher at all three benchmarks than those given for the 1963 survey. They were also identical to readings given for 1957. This pattern implied to Mr Stevenson that the 1983 and 1993 figures had simply been transposed from the 1957 OS sheet without the 1963 re-measuring having been taken into account. He therefore discounted these “measurements” from further consideration on the basis that they were unreliable.

250. The benchmark data which Mr Stevenson considered reliable therefore provided measurements for two years before the onset of mining in the vicinity of the Wentworth Woodhouse buildings, 1892 and 1903, and supplied a further three entries during the decades of active mining, in 1930, 1957 and 1963. At the mansion benchmark there was no change in the first four readings, from 1892 to 1957. At the stable block and the Ha-ha wall the only change in the readings up to 1957 coincided with the change from the original Liverpool datum point used in 1892 and 1903 (although no figure was given for the ha-ha for 1903) and the figures taken from the Newlyn datum after 1930. Thus in 1930 and 1957 the stable block benchmark was shown as being 5 cm lower than it had been in 1903, and the ha-ha benchmark as being 3 cm lower than it had been in 1892.

251. All three benchmark readings taken in 1963 were lower than those given for 1930 and 1957: by 94 mm in the case of the mansion benchmark, 108 mm at the stable block and by 87 mm at the ha-ha wall.

252. In 2008, 2010 and 2015 three further sets of readings were taken from the benchmarks by Met Surveys Ltd, a firm of commercial surveyors instructed by Arup, who used GPS based technology. The readings were said by Met Surveys to be subject to an error band of +/-15mm. Met Surveys provided an explanation of their methodology.

253. The Met Surveys readings taken in 2008 were all lower than the readings given by the Ordnance Survey from its 1963 survey.

254. Mr Stevenson collated this data in two tables which we have adapted slightly below to show the individual Met Surveys readings. The results suggest that, since before the commencement of mining in the 1920s, up to the time of the latest benchmark readings in 2015 the recorded net subsidence in millimetres at the three benchmarks was as follows:

Benchmark	Subsidence	Subsidence	Subsidence	Subsidence	Total
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location	1892 to 1963	1963 to May 2008	May 2008 to December 2010	December 2010 to October 2015	Subsidence 1892 to 2015
Mansion	94	17	10	6	127
Stable block	158	99	8	10	275
Ha-ha	117	30	17	6	170

The accuracy and implications of the data

255. Mr Stevenson regarded the benchmark readings as providing clear evidence of progressive subsidence at all three locations since the commencement of mining in the 1920s, and in the period between 1963 and 2008 and also in the years from 2008 to 2015.

256. Although damage to the stable block and the ha-ha wall was not the focus of the preliminary issues, Mr Stevenson relied on the consistent pattern of movement in all three locations; he described the pattern as precisely what he would have anticipated and said that it indicated estate-wide subsidence. In particular, because the Parkgate workings extended under the stable block, but not directly under the mansion, the greater subsidence at the former location was to be expected. The significant subsidence at the stableblock between 1963 and 2008 was attributed by Mr Stevenson partly to the delayed collapse of the Parkgate workings in reaction to rebounding minewater; the same mechanism, he considered, explained the downward movement of the mansion benchmark. He also suggested that as the mansion is a very large linear structure, movement would be likely to vary at different locations; in his view the benchmark on the east façade was at a point where he would expect ground movement to be lower than elsewhere. The pillared hall and the east portico, which were closer to the Parkgate workings, could be expected to experience greater settlement.

257. The claimants pointed out that, at the mansion benchmark, more than a quarter of the total suggested subsidence had occurred since mining in the area had finally ceased. Although the subsidence was decreasing in recent years, the true extent of ground movement data could be being masked by the phenomenon of regional uplift.

258. Mr Wilshaw made no reference to the Ordnance Survey benchmark data in his first report. Subsequently he drew attention to some of the uncertainties over the data (consequent on the conversion from Liverpool to Newlyn and the poor condition of the mansion mark) but he did not call into question the reliance Mr Stevenson placed on the benchmarks records and acknowledged that they suggested subsidence at the mansion benchmark of 94 mm between the commencement of mining and the 1963 survey. He did not comment on the other benchmarks on the grounds that the stable block and ha-ha wall were not structures identified for consideration in the preliminary issues.

259. Mr Wilshaw was more critical of the value of the Met Surveys measurements of the level of the benchmarks, suggesting that an error band of +/-30mm should be applied to the readings, rather than the +/-15mm for which Met Surveys offered a contractual commitment. His concerns about the accuracy of the measurements were explored in cross examination from which it was apparent that the critical difference between the rival assessments related to the condition of the mansion benchmark. Met Surveys allowed a margin of +/-4mm for the erosion of the marks at the mansion and on the ha-ha wall, (in contrast to the sharper stable block benchmark which merited an allowance of only +/-1mm), while Mr Wilshaw considered that +/-15mm was required.

260. Taking into account what he regarded as the uncertainties of the Met Surveys data Mr Wilshaw preferred to take an average of the three readings for the mansion benchmark, and to compare the resulting figure with the 1963 Ordnance Survey measurement. This suggested that a further 26mm of subsidence had occurred at that location between 1963 and 2015, giving a total subsidence of 120mm between the commencement of mining and the most recent measurements. In cross examination Mr Wilshaw's view was that this subsidence would have been complete by 1980 at the latest (rather later than his original assessment of the late 1960s) and that there was no reliable evidence that any subsidence had occurred since.

261. Mr Wilshaw accepted that, in principle, data based upon measured ground movement was likely to be more reliable as an indicator of subsidence than the Mulpan predictions on which he had relied in his original report.

Conclusions – Ordnance Survey data

262. The Ordnance Survey benchmark data presents a number of puzzles, but allows some limited but fairly solid conclusions to be reached.

263. As far as the general reliability of the data is concerned we approach the evidence on the basis that, where measurements appear to have been taken, these are entitled to a high degree of confidence. The variances under consideration between 1892 and 1963 are not insignificant, and in the absence of any alternative measurements we are not inclined to give weight to unparticularised warnings about the risk of inaccuracy. Where there are good reasons for caution we take that into account, and where figures appear to us not to be the product of re-measurement we give them no weight.

264. As far as the Ordnance Survey figures for the mansion benchmark are concerned, with the single exception of 1963, all of the readings between 1892 and 1993 are identical, being given as 97.99 AOD. It is known that benchmarks readings were sometimes simply transposed from one OS sheet to the next without re-measurement; the only data known to have come from an Ordnance Survey re-measuring exercise was for 1963. Mr Stevenson disregarded the 1983 and 1993 figures on the grounds that they were the same as for 1957, whereas 1963 had been lower. For substantially the same reasons we consider that the readings for 1930 and 1957 must also be regarded as unreliable and as simply having been carried over from a previous measurement.

Those reasons are first that the absence of any change between 1892 and 1957, despite the adjustment required to take account of the relocation of the datum point from Liverpool to Newlyn, suggests that no re-measurement took place between those dates. Secondly, as Mr Stevenson accepted in cross examination, subsidence would have been caused by the mining of the Thorncliffe seam in 1946 and 1947, yet the benchmark measurement remains unaltered throughout the whole period. On this basis we conclude that the figure of 97.99 AOD given for the mansion benchmark in all the Ordnance Survey sheets from 1892 to 1993, with the single exception of 1963, is a Victorian measurement taken before mining in the vicinity commenced.

265. The first conclusion we draw, therefore, from the Ordnance Survey data at the mansion benchmark is that, between the commencement of mining and the survey in 1963, the ground at the benchmark location subsided by approximately 94mm (with some small but unquantifiable portion of that change possibly being attributable to the change in datum point in 1921).

266. The fact that damage at the ha-ha wall and the stable block are not the subject of the preliminary issues does not seem to us to be a sufficient reason for excluding consideration of the benchmark data from those locations as part of the overall picture.

267. The readings at the ha-ha wall and the stable block benchmarks do show a change between 1892/1903 and 1930. The stable block benchmark is shown in 1930 as being 5 cm lower than it had been in 1903, and the ha-ha benchmark as being 3 cm lower than it had been in 1892. The fact that there was any change suggests that the 1930 readings were the product of a re-measurement (although presumably not one which had extended to the mansion benchmark where the figure remains unaltered). Exactly when this re-measurement took place is not known, except that it must have been before 1930; whether it was before the undermining of the stable block by the Parkgate seam in 1924 is unknown but it might be thought unlikely.

268. It follows that some part of the total change shown at the ha-ha wall and the stable block between 1892/1903 and 1930 may have been the result of the change in the datum point to Newlyn, some part may be attributed to the margin of error of both readings, and (as Mr Stevenson acknowledged) some part may be a measurement of true subsidence caused by the Parkgate workings.

269. Subsidence between the conjectured re-measurement of the ha-ha wall and the stable block benchmarks before 1930 and the re-measurement in 1963 was much more significant: 108mm at the stable block and 87mm at the ha-ha.

270. At the stable block some of the movement between 1930 and 1963 may have been attributable to the workings in the Parkgate seam, which lay directly underneath the building, but we do not feel justified in finding that that was the case. The Mulpan analysis carried out for the stable block in 2007 predicted subsidence along the line of the northern wall attributable to the Parkgate (1924), Thorncliffe (1948) and Silkstone (1963) seams. Although not directly undermined by the Thorncliffe and Silkstone seams the north wall of the stable block and the ha-ha were both within their angle of draw. As the Parkgate seam was worked in 1924, the

measurement of subsidence in 1963 provides no reliable indicator of the condition of the seam at the time it was abandoned or subsequently. It may have collapsed wholly or partially at or about the time of mining, causing movements captured in the 1930 data; it may have collapsed wholly or partially after the 1930 measurement was taken so that some or all of its impact was measured in 1963; or (less likely) it may not have collapsed at all, so that the whole or much of the subsidence recorded at the benchmark in 1963 was attributable to movement caused by the other two seams.

271. Our second conclusion from the OS data is therefore a negative one, namely that the data relating to the stable block does not provide a reliable basis for drawing conclusions about the condition and date of failure of the Parkgate workings.

272. A further downward movement in the level of the stable block benchmark by 99mm is indicated between the 1963 OS survey and May 2008; the downward movement at the ha-ha in the same period was 30mm and at the mansion benchmark 17mm. Whether the subsidence at the stable block was caused by the distant workings in the Silkstone seam in the early 1960s, or was contributed to additionally by a delayed collapse of the Parkgate seam is important to the claimants' case but is not capable of being determined by reference to the benchmark data alone.

Conclusions –Met Surveys data

273. The movement suggested by the measurements taken from the benchmarks by Met Surveys is within a much narrower range. We are not inclined to be as dismissive of the figures as Mr Wilshaw and we see no reason to prefer his much greater error band to that attached to the data by Met Surveys themselves. No alternative measurements were offered on behalf of the Coal Authority and we were given no reason to doubt the professionalism and competence of the surveyors involved in the exercise.

274. However, we also take seriously the fact that Met Surveys provide their figures with a margin of error of +/-15mm at the mansion and the ha-ha, and +/-12mm at the stable block (where the benchmark is less weathered). We also acknowledge the force of some of the points made on behalf of the claimants in closing submissions. First, the trend of the readings at all three benchmarks is consistent on each occasion with a downward movement of the ground since the previous reading; this adds confidence to the interpretation of the general picture as it clearly does not suggest a random scatter of data. Secondly, the error band of +/-15mm is the combination of three risk factors which have simply been aggregated by Met Surveys (and by Mr Wilshaw) and so give a worst possible assessment; it might reasonably be expected that some errors might cancel each other out, and that there is an equal chance of an error causing the extent of subsidence to be under-recorded, rather than exaggerated. These ameliorating features justify placing greater confidence on the Met Surveys' data, although we do not consider that it would be appropriate to regard the readings as a precise determination of the extent of additional subsidence where the individual changes they have measured fall within their own margin of error.

275. Based on the Met Surveys data we feel justified in concluding that between the OS survey in 1963 and May 2008 additional subsidence occurred in all three benchmark locations, with by far the greatest impact being experienced at the stableblock. The data itself does not enable a more precise estimation of when within that period of 45 years the subsidence occurred, but it is necessary to recall that the Silkstone seam was mined until 1963, and that no mining occurred in the vicinity of the benchmarks after that. Mr Stevenson's hypothesis that minewater rebound caused the progressive collapse of the Parkgate seam from the late 1990s is consistent with the downward movement at the stableblock and the mansion benchmarks, but without evidence that some of the measured movement occurred later than about the mid-1970s, the hypothesis remains unproven.

276. The case for further movement having occurred between May 2008 and October 2015 is not proven by the very modest changes demonstrated by the 2010 and 2015 benchmark readings. The extent of subsidence on each occasion is less than the margin of error. Although the consistency of the trend at all three locations bolsters the data somewhat, the evidence is too faint to permit a firm conclusion on its own. On the other hand, the data is not discredited or unreliable, and we do not rule out that, taken with other evidence, it may support a conclusion that there has indeed been recent movement in the structures at Wentworth Woodhouse.

277. Taking all of the benchmark evidence together we are therefore not persuaded that, by itself, it justifies the conclusion derived from it by Mr Stevenson of successive phases of downward movement at the three benchmarks, commencing during the 1990s and continuing until 2015.

Mulpan data

278. We have already described the Mulpan computer programme (paragraph 41 above). In 2007, following receipt of the claimants' first damage notice, the Coal Authority undertook a series of Mulpan prediction surveys to determine the levels of settlement and horizontal strains that they would have expected to be experienced as a result of mining in the vicinity of Wentworth Woodhouse. The study considered 15 prediction lines at various locations through the site. This information was provided to Arup in July 2007. Mr Stevenson summarised the range of predictions in the following table:

Location	Maximum subsidence (mm)	Maximum strain (mm/m)
Mansion	11.4 - 99.2	0.963
Stableblock	50.2 - 135.6	0.869

Camellia House	859.0 – 1036.9	1.989
Terrace Wall	135.6 – 1614.1	51.540
Ha-Ha	129.7 – 1301.4	8.276

279. The calculations took into account the presence of all seven worked coal seams in the vicinity of the property, although no figures were provided for the Barnsley seam which was mined by the pillar and stall method. The individual contributions of each of the seams were provided separately, with the figures above being the aggregate of those contributions giving the total subsidence attributable to all seams.

280. The subsidence predictions indicated that the mansion was ‘hogging’ along its north-south axis (i.e. simultaneously curving up in the centre and sagging at the ends) and tilting towards the east. Three lines on an east-west axis were taken through the Mansion which predicted that the east façade would have been expected to subside by around 35 to 40mm. As Mr Stevenson pointed out, that was significantly less than the movements suggested by the benchmark readings which broadly suggested about 94mm of subsidence between 1892 and 1963, and perhaps a further 33mm by 2015, totalling together up to 127mm.

281. Mr Wilshaw undertook a revised Mulpan analysis in 2015, relating only to subsidence and not to strain. He plotted the results as ground contours on a plan of the buildings, and these predicted total subsidence at the mansion benchmark of only 25mm since 1923. On behalf of the claimants Mr Barnes pointed out that the total subsidence to the east façade of the mansion indicated by the benchmark data was some five times this level.

282. The experts agreed that Mulpan could be relied on to predict what they referred to as “the background pattern” of subsidence attributable to longwall mining which they also agreed would have been completed by the mid-1960s at Wentworth Woodhouse, or in the fault area by the mid-1970s. It could not be used reliably to estimate ground movement where room and pillar working had been employed or where a geological fault zone was present; nor did it predict the consequences of substantial mine water rebound.

283. For these reasons Mr Stevenson considered that neither of the Mulpan predictions provided a reliable estimation of recent subsidence, and he regarded the results as inconsistent with other evidence of movement observed over the past 10 to 15 years, and with the significant historical damage, the claims history and the benchmark readings. For his part, Mr Wilshaw agreed that benchmark readings could provide a more reliable basis for estimating the amount of mining induced subsidence which had occurred.

284. The Mulpan programme also provides an estimate of lateral strain. In this context “strain” means the deformation of an object as a result of the application of stress. It is measured as a ratio of a dimension of the object after the deformation to the same dimension of the object prior to the deformation and is expressed in millimetres per metre. Whereas subsidence is movement on a single plane (vertically downwards), strain will normally be recorded as measurement of movement on a lateral or horizontal plane.

285. The predicted strains were said to show a similar pattern to the predicted subsidence profiles, with the greatest strain in the Mansion being between the north and south wings. Mr Wilshaw considered that there was limited evidence upon which reliable conclusions could be drawn in respect of strain and indeed neither of the mining experts sought to attach particular weight to the Mulpan strain calculations. Mr Wilshaw agreed that if the Mulpan programme underestimated the level of subsidence actually experienced it was likely also to have underestimated the degree of strain. Nevertheless, despite the limitations of the evidence, both experts considered that strain was an important contributor to mining related structural damage, Mr Stevenson agreeing with a statement made by Mr Wilshaw that “vertical displacement is not in itself the primary factor governing structural damage whereas differential strain values are more relevant.” Mr Stevenson indicated in particular that he considered strain to be more important than subsidence as an explanation of the damage experienced at the mansion since 1999, with horizontal movement occurring towards areas of mining in the south and the north causing the building to stretch and hog. He explained by reference to the 1975 SEH that the length of a structure has a significant impact on the severity of the damage it might be expected to sustain as a result of lateral strain; strain of 1mm per metre was classified in the SEH as very slight in a building which was 25 metres long, but the same strain was very severe in a structure of 150 metres or more.

286. In our judgment the Mulpan data is of only limited assistance in this case. It is useful as an indication of the relative orders of magnitude of subsidence at the different locations caused by longwall mining, and suggests that, of all the structures, the mansion should be expected to have been the least severely impacted. This is consistent with the pattern of mining in the area which was obviously intended to protect the mansion. Mulpan is also useful as an aid to understanding the likely pattern or direction of movement. It is of much more limited assistance as a tool for reliably assessing subsidence to exceptional structures in these complex circumstances; nor was reliance placed on it as providing a reliable diagnosis of strain. The case histories from which the programme was developed were of mining in large panels by the longwall method, and although both the Coal Authority and Mr Wilshaw included the Parkgate seam in their assessment of immediate subsidence, we do not regard Mulpan as reliable for that purpose. Finally, if reliable measurements of subsidence are available these should obviously be preferred to a computer model predicting what is likely to have occurred. Mr Wilshaw acknowledged that the benchmark readings are likely to provide a better account of the extent of subsidence and we agree with him.

InSAR data

287. In seeking to determine whether and to what extent the mansion has experienced subsidence both parties have made use of InSAR data. We have already described (in paragraph 186 above) how this satellite radar technology enables precise measurements to be made of the level of hard surfaces over a period of time.

288. Since 1991 raw InSAR data has been sold by the European Space Agency to firms of commercial analysts who can isolate, cleanse and present the data applicable to a particular structure or region. The original InSAR satellite was replaced in 2002 and data series are supplied separately for the new and the old satellites; there have also been changes in techniques of analysis and processing between 2008, when Arup acquired its data, and 2015, when the Coal Authority purchased data of its own.

289. We received evidence and detailed submissions on InSAR data for both the stable block and the mansion. No InSAR data is available for smaller or narrower structures such as the camellia house or the terrace wall. The data which has been collected for the mansion does not include any readings for the north tower.

290. Both parties commissioned the same firm, NPA Fugro Ltd to report on data derived from the same satellites. As a result four separate series of data are available for the mansion and for the stable block; two series cover the whole of the period 1992 to 2001, a third covers 2002 to 2008, and a fourth 2002 to 2010.

291. Despite their common provenance it eventually became apparent that the data sets provided to each party were not identical and the parties were informed by NPA that its processing techniques had been modified since the original data was supplied to Arup. This somewhat reduces the confidence which we feel in making comparisons between the different data sets, or in placing significant reliance on this technique. Generally the 2015 data, which NPA suggested was the product of improved and refined techniques, suggested that less, or no, movement had taken place.

292. None of the experts who made use of the InSAR data were themselves experts in the technology. Nevertheless, they each agreed that, considered in conjunction with other types of data and observation to aid in its interpretation, InSAR is a useful way of indicating ground movement in a given area. The technology was used in a 2013 study in which the Coal Authority participated (and where the data was processed by NPA Fugro), to investigate the causes of subsidence following the cessation of mining in the Northumberland coalfield.

293. A number of limitations were identified. The points to which measurements are taken are not invariably the same unless dedicated receptors are installed, which has not been done in this case. The availability and accuracy of the data is capable of being affected by cloud cover and climactic conditions. The technique only detects movement at roof level in a building which may not be identical to movement at the foot of the building, especially in a large and complex structure like the mansion. The technique is not designed to measure lateral movement and the experts are agreed that in this case lateral movement or strain may potentially be an important

factor in the causation of damage. Lateral movement may also cause variances in the detection of vertical movement: as the orbit of the satellite is not directly over Wentworth Woodhouse, the phasing of the radiation wave when it returns to the satellite at an angle to the vertical may be affected by a lateral as well as a vertical movement in the location as compared to a previous reading.

294. InSAR data is capable of being analysed in different ways. Successive readings may be averaged over a long period to show the annual average rate of movement of a particular location over that period, or individual readings may be plotted on a chart in what was referred to as a time series. An annual average rate of movement will smooth out any seasonal variations and reduce anomalies, while a time series may better illustrate short term fluctuations which may be masked by the averaging process. The significance of the average movement in levels of a location over a period of time may depend on the period chosen for the averaging exercise. In principle, where there has been variable movement in different directions an annual average movement rate over a long period, such as from 1992 to 2010 for which data is available in this case, may give a different impression from an analysis of movements over a much shorter period.

The reliability of the data

295. The providers of the InSAR data in this case suggest that, in optimal circumstances, it has been used to measure fault movement in London to within 0.5mm per year. Nobody has claimed that that degree of accuracy is possible in a rural environment such as at Wentworth Woodhouse. Tests of the technology undertaken in the Netherlands as part of a European Space Agency validation programme have demonstrated an accuracy of +/-1mm per year for the average annual motion rate data. Correspondence between a colleague of Mr Wilshaw's and the providers of the data suggested that a margin of error range of 1 to 1.8mm per year was applicable, and we think it likely, as suggested by Ms Rawley QC, that in a rural area with relatively few scatter points the upper end of that band would be more relevant. It was apparently for reasons related to the potential for error within that range that the providers of the data suggested that they treated variances of +/-1.5mm per year as "stable", although they described that measure as an arbitrary choice.

296. No comparable margin of error was identified by the data providers as applicable to the time series data, but in his oral evidence Mr Wilshaw suggested that individual readings were subject to tolerances of +/-4mm to +/-6mm. We do not know the source of Mr Wilshaw's information, nor was Mr Stevenson asked for his view, but we think it probable that even after the data has been cleansed to remove as many anomalies as can readily be identified, the individual time series readings are likely to be subject to a margin of error rather greater than the +/-1 to 1.8mm indicated for the annual averages. We are conscious that the material on which we base that assessment is limited, as neither party chose to call evidence from the providers of the data, but it nevertheless appears to us to be solidly based on the nature of the data and its acknowledged limitations and difficulties of interpretation.

What the InSAR data shows

297. Data for four locations on the stable block (on which Mr Stevenson principally relied) indicated a pronounced net downward movement of about 100mm over the period 1992 to 2006, followed by a lesser reduction of about 10mm from 2006 to 2008. Mr Wilshaw agreed that the data indicated that the stable block had undergone subsidence and acknowledged that in the absence of any alternative cause this was suggestive of a further settlement of the overburden into the Parkgate seam worked out beneath the building by the room and pillar method in 1924. Neither party had investigated the stable block to see if there was any alternative non-mining related explanation for this movement.

298. The data for the mansion is markedly different, with no clear downwards or upwards overall movement, and shows a picture which Mr Wilshaw interpreted as broadly stable. Mr Stevenson agreed that the data for the north wing of the mansion showed no average net movement in the period 1992 to 2001, while the south wing showed an average small uplift. To the extent that there is any real disagreement between the experts on this period, having regard to the tolerances applicable to this data we prefer Mr Wilshaw's assessment and conclude that the InSAR data does not support the suggestion that there has been subsidence of the mansion during the 1990s. That conclusion still leaves open the issue of whether the net stability demonstrated by the InSAR data could mask a more complex picture in which a modest but real localised downward movement of the structures has been counteracted simultaneously by a regional uplift in the ground as a whole. That would be quite a coincidence, but it was one to which Mr Stevenson adhered.

299. For the period 2002 to 2008 Mr Stevenson considered that the time series data demonstrated a general fluctuation of levels of between -16mm and +4mm with the data for most points moving together in the same direction (although there were some more marked variances of up to 20mm upwards and up to 24mm downwards which may either be unreliable outliers or may reflect significant short term movement). Readings for 13 scatter points on the mansion roof were available for 24 days in the period from the winter of 2002 to the spring of 2008; these readings were not taken at regular intervals due, we assume, to the influence of weather conditions when the satellite passed overhead. The variances in the scatter points were plotted by Mr Stevenson on a chart on which he was closely cross examined. It appeared to us that the pattern of general fluctuations up to the end of 2006 was very similar to the modest variations exhibited during the 1990s. Data collected on 10 October 2006 was above this general trend band but returned to the norm on the next readings; it then spiked down on one date in the autumn of 2007 before reverting once again to the norm by the end of the series in the first quarter of 2008. We also note that when Mr Stevenson plotted the data provided by NPA to the Coal Authority (which the supplier considered to be more reliable) such variances as there were seemed to be less marked.

300. When Mr Stevenson was able to consider the InSAR data obtained by the Coal Authority, which covered the additional period from late 2008 to mid 2010, he drew attention to the consistent fluctuations in readings from all scatter points on the north wing of the mansion during this period. These suggested to him a potential net movement of 10 to 15mm, over a similar period to that in which Met Surveys also detected a drop in the level of the mansion benchmark of 10mm. He struggled with that correlation simply being a coincidence.

301. In its August 2008 report to Arup, NPA described the mansion data as exhibiting “subtle differential motion (mostly within -1.5 to +1.5mm/yr)” and suggested that the central area of the house was primarily stable, the northern end subsiding in places but with isolated uplift, and the southern part showing a mixture of motion. When NPA reported to the Coal Authority in 2015 it considered that the data showed that the mansion was stable during this period.

302. Taking the data at face value (i.e. without regard to the potential for downward movement to be compensated by regional uplift, which this data cannot demonstrate) we do not think the experts were significantly apart. To the extent that they were, we prefer the assessment made by Mr Wilshaw and interpret the data as showing a general picture of net stability at roof level in the mansion in the period 2002 to 2008. We do not consider that the very small variances identified by Mr Stevenson in 2006 and 2007 can properly be regarded as significant in demonstrating net movement; the margin of error for the time series is too great to allow individual readings, or sets of readings from the same passage of the satellite, to be regarded as precise. Nor do we regard the picture as significantly different for 2008 to 2010. Once again the fluctuations or anomalies, although consistent across the scatter points, are too modest and episodic to allow any reliable diagnosis or quantification of movement. At all times in his evidence Mr Stevenson recognised this and was at pains to insist that no conclusions could be drawn from this data alone, that caution was required and that at most it indicated the potential for movement.

303. In his report of 15 April 2016 Mr Stevenson identified the key difference between the parties as being whether the movement data should be interpreted on the assumption that there had been large scale mine water rebound in the Wentworth Woodhouse area, with the potential for associated regional uplift. We agree. If that hypothesis is accepted the InSAR data for the mansion and the benchmark data for the mansion, the ha-ha and the stableblock is capable of being interpreted as not inconsistent with modest but real short term ground movements.

304. Because they are each within their own tolerance bands the individual benchmark and InSAR data sets do not suggest significant new subsidence has taken place at the mansion since the claimants acquired their interest in 1999, but when they are read together the consistency between independent measurements is suggestive of something more complex. When the InSAR readings for the stable block are considered in conjunction with the stableblock benchmark data, support is found for the proposition that much of the downward movement of that benchmark between 1963 and 2008 occurred after 1992. The occurrence of movement so long after the conclusion of active mining is not consistent with a conventional chronology of mining related subsidence. On the contrary, and in the absence of any alternative explanation for subsidence at the stable block, it tends to support Mr Stevenson’s view that returning mine water has precipitated further ground movement at the stable long after conventional wisdom would have predicted that a state of stability had been achieved and would thereafter be maintained. If rebounding mine water may have caused the collapse of mainly undamaged Parkgate workings beneath the stable block, it may also have caused further damage and consolidation in the already heavily disrupted workings to the east of the mansion in the manner we have contemplated in paragraph 238 above.

Crack monitoring

305. The first active technical monitoring of the building fabric was instigated in October 2005 by the Newbolds' insurers, who arranged for the installation by their appointed loss adjusters, Ashworth Mairs, of 8 sets of crack monitoring studs at low level on the mansion. A further 34 sets of studs were installed by Arup shortly after their appointment (in pairs or groups of three for greater accuracy); these were placed on the external facades at high level and at points internally where cracking had been noticed in walls and ceilings. An additional 38 sets of studs were later added, making 80 groups in total, and we were provided with monitoring data for each of the groups.

306. The distance between pairs of stainless steel studs straddling a crack was recorded and then periodically re-measured using digital callipers. By this method any widening or narrowing of a crack can be noted accurately. Initial readings were taken by Ashworth Mairs but the insurers refused to authorise further expenditure on monitoring after resolving to deny liability. The studs were then monitored personally by Mr Scholey on seven occasions: three times in 2005, three times between December 2009 and February 2011, and once more in February 2016.

307. Mr Scholey confirmed that varying degrees of movement had taken place. In February 2011 he had noted that the eight Ashworth Mairs' stud groups indicated a generally slight opening up of cracks at all locations with the most significant movement relating to four locations on the North Tower, with one crack widening by 2.86mm between October 2005 and February 2011. Fifteen of Arup's additional 32 stud groups installed in 2005 showed either no increase or a very slight decrease (closing) of the cracks. The remaining 17 showed opening up – in one case to a maximum of 1.66 mm. The largest movements were on the east elevation of the north wing, and to the south of the pillared pediment. Stud groups 56 and 57 are within the vicinity of the Wentworth Fault. Recent cracking had also become apparent in the ceiling of the library where further studs have been installed. Mr Scholey thought that the periods of monitoring and the number of readings were not sufficient to confirm any particular trend of movement other than that it is progressive which indicated to him a more widespread cause than pure cyclical or temperature related movement.

308. Dr Beattie said that the Arup monitoring between 2005 and 2011 did indicate that movement, over and above that which would be expected, was continuing during that period especially in the areas of Bedlam (the south wing of the mansion), the north tower and the quadrant (the latter two of which were also shown to be leaning by Mr Scholey's verticality monitoring). In his first report of October 2015 Mr Stevenson noted a general increase in the measured displacement of studs over the monitoring period, but only 5 of the stud sets increased by more than 0.5 mm with the greatest movement being in the areas of the north tower and the junction with the quadrant.

309. Mr Richardson considered the graph of relative stud monitoring displacements produced by Arup for the period 2005 to 2016. He produced the following table of the fluctuations

recorded at the seven stud groups on the 20 metre section of the east façade straddling the assumed position of the fault:

Stud No	Period	Fluctuation (mm)
17	2005 - 2016	-0.2 / +0.4
18	2005 - 2016	-0.1 / +0.3
19	2005 - 2009	-0.2 / +0.1
56	2005 - 2016	-0.2 / +0.1
57	2005 - 2016	-0.1 / +0.1
58	2005 - 2016	-0.1 / +0.1
59	2005 - 2016	-0.1 / +0.2

310. Mr Richardson considered that these readings indicated that this elevation has variously expanded and contracted horizontally over a period of some 11 years. The magnitude of movement was slight and he regarded it as consistent with the normal seasonal movement of a 20 metre long wall. The readings, he said, clearly do not show any progressive movement during the period in question in this location.

311. Demec crack monitoring was also undertaken by Obsurvus on the instructions of Mr Richardson between September 2015 and March 2016 to the east and north elevations of the north tower, the rear wall of the north wing facing onto Basin Court and the rotunda. Constant electronic (L.V.D.T.) measuring of cracks was carried out at 11 locations including above and below the first floor window openings on the east wall of the north tower, across the large vertical crack at the junction of the tower and the quadrant, and at eaves level on the east wall of Basin Court. The only movement detected of more than 0.22mm was at the junction of the north tower with the quadrant where the crack widened by 0.7mm during October 2015.

312. We were presented with a considerable amount of technical data relating to crack monitoring which we found extremely helpful, as we did Mr Scholey's explanation of Arup's involvement. It is clear and, we think, not seriously in dispute, that the degree of movement in virtually all 80 monitoring stations has been well within expected tolerances and does not suggest significant structural movement. Nor does it support a case of ongoing mining related movement along the line of the fault. We accept Mr Richardson's conclusions above, having regard in particular to his impressive experience of period and specialist structures, but neither Dr Beattie nor Mr Scholey urged a different conclusion as far as that location was concerned.

313. The slightly more extensive cracking to the monitoring points on the north tower and the junction with the quadrant, will be considered later when we address the specific areas of damage in greater detail. Our general conclusion however is that there is insufficient evidence from the crack monitoring alone for us to conclude that movement in that area is attributable to mining subsidence.

Level surveys

314. In June 2015 the Coal Authority commissioned level monitoring investigations by Obsurvus. These investigations commenced in June 2015 and comprised 10 monthly surveys, with the final readings being taken in March 2016. 96 Fixed studs were attached along the plinth at the base of the east façade of the mansion including the north and south towers, the quadrants and the pillared pediments, to enable any changes in the level of the plinth to be detected. 48 studs were installed around the outside walls of the camellia house. 72 studs were fixed along the top of the terrace wall with two additional monitoring points on urns in the vicinity of the bastion and on the centre of the rotunda at the eastern end of the wall. The levelling of the studs was said by Obsurvus to be accurate within a range of not more than +/- 2mm.

315. The level of the studs was monitored using a bar code measuring staff and a digital surveying instrument mounted on a tripod. The measured levels were recorded and any changes in height reading and horizontal distance since the previous reading and cumulatively from the first reading were noted. Obsurvus are understood to have identified the OS value for the datum in June 2015 by GPS and used it as the baseline for all of the readings rather than obtaining separate GPS values on each survey; by this means each monthly reading was compared to a single “base” reference the level of which is checked from markers on local structures. Mr Wilshaw considered this good practice as values determined by GPS are prone to significant variation, and he thus regarded the resulting data as being of the highest standard.

316. Dr Beattie commented that the Obsurvus monitoring occurred over far too short a period for it to be of much practical value. He also had some concerns about the accuracy of the Obsurvus readings because the level of the survey control station was established by reference to markers around the estate which were themselves potentially subject to ground movement. He considered that readings of absolute levels could therefore be questionable whereas those for relative levels across the building on a given date were likely to be more reliable. Mr Stevenson shared these concerns and pointed out that the procedure adopted by Obsurvus was not in accordance with the method agreed between the parties in February 2015. The agreed brief, issued to Obsurvus by URS, had been designed to assess movement of points along the east façade of the mansion and the terrace wall relative to each other rather than to a reference point which might itself be moving; the base point and the reference points used to establish the level of that base were above areas of former mining and therefore at risk of exactly the same sort of movement as the level monitoring was intended to measure on the mansion and terrace wall.

317. Mr Wilshaw considered that the level surveys demonstrated no movement during the period of investigation. The only changes in levels detected in the mansion during the monitoring period were well within the accuracy range of +/- 2mm. This was also true of the monitoring studs on the plinth on the east façade where it was deformed downwards in the area of the fault line. The picture was one of stability.

318. Mr Stevenson considered that at the mansion the level monitoring showed relative subsidence consistent with the other evidence, although he considered that by 2015/16 the process of groundwater recovery would be so far advanced that only very small residual movements were to be expected. Because of his concerns over the methodology employed by Obsurvus he sought to analyse the level survey data in accordance with the original brief to determine relative movement, i.e. movement of the studs relative to a point selected on the building as a reference point. He reorganised the data taking the stud nearest to the mansion benchmark location (L.20) as his point of reference. He found that the relative movements were small but detected a pattern of movement across the fault zone which he regarded as consistent with the evidence of Giles Newbold that the gap between the doors in the George IV suite had first widened early in 2015 so that they would not close, and later narrowed again.

319. In her closing submissions Ms Rawley QC criticised Mr Stevenson for over analysing the data in an attempt to identify patterns supportive of his hypothesis where none existed. His reorganisation of the data was undertaken late in the exchanges of evidence and the Coal Authority had had little opportunity to understand or respond to it. We do not think these criticisms are justified. The Obsurvus data itself was a late addition to the available information and if, as appears to have occurred, the level monitoring surveys were not undertaken in the manner originally agreed, we do not think Mr Stevenson can legitimately be the subject of complaint for seeking to reinterpret the data. We nevertheless agree that, however the data is analysed, the recorded variances in levels are so small as not to be capable of establishing any pattern. It also appeared to us that the relative variances across the fault zone were no different from those observable at several other locations along the east façade and were too small to be significant.

320. The level readings to the camellia house were also all well within the accuracy parameters, again indicating no movement during this monitoring period. Mr Stevenson agreed with Mr Wilshaw that no relative movement trends were apparent from the level monitoring on this structure.

321. Along the crest of the terrace wall all of the level readings fluctuated within +/- 1.7mm, with no apparent trend that could suggest continuing settlement due to mining or any other factor during the 10 months of the Obsurvus study. Mr Wilshaw and Mr Richardson concluded that no ongoing movement had occurred. Mr Stevenson carried out the same analysis of the Obsurvus data in respect of the terrace wall and once again concluded that small relative movements were apparent at the east end of the wall over the area of the Parkgate workings.

322. The movements recorded by Obsurvus at the terrace wall were all well within the margin of error and taken at face value can only be considered to confirm that the terrace wall was generally stable between June 2015 and March 2016. We do not think Mr Stevenson's re-working of the data showing relative movements of only between 1.5 and 2.5mm over 10 months can be relied on in support of a different conclusion. The data does not reveal any significant movement or trend, and the minor variances detected (mostly within +/- 1mm in any event) do not suggest ongoing settlement due to mining or any other factor.

323. In general, because of the controversy over the level survey methodology and the very limited duration of the study we give very little weight to this data.

324. Finally, Mr Richardson referred to his experience of the tunnelling operations undertaken as part of the Crossrail project. The safeguarding procedures for buildings potentially affected by the work (including buildings of an age and scale comparable to Wentworth Woodhouse) was agreed by international experts and approved by Parliament. Unframed masonry structures like Wentworth Woodhouse which were predicted to settle by less than 10mm or to suffer tensile strains of less than 0.05 were considered to have a negligible risk of damage. Further, such structures, if they have been disturbed, cease to be monitored once settlement has reduced to below 2mm per annum. Comparing these thresholds of 10mm immediate settlement and up to 2mm annual movement suggested to Mr Richardson that attributing movements of less than 1mm to mining was misconceived. We agree.

325. Obsurvus also carried out verticality studies and bulge monitoring at the terrace wall, the quadrant, the north tower and the camellia house, the results of which were accurate to +/- 5mm. Level surveys were also undertaken in Basin Court and internal floor contouring in the first floor library. All of this information aided understanding of the condition of the structures.

Where does the burden of proof lie?

326. At this stage in our decision, and before examining the damage to the buildings at Wentworth Woodhouse in greater detail, we return once again to section 40(2) of the 1991 Act. The purpose of that provision is to allocate the burden of proof on the question of whether damage which has been shown to exist has been caused by the withdrawal of support from land in connection with lawful coal mining operations and is therefore subsidence damage. The subsection provides as follows:

“Where in any proceedings under this Act the question arises whether any damage to property is subsidence damage, and it is shown that the nature of the damage and the circumstances are such as to indicate that the damage may be subsidence damage, the onus shall be on the Coal Authority to show that the damage is not subsidence damage.”

327. It is common ground that the burden of proving the existence of damage is on the claimants. Without prejudging points of detail, we are satisfied that that burden has been discharged in relation to each of the four structures comprised in the preliminary issues. For the

most part the existence of damage was not really contentious. In the preamble to the first draft of the Scott schedule, and referring to the Arup room data sheets and visual inspection report of 2007, the Coal Authority's advisers recorded that they had no reason to doubt the general veracity of Arup's factual records. Of the 10 examples of damage to the terrace wall recorded in the Arup 2014 report the Coal Authority agreed that nine existed; most items of damage identified in the other structures were similarly agreed.

328. It is then necessary to consider whether the nature of the damage and the circumstances in which it has been shown to exist, are such as to indicate that the damage may be subsidence damage. If we were able to conclude that there was no real possibility of the damage having been caused by the withdrawal of support from the land in connection with mining, our task would be relatively simple and the reference could be dismissed at this stage. If, on the other hand, the nature of the damage and other circumstances were sufficient to create a *prima facie* case of subsidence damage the effect of section 40(2) would be to place the onus on the Coal Authority to establish on the balance of probability that the damage was not subsidence damage. The effect of switching the burden of proof is likely to be of significance only if, after considering all of the evidence, we are unable to say whether the damage in question is or is not subsidence damage, which neither Mr Barnes nor Ms Rawley thought was likely.

329. It is not difficult to understand why Parliament should have considered it appropriate to reverse the usual burden of proof in cases where mining subsidence is alleged. It has obviously been considered only fair that those whose land and property may have been damaged as a consequence of making energy available to the consumer should not face the difficult and uncertain task of having to prove that the damage they have sustained is due to mining subsidence. The 1991 Act therefore confers on them a statutory benefit of the doubt, and requires that, for the Coal Authority to avoid liability for the cost of remediation, it must establish on the balance of probability that the relevant damage was not subsidence damage.

330. We are satisfied that section 40(2) is engaged on the facts of this case. The matters we take into account in reaching that determination have already been described. They include the pattern of mining beneath and around the structures, and the history of accepted damage claims, including claims in respect of damage occurring long after mining related ground movement would conventionally have been adjudged to have ended. We have regard also to the identification by Mr Stevenson of a credible potential mechanism of causation, well supported by studies of other coalfields, namely the progressive collapse and consolidation of the old workings in the Parkgate seam when already disrupted pillars may have been further destabilised by a general rise in mine water levels in the district. At the stableblock the evidence suggests subsidence was occurring during and after the 1990s. The evidence of further subsidence at the mansion and the camellia house is at best equivocal, but it is common ground that lateral strain may be a cause of significant damage to structures at the edge of the zone of influence of collapsing underground workings. Despite the technical monitoring suggesting a picture of stability we therefore feel unable to rule out mining related movement as a cause of further damage since the 1980s.

331. We have therefore concluded that the damage at Wentworth Woodhouse *may* be subsidence damage. Accordingly, it falls to the Coal Authority to prove on the balance of probability that the damage has some alternative cause or to establish that on close investigation subsidence can be ruled out. With that conclusion in mind we now turn to consider the individual areas of damage in greater detail.

The damage in detail: north tower and quadrant

332. The square north tower of four storeys with its elaborate roof structure has undergone a series of alterations over the years. In the nineteenth century the building was extended at ground and first floor level on the west side; two new doorways were cut into the original walls on that side at ground level and a further doorway on the southern side adjacent to the south west corner at first floor level to provide access to the quadrant. Further up the building a staircase has been removed. At attic level the roof timbers were originally supported by a ring of beams with diagonal “dragon” beams spanning between adjoining walls in each corner. Two of these dragon beams have been cut at each end having lost their structural integrity due to decay, much of which was caused by rainwater ingress through defective roof coverings and secret gutters. Their function of supporting the roof is now taken by a pair of steel beams running from west to east across the tower, on to which are attached pairs of shorter steels which abut the walls and support the severed ends of the dragon beams. An architectural survey of the tower in 1999 noted that these beams were “marked 1920” and there is no suggestion that they are recent additions or that they are associated with mining subsidence.

333. Within the roof structure runs a pair of concealed parapet gutters which show signs of leaking or overflowing, with water staining and cracking of plaster where they intersect the interior faces of the walls. These discharge to a lead hopper bearing the date 1743. Below these gutters the timber beam supporting the attic floor has deteriorated and now sags dangerously, requiring support from below (the second floor) by a series of adjustable steel Acrow props. The floor at second floor level is not original but is a twentieth century timber replacement of the original lime-ash concrete construction. At first floor level the floor is also a later addition, which rests on the original; it is reached by a stone staircase which is also considered not to be original, as it is open without a step onto the raised modern level of the first floor.

334. The quadrant is a prominent feature on the east façade of the building; a curved stone structure of three storeys, enclosing a corridor, it links the north tower with the north wing of the mansion. It has its own shallow, lightweight lean-to roof. Within the quadrant a timber staircase leads to the upper floor of the tower; there is a gap between this staircase and the wall, where the wall leans out. There is evidence, as elsewhere, of significant erosion and weathering of the ashlar stonework of the quadrant, particularly at ground level, and to a lesser extent the east and west elevations of the tower, which Donald Insall suggested in 1976 was caused by rising damp. It is agreed that the erosion is not mining related.

335. Dr Beattie and Mr Richardson agreed that there were seven individual items of damage in the quadrant and north tower which require to be considered. Excluding those which are agreed

not to be mining related, these conveniently fall into four categories: the lean of the quadrant wall; cracking to the masonry and joints in the external walls of the tower; cracking to internal plasterwork; and the lean of the tower.

The quadrant wall - agreement and disagreement

336. The quadrant wall has sunk and tilted outwards over the whole of its length, leaning to the south-east (in contrast to the adjoining tower, which leans to the east). The outward movement at the top of the wall was measured by Obsurvus as 200mm at the centre where it is most pronounced. At one stage Dr Beattie had also suggested that the wall bulges, but he later acknowledged that the verticality survey establishes that this is not so.

337. The leaning of the quadrant wall is not a recent feature; its presence and effects were visible both internally and externally in 1976 when it was described in the Insall survey as follows:

“There are two particular points of structural movement that should be mentioned specifically.

1. Movement between the North end of the Quadrant and the Tower structure. The joint between these two sections of building has opened up to a width of about 1 1/2” [38mm] at the top tapering down to nothing at the bottom. This has been pointed up, and joints between adjacent stones in the Quadrant have opened and been filled. The movement is reflected inside by dampness on related wall surfaces.
2. Within the roof space, above the top of the stair, a broad crack rises through the plaster to the underside of the top gutter. This is continued in the room below. The stair shows signs of parting company with the wall, which in turn appears to lean out slightly...”

338. It was first submitted on behalf of the respondent that the leaning wall did not amount to damage at all, as there was no structural deficiency that was in need of repair. We do not accept that submission. The fact that the wall leans out has caused it to part company with the tower and, as Insall pointed out, this has implications for the weatherproofing of the structure and the stability of the internal staircase. The wall has changed for the worse from its original condition and in that sense it is damaged; the extent of any work required to restore it to its intended state is a different question.

339. Mr Richardson thought that none of the movement to the quadrant wall was mining related and suggested a number of alternative explanations, some of which may be interconnected. The most likely cause was that part of the structure may have been built on an area of softer ground or over old drains that had collapsed, creating a weak spot into which the wall had settled. The movement towards the south east was too localised to be associated with deep mining (which because of the location of the nearest workings would have been expected to cause movement to the north east), but was consistent instead with the presence of soft ground.

340. The quadrant wall faces south-east and feels the full effects of the sun, and Mr Richardson considered that this would cause much more thermal expansion and contraction, and consequent rotation, than in the corresponding wall adjacent to the south tower which exhibits no similar lean. Forward thrust caused to the top of the wall by the presence of the lean-to roof bearing against what is a largely unrestrained section of wall also contributed to the lean. On its own, the relatively lightweight roof would not cause the wall to lean out to the extent now exhibited, but Mr Richardson considered that, acting on the unrestrained centre of the wall, the thrust at the top of the structure would exacerbate the effect of its horizontal expansion in summertime. Dr Beattie agreed that the presence of the crack or gap between the quadrant wall and the south-east corner of the north tower, and the presence of the internal staircase within the quadrant, leaves the wall free to move. The more stable south quadrant lacks a comparable roof and internal staircase, allowing the floor joists abutting the wall to provide additional restraint.

341. Mr Richardson also pointed out that the Donald Insall and Martin Stancliffe surveys show that much of the damage complained of is old, and that the quadrant and the north tower have a history of neglect. Those who had investigated the structures in the 1970s and 1990s had not attributed the damage to recent mining; in 1999 Martin Stancliffe concluded, in relation to the whole property, that “despite being in a mining locality and despite the clear evidence of former movement of the structure in the past, there appears to be no significant movement at the moment.”

342. A further clue that movement in the quadrant wall occurred a very long time ago was provided by the cast iron folding wedges and steel plates which were revealed in the base of the quadrant wall at its junction with the south-east corner of the north tower when one of the trial pits was excavated in that location. These wedges were driven horizontally between the masonry courses at the base of the wall; although their precise function is unclear it is agreed that they were not part of the original construction, but were installed sometime after 1870 when steel was first manufactured in this country.

343. Apart from revealing the existence of the wedges the three trial pits dug at the base of the quadrant wall yielded little useful information. Mr Richardson acknowledged that they had not been dug to the depth agreed between the parties and that excavation had halted at a depth of 1.2m, below which it would have been necessary for shuttering to be introduced at much greater expense. The base of the wall had not been reached and the state of the ground beneath the footings had not been established. Dr Beattie did not consider that a localised soft spot in the ground of the sort hypothesised by Mr Richardson would have caused the wall to lean as it does; the ground would have to be soft beneath the whole length of the wall for it to have rotated.

344. Dr Beattie considered that it was movement in the foundations that was causing the wall to tilt, rather than thermal expansion and contraction or the wall’s natural propensity to lean outwards, but the failure to dig the trial pits to the agreed depth meant that this remained conjectural. Nevertheless, Dr Beattie accepted that curved walls have a tendency to lean outwards, although he thought not to anything like the extent that this wall leans, and he acknowledged the absence of restraint to the wall on which Mr Richardson relied.

The quadrant wall – discussion and conclusion

345. The discovery of the iron wedges and steel plates in the base of the quadrant wall gave rise to a great deal of speculation about their purpose, and both how and when they could have been installed. We agree with Mr Richardson's conclusion that they indicate that the stability of the quadrant wall and movement of the tower are issues of very long standing, but apart from rejecting the suggestion put in cross-examination that the wedges might have been used to level up masonry courses whilst the property was being built, and agreeing that they must have been intended as a remedial response of some sort to movement which occurred long after the wall was built, we are unable to come to any firm conclusion as to their purpose. Their presence, and the evidence of repeated repointing of the vertical gap up to 100mm wide at the junction of the quadrant wall and the corner of the north tower, confirms that whatever the cause of the leaning wall the structure has been in this condition for many years. The considerable age of the lean and resultant opening of joints and other damage is confirmed by Insall's 1976 survey, and although the separation between the quadrant and the tower would appear now to be greater than it was 40 years ago, that is only to be expected due to the absence of adequate tying in and the regular cycles of thermal expansion and contraction.

346. We received no evidence that there had been any recent movement to the quadrant wall, and the tiny fluctuations in the Obsurvus level readings were consistent with the absence of subsidence over the short period of monitoring in 2015 and 2016. We draw the same conclusion from the Arup crack monitoring, which was conducted over a much longer period. The largest movement was at stud 4, which monitored the long standing crack at the junction of the quadrant wall and the tower, and recorded an increase of 5.65mm in the width of the crack over a period of 11 years from 2005 to 2016. We agree with Mr Richardson that this is not significant. It is likely to have been caused by normal thermal movement and by the ratcheting effect of debris accumulating in the crack (a phenomenon acknowledged by Dr Beattie). A greater potential for inaccuracies in monitoring readings also exists in this location due to the difficult position of the studs and the absence of a control stud. The results from the other monitoring points in this location all indicated either no movement or miniscule differences within the quoted margins of error.

347. We bear in mind that, as he acknowledged, Mr Richardson could produce no tangible evidence to support his hypothesis that the leaning wall was attributable to a soft spot beneath the foundations; moreover, it was he who had supervised the contractors digging the trial pits and must take responsibility for their failure (contrary to the agreed brief) to go deep enough to find precisely what the wall's foundations bear upon. Nor was there any evidence of drains or of a drainage failure at this point. Nevertheless, we are persuaded that a combination of design features, which may include the localised condition of the foundations, is the more likely explanation for the condition of the wall. There is no evidence of generalised mining subsidence in this location and, as Ms Rawley QC pointed out, the quadrant wall and the tower appear to be behaving differently. Any curved wall has a natural inclination to lean outwards, but we agree that in this case the lean is so pronounced that it is not adequately explained simply by thermal expansion and contraction over so short a distance. We consider that some contribution may have been made by roof spread (although as Dr Beattie pointed out, a visual inspection revealed no signs of that having occurred), and a greater part by the absence of adequate lateral restraint behind the wall caused by the presence of the staircase.

348. The different geometry of the two structures means that the quadrant and the tower would not necessarily respond in the same way to mining related subsidence, but the south eastward movement of the quadrant is so significantly greater than the eastward lean of the tower that we agree with the respondent's submission that different things are happening to them.

349. On behalf of the claimants Mr Barnes QC invited us to conclude that the tilt and rotational settlement of the quadrant wall was far more plausibly attributed to the effects of mining subsidence. We are unable to do so. Dr Beattie did not persuade us that the movement was mining related and largely deferred to Mr Stevenson in justifying the claimants' analysis. We found Mr Richardson's diagnosis to be by far the more cogent.

350. In summary therefore, we are satisfied that the movement to the quadrant is not mining related. Furthermore, whatever its cause, the movement is historic and cannot be related chronologically to the claimants' wider case on the causation of damage as a result of rebounding minewater in relatively recent times.

The north tower

351. A number of items of damage evident to the north tower were agreed to be due to poor maintenance of roof coverings and gutters and to rising damp rather than mining subsidence; these included water damage at roof level and to the upper floors, damp penetration and resultant decay to structural timbers, and the erosion of stonework at both ground and parapet level. It was the Coal Authority's case that poor maintenance and disrepair were also significant causes of the movement and cracking that had occurred both internally and externally.

352. The damage remaining in issue comprises the following items: full-height cracking to the ashlar stonework on the east elevation; vertical cracking to the brickwork on the west elevation through 1st and 2nd floor window aprons and heads; vertical cracks to the ashlar on the north elevation; internal cracking to walls and ceilings and floor levels out of true; the lean of the tower to the east; and internal walls being out of plumb. Dr Beattie suggested that these issues should be considered globally because, although some of the damage could be associated with other causes, in his view it was clear that the majority were consistent with ground movement caused by mining subsidence.

353. The tower has developed a slight tilt, principally towards the east. The Obsurvus measurements also show that it has twisted or rotated very slightly towards the south. The lean is visible to the naked eye, and the "hogging" to the east and north walls (differential movement at the bases of the walls) is also evident on close inspection and in photographs showing plumb and level lines in place. Nevertheless, it is agreed that neither the extent of the lean nor the other recorded movement could be described as significant.

354. The lean to the east is at its greatest at the top of the north-east corner of the tower where it was measured at 75mm (which equates to 5mm in 1,000mm). Mr Richardson explained that Georgian builders worked to a tolerance equivalent to 1:300 (beyond which a tilt would be

observable with the naked eye). In a structure as tall as the north tower this would equate to 40mm at the top. Assuming this standard was achieved in the original construction, and allowing for a level of accuracy of +/- 5mm in the Obsurvus measurement, the additional lean since the building was completed could be as little as 30mm or as much as 80mm. The extent of deviation from plumb in the south-east corner was between 20 and 25mm (to the south-east) and to the west wall between 35 and 45mm (to the east). Given the possible margins of error, Mr Richardson did not consider that the tilt exhibited by the tower could be described as damage. He agreed that the fact that the tower now leans beyond what would have been acceptable to the original builders could be the result of historic mining related movement, but this would have occurred many decades ago. There was no evidence of continuing movement at anything more than inconsequential levels. The rotation could have been caused by the same localised ground conditions as he considered responsible for the rotational movement of the quadrant or by the spreading of the tops of the walls caused by interference with the ring beam supporting the roof.

355. In Dr Beattie's first report, which he based on his review of observations by others of movement and internal and external cracking within the tower, including those of Mr Scholey since 2005, he concluded that the lean and the separation of the tower from the quadrant wall was the result of past ground movement, and that such movement was continuing with a number of new defects and areas of damage being noted at each inspection. He later explained that the fact that the main pattern of movement of the tower was to the east was consistent with Mr Stevenson's hypothesis of ground movement in the Parkgate workings which are at their closest to Wentworth Woodhouse to the east of the north tower.

356. Dr Beattie acknowledged that there had been no monitoring of the lean in the 10 years since Mr Scholey first assessed it as being "about 70mm", and he was unable therefore to say whether it had increased over that period. The Obsurvus measurement of a 75mm tilt at the north east corner of the tower suggests to us that it has not.

357. Dr Beattie acknowledged in cross-examination that it was common for towers to lean, but pointed out that this tower does not just lean, it has also deformed and twisted, although the opposing movements are slight. He also placed weight on the fact that the cracking towards the base of the tower and at the junction with the quadrant has progressively increased, but acknowledged that the evidence was of only very small movements: apart from at stud 4 (at the junction of the base of the tower and the quadrant) where movement between 2009 and 2011 was recorded at 5.65mm, and at stud groups 1, 7 and 11 which showed 2.17mm, 1.75mm and 2.69mm respectively, all the other monitoring points on the north tower showed miniscule opening or closing of cracks of less than 1mm.

358. Mr Richardson suggested a combination of possible causes of the cracking to the stonework and mortar joints, and the brickwork to the west elevation. He first suggested that the brick backing skin of the stone faced walls may have undergone horizontal expansion. The stonework "wrapped around" the brickwork at the corners of the tower, clamping it in place, and the original builders may not have appreciated that newly fired bricks would take up moisture and expand. The bricks would have been made on site and if used too soon after firing

their expansion could push the stone facings apart (particularly at weaker points around window and door openings) and the significant pressure could also crack the stones. Mr Richardson noted that the stone facings of the south tower also exhibit cracking, which is not mining related. Dr Beattie considered that 18th Century builders would have been very familiar with the performance of their materials, and doubted, in any event, that expansion of the brickwork would have been sufficient to cause cracking of the stones.

359. Mr Richardson next suggested that the cracking to external wall surfaces may be the result of the failure of the substantial timber dragon beams which had originally been tied at the top of the walls to the ring beam which supports the roof structure. The ends of two of the four dragon beams have been severed from the ring beam and are now supported on box section steel work which Mr Richardson considered would not have the same tying effect as the original design, and may have allowed the weight of the roof to spread, effectively pushing the walls apart. This would explain the recorded outward movement of the tower at all four corners. Other modifications would have contributed to this loss of structural continuity, including the replacement of the second floor structure by timber joists laid over steel cross-beams. Dr Beattie disagreed and thought the replacement steelwork would have provided some degree of restraint. Dr Beattie also thought that the Obsurvus readings did not support the theory that the walls had been pushed apart – on the contrary, opposite walls had moved in the same direction and there was no evidence of bulging or buckling at second floor level.

360. Mr Richardson considered that the internal defects were principally the result of poor maintenance and significant water penetration through the leaking and defective flashings, gutters and rainwater goods. Damage had been caused to timbers (particularly the dragon beams and ring beam supporting and tying in the roof structure), and the ashlar floors had been overloaded. The significant structural alterations which had occurred, including new door openings and the installation of a heavy stone staircase, meant the building had had to adjust to altered load paths and stresses; significant load transfers would also have been created by the installation of the acrow props supporting the upper floor structure. The internal cracking and distortion that had occurred was the result of these changes, and was only to be expected in buildings of this age.

361. Although his written evidence included an emphatic statement that the damage to the tower could only have been caused by ground movement, Dr Beattie made a number of concessions to Mr Richardson's reasoning in his oral evidence. He accepted that some of the internal cracking and structural movement was due to the alterations, the severing of the dragon beams and the resultant loss of tying action to the roof structure, a general lack of maintenance and the effects of water damage. Nevertheless, he believed the pattern of external cracking, although slight, was consistent with the distortion of the building having been caused by ground movement due to mining. In answer to a question from the Tribunal, he accepted however that he was deferring to the views of Mr Stevenson in reaching that conclusion.

Conclusions – north tower

362. Once again, it is clear from the evidence that the problems of the north tower are not new. The 1976 Insall report noted structural movement between the north end of the quadrant and the tower and that the west wall appeared to lean out. A loose keystone and some cracking and poor mortar jointing were evident on the external walls, and extensive re-pointing of the stonework was considered necessary. The 1987 report prepared by the Estate Office to the Fitzwilliam Estate referred to extensive plaster cracking in internal walls on several floors. The 1999 Martin Stancliffe report also referred to substantial movement having occurred to the parapet of the tower and recommended consideration be given to rebuilding in this area. The structural survey appended to that report mentioned the differential movement between the tower and the quadrant but concluded that there were no signs of recent movement and did not consider that remedial works to the foundations were necessary. The same conclusion was reached by Alan Baxter in February 2009 who reported to the Coal Authority that the tower and the quadrant appeared to be tipping away from each other, but did not consider this to be mining related. There was no suggestion that any of the movement or other defects recorded in these surveys was mining related.

363. The early surveys and inspections, and the evidence of a major remedial intervention by the introduction of the steel wedges, confirm that the movement of the north tower and the quadrant is historic. Despite Arup being involved with the structure for more than 10 years the limited measurements which have been gathered suggest no significant changes have occurred in that period. No intrusive structural investigations were undertaken until Mr Richardson became involved.

364. We do not agree with Mr Richardson's suggestion that Georgian builders may have been unaware of the performance of their materials. There is more than sufficient evidence at Wentworth Woodhouse and at many other fine eighteenth century houses of the outstanding quality of workmanship that could be achieved in those days – much of it significantly better than occurs under modern working practices. The tower is certainly damaged. The internal and external cracking and the lean, which we are satisfied is greater than would have been tolerated by the original builders establishes that. We also think that the lean to the east is probably attributable to mining, as this part of the building is closest to the Parkgate workings which are likely to have collapsed many decades ago. We are mindful that it is common for tower structures like this one to lean over time, but the fact that the south tower, which is otherwise virtually identical, does not exhibit this feature supports our conclusion that mining either caused the tower to lean or exacerbated a less pronounced "natural" lean.

365. We have noted the many concessions made by Dr Beattie, and find that Mr Richardson's evidence is generally more persuasive. We have regard to the criticisms by Mr Barnes QC of Mr Richardson's failure to arrange for the trial pits to be dug to a greater depth at the junction between the quadrant and the tower but, overall, the limited extent of the investigations carried out to these structures is the responsibility of both parties. Partly because of his late addition to the claimants' team and partly, no doubt, due to limited resources, Dr Beattie was unable to provide evidence that the damage was continuing, or that the tiny movements recorded by Obsurvus were not attributable to natural thermal movement. In reaching his conclusions he had also deferred to Mr Stevenson to an extent which began to rob his evidence of much of its authority.

366. We are satisfied that if the lean to the tower is attributable to mining (and having regard to the burden of proof we accept that as being the case), the movement occurred long before the current owners took occupation and was not the result of a relatively recent phase of ground movement. There has been no such movement while Arup have been monitoring the building and the historic surveys do not support the case for significant deterioration having taken place since the 1970s. On the contrary they describe a building which is in very similar condition to its current state. We accept Mr McWilliams's evidence that some further cracking to internal plaster finishes has occurred, but with the exception of the modest lean, the other faults, including the very slight rotation of the structure, the internal and external cracking and the other damage are, in our judgment, far more likely to be the result of very long term poor maintenance, water damage, decaying timbers and particularly the loss of the dragon beams.

The line of damage through the mansion

367. The second of the four areas we have investigated in detail consists of a line of damage running through the mansion which is visible at different levels as it bisects the east front of the north wing (to the north of the portico), the library, Basin Court, and various living rooms before finally emerging on the west front.

368. The items of damage along this line were grouped together in the Scott schedule in the following eight categories:

Item AC	Previous movement and cracking to brick walls and barrel vaulted ceiling in cellar room B20 below Basin Court
Item AD	Differential settlement running north to south across the main 1 st floor library (room P7) and the ground floor shower room below it (G24); the small 1 st floor library (P8) adjacent to the main library and the adjoining librarian's room (P9); the main east front wall of the main library
Item AE	Large crack in the front wall of the main library visible internally behind the boxing below one of the windows
Item AF	Cracks in the ceiling of the main library (P7)
Item AG	Cracks in the ceiling of the adjacent state room (P6)
Item AH	Slope to the floor in a first floor room P41/42 in the extension to the rear of the west wing
Item AJ	Major cracking and displacement of ashlar stonework on the external wall of east front elevation of the main library above and below the main left hand window corresponding with the internal crack (item AE)

Item AK	Further external cracking adjacent to other windows on this elevation
Item AL	Diagonal cracking to the west wall of the north wing where it forms the east wall of Basin Court
Item AM	North wall of Basin Court leaning outwards with cracks to rendered finish
Item AN	Previously repaired windows and brickwork to Basin Court
Item not in schedule, but damage agreed to exist	Cracking to the west wall of the west wing extension (enclosing rooms G56-58 and P41/42)

369. The claimants' case is that all of the damage, settlement and distortion along this line has been caused by the reactivation of the Wentworth Fault which runs beneath the mansion and which we have described generally in paragraph 31 above. It is common ground that the original movement along this line is old, and that extensive repairs were carried out along the same line of damage at the NCB's expense between 1962 and 1985. Dr Beattie nevertheless considered that there is evidence that ground movement is still occurring, albeit at a slower rate than in the past. Mr Stevenson's hypothesis is that this movement is due to further disturbance of the fault caused by the effect of mine water rebound.

370. In contrast, Mr Richardson's view is that there is no evidence of ongoing or recent movement and, moreover, that the historic damage which occurred along this line is unlikely to have been caused by mining. He attributed the damage predominantly to the collapse of culverts or drains running beneath the building, the route of which corresponds to most of the areas of settlement, deformation and cracking.

The location of the Wentworth fault

371. In reaching their conclusions on the most likely cause of the damage each of the building surveyors relied on advice they were given by the mining experts on the location and extent of the geological fault. Mr Richardson was informed by Mr Wilshaw that the line of the fault is some 20m to the south of the line of damage, a view which was said to be supported by the most recent (1997) geological survey and by the abandonment plans. On that basis Mr Richardson reasoned that movement of the fault, whether recently or in the past, could not have been responsible for the damage which is apparent in this part of the mansion.

372. For his part Dr Beattie adopted Mr Stevenson's assessment of the location of the fault which is shown on a number of plans as running in a south-east to north-west direction, slightly to the north of the northern corner of the main pillared pediment. These plans suggest that the

fault intersects the building midway along the east façade of the north wing from where it is thought to run directly below the internal dividing wall between two ground floor rooms (G20 and G21), and the first floor rooms immediately above (P6 and P7, the main library). After continuing below the north wing the conjectured fault line then emerges at a point midway along the east wall of Basin Court and runs across the open courtyard to the corner at the junction of its north and west walls. The route continues beneath a two story extension adjoining the north–west corner of the west facade of the mansion; this modest extension was constructed above an old garden wall at a date sometimes after the completion of the original structure in the 1730s. The extension houses some ground floor storage rooms G56 to G58 as well as the green bathroom (P41/42) on the first floor immediately above.

373. Dr Beattie also considered that the nature of ground movement along fault lines meant that the damage at the surface could occur within a “zone of influence” rather than being confined directly above a precise line. That view was supported by Mr Stevenson who believed that the zone could be up to 40 metres wide.

374. The location of the fault where it reaches the surface is difficult to identify with precision and has not been established definitively by the British Geological Survey on whose 1997 map it is marked as “conjectured”. The fault is not perpendicular to the surface and, in practice, the ground disrupted by it is likely to be within a zone, perhaps as much as 30 or 40 metres wide, rather than along a single line. The fault was encountered at different levels beneath the estate when seams of coal were being mined and the location of those encounters are shown on the mine abandonment plans for the Barnsley, Lidgett and Swallow Wood seams. The abandonment plan for the Barnsley seam identifies where the line of mining first met the fault, or ground affected by the fault, because that was where mining stopped; in the Lidgett seam a pair of tunnels was driven through the fault zone and its boundaries were marked on the abandonment plan for that seam in 1962.

375. The mining experts agreed that the fault outcrops in a zone or corridor running through the mansion, although within that zone Mr Stevenson considered the northern boundary indicated on the Lidgett and Swallow Wood plans to be more significant than the encounter with the fault zone 20 metres to the south shown on the Barnsley plan on which Mr Wilshaw placed greater weight. The line of damage which we are now asked to consider lies along the northern perimeter of this corridor. The more northerly line is also consistent with a sectional sketch of the strata and fault drawn by NCB engineers in July 1962, and with the location of subsidence damage attributed to movement in the fault for which compensation payments were made in 1969 and 1985. A later plan produced by the Chief Mining Engineer’s Section of South Yorkshire District Council and dated 26 January 1981 shows the “approximate extent of fault zone at surface” as a zone about 20m wide proceeding in exactly the same south-east to north-west direction, but with its southern edge lying across the line of damage. Thus, the line of damage falls approximately in the centre of these two conjectured zones.

376. We accept that the damage might not lie precisely above the fault line but could be within a zone of influence, and we are satisfied that it is more likely than not that the majority of the damage along the line was caused by historic movement in the fault. On balance, as was

accepted at the time the damage occurred and was inspected and subsequently repaired, the damage follows the putative line of the fault too closely to be attributable to other causes.

377. Since it was always possible that we might disagree with Mr Wilshaw on the location of the fault, it is surprising that Mr Richardson did not approach the cause of the damage along the putative line of the fault with a more open mind, at least acknowledging the possibility that the two might be related. Having relied on the views of Mr Wilshaw to rule out mining induced fault reactivation as a potential cause of this damage, Mr Richardson's search for an alternative explanation became a matter of necessity rather than of his own judgment. It drove him to adopt the hypothesis that the culverts beneath the building may have collapsed, for which there was never any firm evidence. It also caused him to suggest that the engineers who saw the damage along the fault line in the 1960s through to the 1980s and concluded that it was mining related must have been wrong. Whilst, as we have said elsewhere, Mr Richardson's evidence was thoughtful, well researched and, in the main, persuasive, his total dismissal of the theory that the damage could have been caused by fault reactivation was surprising, and his evidence on this aspect of the case was less persuasive as a result.

The collapsed culvert theory

378. Architectural plans of the mansion, the earliest of which dates from the nineteenth century, show the known or assumed layout of drains and culverts beneath the building. As Wentworth Woodhouse is built on the side of a gentle slope, and as both the stables and the formal gardens are located to the west, as it were, uphill of the house, it was obviously necessary for the original builders to give some attention to the removal of surface water from the site, as well as the disposal of waste water from the house itself. This was achieved by a series of drains and culverts running around and beneath the house into which the domestic drains discharged.

379. One such culvert was believed by Mr Richardson to follow the line of damage through the mansion, running west to east through Basin Court and beneath the internal load bearing wall on the east side of the building separating G20 and G21 on the ground floor and the state room (P6) and the main library (P7) on the first floor. The precise location of the settlement and the extent of the movement along the line of the plinth was shown by the level monitoring studs. It was therefore Mr Richardson's view that the culvert had sunk or caved in beneath the north wing due to a partial collapse or because the infilled ground surrounding the culvert had settled and consolidated. The settlement would have been exacerbated by the construction above the line of the culvert of the heavy, load bearing wall between rooms G20 and G21 and P6 and P7. In Mr Richardson's view these were the most likely reasons for the subsidence and cracking in the front wall, the internal cracking and the floor levels in this part of the building being out of true.

380. In the Alan Baxter report of 2009 the line of damage through the building was noted at paragraph 5.1.2.1 with a similar dip or a sag in both the external walls of the south wing (referred to as Bedlam), and some signs of corresponding movements in the internal walls and floors (paragraph 1.2.2). Baxter had also attributed these defects to local softening or erosion of the soil immediately below the foundations by leaking or collapsing drains or culverts.

381. The precise route and dimensions of the culvert were the subject of considerable debate at the hearing. It is known to run at a depth of 4.4m below the surface where it passes through an inspection chamber in Basin Court but until relatively late in the proceedings little further information was available about it.

382. Two plans attached to the Alan Baxter report, which were themselves based on a drainage layout plan of 1843, led Mr Richardson to conclude that the culvert followed a straight line below the north wing of the east front and under the lawns in front of the house where it joined up with another large brick culvert running from the stables and passing below the building at a point further to the north. This large culvert had been the subject of investigation in the past and was referred to as a 'principal culvert' with known dimensions of 1.2m deep by 0.6m wide. In the autumn of 1953 it had suffered a partial collapse, causing raw sewage to enter a pond, and resulting in correspondence regarding responsibility for repairs between West Riding County Council and the Ministry of Education (on behalf of the Lady Mabel College). On investigation, the invert level of the culvert was found to be 10 metres deep in the location of the partial collapse, rather than 6 metres as had originally been thought. Mr Richardson agreed that the 1953 collapse of the principal culvert was not associated with the damage with which we are concerned, but he drew conclusions about the size of the culvert beneath the line of damage from what was discovered in the 1950s about the dimensions of the principal culvert. If a culvert of a similar size had suffered a collapse or fracture where it ran beneath the house, it would be capable of causing substantial damage either immediately or more gradually as escaping water washed away the material surrounding the structure.

383. In view of the significance attributed to the culvert by Mr Richardson, an inspection was undertaken by Mr Scholey and others on 7 April 2016 (after the first week of the hearing). Visual access was obtained through the shaft in Basin Court, but the presence of pipes discharging into the shaft made further access difficult. The culvert was found to be of stone construction, rather than the brick of the principal culvert, and its dimensions are 450mm by 450mm. It was possible to measure and photograph the inside of the culvert but its uneven random stone or rubble base and some debris lying in the bottom, including some cracked and partly collapsed roof stones or slabs upstream of the inspection chamber, made it impossible to deploy a motorised video camera to explore the tunnel further.

384. Photographs taken using a camera lowered into the culvert were examined to determine whether it follows the straight course understood by Mr Richardson, or whether it bends at the point where it exits Basin Court and heads north-east, away from the route of damage. Although the quality of the evidence was not perfect it seemed to us to be likely that the tunnel does indeed change direction towards the north east on leaving Basin Court heading east, and similarly curves towards the south in the upstream section. With the benefit of the photographs Mr Scholey depicted the route (we consider accurately) as a shallow s-curve on the plan, rather than a straight line. Mr Richardson was very reluctant to accept that this was what the photographs show, although he eventually accepted it as likely (at least as far as the arrival of the culvert in Basin Court from the south west which would rule it out as the cause of old damage to the basement corridor (B20)). He also acknowledged that the main line of the culvert does not therefore accord with Alan Baxter plan or the 1843 plan, and that its

dimensions are considerably smaller than the principal culvert described in the 1954 correspondence, contrary to his own and Alan Baxter's previous assumptions.

385. It was submitted for the Coal Authority in closing that the lateness of the evidence of Mr Scholey's most recent inspection meant that it had not had a proper opportunity to investigate it. This predicament was taken to provide a springboard for a certain amount of speculation which had not been the subject of evidence. It was pointed out that the Alan Baxter survey plan and a drainage plan from 1954 both show the line of a 'drain or culvert' proceeding beneath the library west to east in a straight line, as Mr Richardson had assumed. The Baxter plan also showed a spur branching off in a north easterly direction, exiting from beneath the north wing under the north wall and then turning through 90 degrees to the east and passing either under or over the principal culvert out in the lawn (and not discharging into it). In closing submissions, it was speculated that, from the evidence of cracking to the east façade, the stone culvert must originally have proceeded straight on but that due to a major collapse or blockage it must later have been diverted into the north easterly route implied by the photographic evidence.

386. That suggestion seems to us to be speculative and improbable. The culvert is some 4.4m below the level of Basin Court, and will be slightly deeper where it passes beneath the north wing. It would have been necessary to dig a very large and very deep hole below the building itself in order to seal off and divert the supposedly damaged section. The stonework shown in the photograph of the culvert shows no sign of any disturbance or stitching in and there is no evidence of any such excavation having taken place.

387. In 1999 Alan Baxter had also thought that a leaking drain or culvert could have been responsible for the cracking to the walls and ceiling of the cellar tunnel (room B20) which the NCB had considered was mining related; it was accepted by both Mr Richardson and Dr Beattie that only a 4 inch vitreous enamel pipe was to be found in this location and that this could not have been responsible for the damage.

The pattern of cracking on the east front

388. Dr Beattie accepted in principle that the collapse of an underground culvert *could* cause subsidence to a structure, but inspection of the pattern and scale of cracking to the east front suggested to him that the damage was much greater than the localised effect that a collapsing culvert would have created. He agreed that the cracks to the east front of Bedlam (the south wing) appeared to coincide with the point below which another culvert passes, but the crack patterns to the northern section are not directly above the culvert. Quite apart from the debate over the route of the stone culvert the pattern of cracking on the north wing of the east front distinctly shows the stonework to be stepped. Dr Beattie considered that sort of pattern to be more consistent with the shearing effect of movement of the fault. If the damage to the east façade had been caused by the collapse of a culvert or the settlement of the softer excavated ground around it, the wall would have sagged. The profile did not, therefore, indicate culvert collapse. Because the cracks to the north wing had been the subject of some fairly major repairs, the crack pattern was now less apparent than it would originally have been.

389. Mr Stevenson noted significant stepped cracking to the east façade and said that one repair showed a 50mm displacement to the south.

390. Dr Beattie considered that the mansion had been affected by previous ground movement along the line of the fault under the north wing and through the east façade of Bedlam. Whilst the pattern of damage to Bedlam coincided with the route of the culvert depicted on the Alan Baxter plans, and while the damage to the north wing east façade and the rooms behind virtually coincided, as one moved towards the west wing and towards the rear of the south wing, the lines of damage are in areas where there is no evidence of the existence of culverts. The evidence of Mr Giles Newbold, the fact that the wedge inserted in the large crack beneath the library window had now worked loose, and the additional internal cracking and partial ceiling collapse recorded since Arup's initial investigations, all suggested to Dr Beattie that the movement was continuing. He did not suggest that all of the damage was necessarily attributable to ground movement but it was impossible, owing to the extent of the available data, to confirm the precise cause of all the recorded damage. He was therefore content to rely upon Mr Stevenson's hypothesis and attributed the cause of recent movement to the conjectured mine water rebound having reactivated the Wentworth fault.

391. Mr Richardson interpreted the pattern of cracking differently. Looking at the whole of the east front of the north wing, it was evident to him that localised sinking had occurred as the cracks around the window openings diagonally oppose each other; this pattern of cracking is different from the pattern associated with the shearing caused by movement along a geological fault. The localised sinking had occurred at the very point where the culvert from Basin Court passed beneath the east front. A similar pattern of sinking was also apparent on the façade of Bedlam above the route of the second culvert. Mr Richardson agreed with the author of the Alan Baxter report (who had referred to a "dip" or "sag" in the external walls above the culverts) that there appeared to be no indication of shearing movement along the line of the fault. If the fault had been reactivated and had sheared, the energy released would have caused extensive damage to the structure above it, but damage on that scale was not apparent and had certainly not occurred in the relatively recent past.

392. Mr Richardson criticised Mr Stevenson cherry-picking those defects in the building which might fit with his theory without considering evidence to the contrary. He contrasted his own approach which he said had been to look at the building along the whole of the alleged fault line and elsewhere, including those parts which were not affected, and to consider all the likely causes, including mining subsidence.

393. Once again, as with the conjectured causes of damage in other locations, we are faced with radically different conclusions drawn by extremely well qualified experts analysing the same quite limited body of evidence. The list of items of damage along the line of inquiry should not be misunderstood. It is not suggested by the claimants that the damage is all recent, and it is agreed that a great deal of it (and especially the major cracking and movement of masonry) is historic and has long since been repaired. When we undertook our inspection of this part of the building we looked closely for signs of recent movement or disturbance of old repairs and found little, if any, on the exterior of the building in this location. Inside the building cracks in the

ornate plaster ceilings in the state room and library were apparent but some of these at least were old. No systematic attempt has been made by either party to rule out alternative causes of deterioration.

394. Mr Richardson's principal hypothesis that the damage was caused by a collapsing culvert did not survive cross-examination. Based on the most recent investigations we are satisfied that the route of the culvert leading out of Basin Court does not follow the line shown on the Alan Baxter plans, as Mr Richardson had understandably assumed, but takes the course described by Mr Scholey. The assumption that the conduit was of similar size to the principal culvert excavated in 1954 is also now known not to be correct. So far as we can tell from the photographic evidence it is of solid construction and in good condition, showing little evidence of damage (with the exception of one cracked and partially dislodged roof stone in the upstream section – which does not indicate collapse). The further evidence satisfies us that Mr Richardson's bold theory is not correct.

395. We placed less weight on the evidence regarding the crack patterns as an aid to diagnosis. We agree with Dr Beattie's conclusions that the crack patterns indicate that the damage was caused by a shearing movement, of the type that would be expected to arise from activity along the line of the fault. Nevertheless, we attach only marginal significance to that feature because the downward movement caused by a major culvert collapse could produce similar results. We therefore prefer to base our conclusions that culvert collapse is not the cause of the damage on our findings concerning the route of the culvert.

396. It is not in question that the heavy load-bearing internal partition wall in the north wing of the east front has settled, but there is no evidence of a major collapse to the culvert under Basin Court and the north wing. Moreover, the conduit does not extend along the whole of the line of damage and could provide no explanation for damage to the west of Basin Court, which follows a distinct line emerging eventually on the later extension to the west front. The historic damage in this western area cannot have been related to the culvert and must have had some alternative cause. We think it more likely than not that that cause was the reactivation of the fault.

397. We have already expressed our own conclusion, in agreement with that of the claimants' experts, concerning the most likely route of the fault, and we are satisfied that the substantial items of damage were caused by its historic movement. We appreciate, as the Arup 2006 desk study also acknowledged, that residual settlement along a geological fault may occur for reasons unconnected with mining or groundwater rebound. Nevertheless there is a consensus now, as there was in the 1960s when much of the major damage is likely to have occurred, that mining can cause fault reactivation. If Mr Richardson's hypothesis was correct, it would mean that the chief Mining Engineer for South Yorkshire County Council and the NCB, which accepted numerous claims for compensation relating to these very areas of damage up to the 1980s, must have been wrong in their conclusion that the damage was due to the fault, and was ongoing. While it was open to the respondent to advance that case, we would have required considerable persuasion before accepting that experienced engineers who had the advantage of inspecting the damage as it occurred had come to the wrong conclusion. We have heard no persuasive evidence which would lead us to the conclusion that the original consensus was mistaken, and

that the movement along the line of the fault had some different explanation, unrelated to mining.

398. Although we have not been asked to determine issues of limitation or the timing of damage at this stage, both parties called evidence intended to persuade us that the damage was either all historic (at least to the extent that it was mining related) or had in part been caused by recent movement. Our clear view is that none of the damage which we are satisfied was mining related is recent; on the contrary, we are satisfied that it is old, by which we mean it was caused and repaired in the period between the 1950s and the mid-1980s, and therefore predates the period when the claimants say the mine water rebound may have occurred.

399. An important example of this is item AC, the cracking of the brick walls and barrel vaulted ceiling in the cellar corridor (B20) which runs from north to south beneath the west end of Basin Court. This item was not really contentious but featured quite prominently in the evidence because the repairs were documented and obvious. We were unable to inspect this corridor due to restrictions on access imposed because of the discovery of asbestos, but reasonably clear photographs were produced which confirmed (as the experts agreed) that there is no evidence of any further movement either to the replaced area of brickwork or to the old cracks still evident in the barrel vaulted roof. The theory that the original cracking to this area was caused by the “hogging” of the corridor over a culvert or pipe was acknowledged by Mr Richardson to be wrong, and we are satisfied that the most likely cause was ground movement attributable to the fault.

400. We regard the complete absence of any evidence of further movement or damage since the partial rebuilding of the walls of the cellar corridor in 1985 as significant. If there had been a resumption of ground movement along the line of the fault for the reasons postulated by Mr Stevenson, the cellar, which had suffered badly in or before the early 1980s, would have been a prime location for further damage.

401. Similarly, there was no evidence of any further movement having occurred since repairs were carried out to remedy the cracking in brickwork and render around Basin Court, and to re-point the stepped cracking on the rear wall of the west wing extension.

402. In general we are satisfied that if there had been a reactivation of the Wentworth fault since the 1980s, the damage to the areas previously affected would have been far more extensive and there would have been evidence all along the line of damage, rather than a few minor and seemingly unrelated incidents. Having reached that conclusion on the main elements of contention we can deal fairly shortly with the remaining issues.

403. We have already dealt with the technical evidence relating to crack monitoring and levels, from which it is clear that there is nothing to suggest that anything other than very slight and structurally insignificant movement has occurred to the mansion during the period of study since 2005. The crack on the front wall of the library into which there was inserted a wedge which worked loose over time was not the subject of any precise monitoring; while we cannot be sure

what caused the wedge to loosen, we are not prepared to conclude that this crack widened significantly when the evidence is that none of the others behaved in that way. The crack is below a large window opening in a relatively vulnerable point in the structure, and it would take only a very small level of movement to loosen a previously tightly fitting wedge.

404. There certainly would appear to have been some additional disruption of plaster mouldings within the building. We do not regard Mr Newbold as a reliable observer, but we have much greater faith in the evidence of Mr Scholey who was adamant that during his 10 years' involvement with the building additional internal cracks had definitely appeared in the library and the state room. No specific internal crack monitoring has been carried out and the inspections of these high ceilinged rooms were conducted from floor level and only once on a systematic basis. It is very difficult to be precise about the number and dimensions of cracks in those circumstances but we accept that this has been a continuing phenomenon.

405. Misalignment of internal floors, jamming of doors and general internal plaster cracking are all historic, but the evidence of additional damage in these areas is of only slight increments or isolated events. No investigation of the fabric of the building has been carried out in the areas affected by ceiling cracking or falling plaster. We heard theories about the performance of tie wires holding ceiling mouldings and finishes and about the considerable thermal movement which may occur where steel beams have been installed. There is no positive evidence which satisfies us that any of this further minor internal damage has been caused by recent continuing ground movement, or even that they could be attributable to the very long term consequences of movement which occurred before the 1980s. We think it very likely that damage to internal decorations associated with the movement of the fault would have been repaired at the time it occurred. Specific evidence of some definite alternative cause is also absent, but the general picture is of an exceptional building which has passed through a number of hands in the last fifty years and which has not always been well maintained. Against that background we think it much more likely that the cause of internal damage is the delicacy of the decorative features coupled with a long standing lack of maintenance of the building fabric in the past.

406. On inspection we concluded that the slight misalignment and change in floor levels between the green bathroom (rooms P41/42) and the adjoining room P40 on the western side (item AH) is simply due to the alignment between two parts of the structure which were built at different times, there being evidence that there was some 'levelling up' of the brickwork externally too.

The camellia house

407. The early 19th century camellia house is a rectangular single-storey masonry building with full height windows along its south facade arranged in nine bays separated by stone pilasters and with four freestanding ionic columns flanking the central doorway. It has a dual-pitched timber and glazed roof supported on cast-iron trusses. The southern parapet is surmounted by stone bottle balustrade from which the original stone ornamentation was removed during repairs in the 1960s. The flank and rear walls are of brick, and the building abuts at the rear onto a range of

much lower single-storey brick and stone outbuildings (thought originally to have been designed as a summer house in either the 17th or 18th centuries) with heavy and valuable stone slate coverings to pitched roofs. The building is located in a relatively secluded part of the formal gardens close to the boundary wall and has been vulnerable to vandalism.

408. Although the building is Grade II* listed it is now in very poor condition.

409. The Arup 2007 condition survey identified a number of defects in the camellia house attributed to extensive and significant movement and it is common ground that the building has been seriously affected in the past by mining subsidence. Mr Richardson said that the damage gave the impression of the whole building having been tilted bodily towards the south, and was consistent with subsidence engulfing its whole footprint. Mr Wilshaw estimated that the angle of tilt was about 1 in 40 and his Mulpan assessment suggested that the building had sunk by up to 1 metre along its southern façade and by perhaps 0.6 metres on its northern side.

410. The damage identified by Arup was later categorised under seven entries in the Scott schedule.

411. Three of the items of damage were acknowledged to have been caused by mining subsidence: the tilt of the building to the south, the (repaired) vertical cracks in the brickwork gable walls, and the lean of west wall. The Coal Authority's case was that, although mining related, these items date from the 1960s. The cracking in the gable walls is the subject of some quite dramatic photographs taken in 1961 which are on the historic claims files inherited by the Coal Authority from the NCB. That chronology was accepted by the claimants' experts in relation to the tilt to the south and the cracking in the gable walls.

412. Two items were agreed by Dr Beattie to be unrelated to mining subsidence: the erosion and efflorescence of stonework, and broken glazing were either attributable to weathering or to vandalism.

413. In his oral evidence Dr Beattie also acknowledged that the collapse of sections of the roof glazing was probably attributable to vandalism; on the basis of that concession the entry in the Scott schedule relating to "collapsed roof sections" was conceded by Mr Caws during his cross-examination of Mr Richardson. Despite that concession the claimants' closing submissions identified the collapsed roof sections as still being in issue, although they then said nothing specific about it. Having re-read the transcript of Dr Beattie's cross-examination (day 5, pp.84-87) it is apparent that he advanced no positive case that damage to the roof existed other than to the glazing. There was evidence from Mr McWilliams that the roof over the rear part of the building had been re-slatted and repaired shortly after the claimants acquisition of the property but had been damaged again by vandals. We are therefore satisfied that none of the roof damage at the camellia house was subsidence damage.

414. The remaining items of damage which are in dispute are the leaning flank wall, missing and cracked balustrading and the collapse of a section of spine wall within the building.

415. Unfortunately, because of the dangerous condition of the building (including the risk of falling glass from the roof) neither Dr Beattie nor Mr Richardson had been able to enter the camellia house to carry out any close inspection of the fabric. Doing the best they could Mr Richardson attributed the damage to general lack of repair and the effects of time and weather and Dr Beattie contended that the continuing impact of mining subsidence was to blame.

416. Both gable walls of the building have been repaired in the past by stitching in new brickwork for almost their full height. Dr Beattie accepted that this work had been done before the claimants acquired Wentworth Woodhouse. It is apparent from the Coal Authority's historic claims files that damage manifested itself in the early 1960s. In September 1961 longwall mining took place in the Swallow Wood seam immediately below and to the south of the camellia house at a depth of between 60 and 70 metres. Severe cracking was recorded in the east elevation in October 1961 together with other damage, and various masonry ornaments were taken down from the parapet at that time, but by January 1962 it was reported that the building was suffering no further movement. A damage notice was served and repairs then took place at the expense of the NCB. In 1964 substantial repairs were carried out to stonework, brickwork, glazing, internal floors and ceilings. In 1970 further re-pointing and roof repairs were completed.

417. It was common ground that the west wall is leaning out; it had originally been suggested by Arup's 2007 survey that the east wall was also leaning, but the verticality study carried out by Obsurvus has shown that not to be the case, as Dr Beattie accepted. He and Mr Richardson agreed that the most likely cause of the lean was that the roof is spreading. Where the experts disagreed was on whether the roof spreading was a consequence of the original ground movement, or was the result of the horizontal thrust exerted by the iron trusses or rafters which are bolted to a timber plate running round the top of the wall.

418. It was also agreed that there was damage to the parapet (open joints) and to the fragile balustrading supported by it. Neither expert had been able to get sufficiently close to make a detailed inspection. The final item of damage occurred in 2007, when a section of the central spine wall of the camellia house collapsed. When first inspected by Mr Scholey the collapsed area measured about 0.9m wide by 1m high. Following further deterioration, the damaged area has enlarged to about 0.9m by 3m.

419. Dr Beattie acknowledged that there was no evidence of new movement in the gable walls. We regard that as an important concession. If the camellia house had experienced a further phase or phases of ground movement, precipitated by mine water rebound disturbing the Parkgate seam, it might have been expected that new damage would be manifest in the same location as the original damage as the building resumed its tipping motion in the direction of the nearest underground workings.

420. While there is no evidence of any recent or continuing movement of the building, there is considerable evidence that it has arrived at its current dilapidated condition after decades of neglect. Mining had taken place in the vicinity and beneath the camellia house in five separate seams and at various times up to 1961. It is reasonable to assume that all significant mining related damage had been repaired by 1970.

421. We are also satisfied that no additional mining related damage occurred while the building remained in the ownership of the Fitzwilliam family whose agents appear to have been assiduous in presenting damage claims where this was felt appropriate. The building was inspected in 1976 by Donald Insall and found to be free of cracking in the areas previously repaired. A number of defects were noted in 1976. The general condition of the building was obviously a cause for concern but of specific relevance were the fact that a number of the balusters above the parapet were missing or loose, and inadequate arrangements for disposing of water and defects in the guttering which did exist was causing pointing to wash out and joints to open. In 1982 a damage claim was made by the Fitzwilliam estate but rejected by the NCB on the grounds that its liability had been discharged by the earlier repairs; the condition of the building was attributed to vandals, who had ripped lead from the rear roof and allowed water to enter causing "rapid deterioration". A further damage notice was given in 1986, but this too was rejected on the grounds that the damage was historic and unrelated to mining subsidence. It was also noted on inspection that previous repairs had opened up (presumably due to the inadequacies of the water disposal arrangements noted by Donald Insall rather than settlement of the building which was not suggested).

422. The building continued to deteriorate under the combined effects of vandalism, defects of design and neglect. In April 1999 it was said to be in very poor condition by Martin Stancliffe, Architects. The steel frame of the roof structure was corroding and the rear roof structure was derelict; internally the building was affected by rising damp. After the Newbold family acquired the building later in 1999 they took steps to make it weatherproof but were thwarted by vandals who removed newly laid lead from the roof on two occasions. The impression we were given by the evidence as a whole was that, since then, no significant work has been done in almost 15 years.

423. Given the limited observations which the experts have been able to carry out, and the extensive history of neglect, we have no hesitation in concluding that on the balance of probability the disputed items of damage at the camellia house are not subsidence damage, but are the result of the continuing degradation of the building over many decades.

424. In concluding that no continuing movement has occurred at the camellia house since the early 1960s we discount the evidence of Mr Giles Newbold that the building has "noticeably shifted forwards since 1999" and has gone from "almost vertical to leaning out" in the period of his family's ownership. That evidence was inconsistent both with the evidence of Mr Scholey, who has had more than 10 years of professional experience of Wentworth Woodhouse, and with the agreement of the experts that the tilt is historic. We do not think Mr Newbold was seeking to mislead the Tribunal but we do not regard him as a reliable source of uncorroborated evidence on the behaviour of the structure.

425. Finally, before moving from the camellia house, we note that the absence of mining related ground movement and subsidence damage to that structure since the 1970s is not supportive of Mr Stevenson's hypothesis that the workings in the Parkgate seam were disrupted by minewater rebound in such a way as to cause new damage at the surface. The Parkgate workings below the camellia house in the 1930s were of the room and pillar variety. They were undermined (not directly but within the zone of influence) by the Thorncliffe seam in 1947. They are therefore likely to have become seriously disrupted (although perhaps not as badly as the less conservative Parkgate room and pillar workings elsewhere). The circumstances are not identical to those at the stable block or the east front of the mansion, but the rise in minewater through the Parkgate seam in the 1980s or 1990s appears to us to have had no impact on the camellia house.

The south terrace wall

426. The south terrace wall has sustained five contentious types of damage: the wall leans forwards by varying amounts in different locations; its face is bulging and cracked (the prelude, in the case of bay 8, to a recent partial collapse); the surface of the ground immediately behind the wall has sunk in places (although it is agreed that for most of its length the depression is simply the route of a former gravel path about which no complaint is now made); the head of the wall is out of alignment; and there is cracking in the face of the wall (distinct from that associated with areas of bulging). The Scott schedule also recorded poor and inappropriate past repairs, but it is acknowledged by the claimants that these cannot be attributed to subsidence damage; it may nevertheless be relevant that, as Dr Beattie explained, the use of inappropriate materials in the repair of historic buildings (such as cement mortar in place of the original lime mortar) may accelerate the deterioration of the structure.

427. The damage in question is not recent, although it is likely to have got worse. When Arup's engineers produced their 2006 report following their first inspections of the site they described a number of large cracks and bulges in the terrace wall, as well as misalignment of the coping stones and many areas where the wall leaned out. They noted many old, inappropriate and poorly executed repairs, many of which had failed.

428. It was not suggested by Dr Beattie that the terrace wall is currently undergoing subsidence, and he considered that the period of monitoring of the studs fixed to the crest of the wall by Obsurvus after July 2015 was too short to be useful. We have already given our reasons for concluding that the patterns of tiny variances in levels which Mr Stevenson tentatively detected after repackaging the Obsurvus data do not support his suggestion that movement may be occurring.

The wall described

429. The terrace wall is a 440 metres long gravity retaining wall which varies in height from about 3 metres high at its western end to about 5 metres in the east. It was constructed by a cut and fill method by which the level of the sloping ground was excavated back into the slope to provide a foundation on which to build the wall and the excavated material was then used to

backfill the space behind the wall to raise it to the level of the terrace. The wall's 25 bays are separated by stone buttresses, although it is not known whether these are original or a modification introduced after the construction of the wall in 1735, perhaps following its collapse and reconstruction in 1736 or at some subsequent time.

430. Both the terrace and the wall itself follow the west-east slope of the hill, so that the eastern end is about 15 metres lower than the western. The slope is gradual, except for an area in about the middle of the wall where the ground drops quite sharply by about 1.5 to 2 metres. This change in ground levels is agreed to be the result of historic subsidence which occurred up to the 1960s and is not the subject of the current claim.

431. The wall was constructed with a batter (i.e. the face of the wall leans backwards) and it is topped by stone coping stones which have been replaced in some locations by concrete substitutes. In some places the wall is built in regular courses, while in others the stones were built up randomly; it is thought that these differences distinguish sections of original regular construction from sections which have been rebuilt more recently. Generally the area to the west of the central bastion has a uniform appearance, with few apparent repairs (except in the area of the gate, which was rebuilt in the 1960s). On our inspection we were not invited to look at the area to the west of the gate, beyond the end of the terrace, which may have been demolished and reconstructed after the opencast mining of parts of the park and formal gardens in 1947. The stretch of wall to the east of the bastion shows signs of having suffered more damage and has clearly undergone more repair.

432. The wall is built up from a solid sandstone stratum and is wider at the base than at the top. Where it has been possible to measure the base (in bay 8 where it has collapsed) it is 800mm thick and comprises about 200mm of facing stone and 600mm of rubble backing. In bay 8 the rubble core appears to have been bonded with mortar and tying stones can be seen securing the face to the backing. Cores taken through the wall in other locations suggest that the use of mortar to bond the rubble backing was variable and that the rubble/masonry backing may be unbonded in places. Further measurements of the thickness of the base of the wall were attempted through the holes from which cores were extracted; Mr Richardson measured the depth of the hole as 795mm while Wardell Armstrong, who supervised the digging of the trial pits and the coring, gave a figure of 950mm. Having heard Mr Richardson's explanation of why he considers his measurement to be accurate we accept his measurement. On the basis of that measurement Mr Richardson considered that the wall had, by modern standards, a low margin of safety against overturning.

433. Although the wall was built without movement joints there are joints between the bays and the adjoining buttresses, which Dr Beattie considered may provide some protection against lateral thermal expansion. Mr Richardson doubted the utility of these joints which he suggested had mostly been filled with mortar. It was common ground that this feature had not been intended to act as a defence against thermal expansion.

434. For periods of its history, including as recently as 1999, the wall was heavily draped in ivy of which only a small amount now remains; on our site inspection we were able to observe aerial photographs showing the ivy formerly to have been much more widespread and there is evidence that it concealed the extent of the damage to the wall in the 1960s and 1970s. The presence is unlikely to have been beneficial to the bonding of the stone face and the general stability of the wall.

435. Recent investigations have disclosed the remains of a gravelled path running along the terrace above the wall. The path is now grassed over and its surface appears as a depression about 2 metres wide immediately adjacent to the parapet; a drainage culvert runs beneath the path to take off surface water. The depression was originally attributed to ground movement by Dr Beattie and to the backfill having slumped as the wall either leaned or slid forward by Mr Richardson, but further investigations have shown that neither of these hypotheses is correct. In at least one location there is a more localised depression behind the wall, which appears to be the result of the wall tipping forward, as it does for much of its length.

436. In areas of the wall which have been repaired new weep holes have been created at low level, to allow any water accumulated on the terrace side to escape into the field and prevent pressure from building up. On our inspection it was agreed that the weep holes were currently dry and showed no signs of water staining. There is no evidence of a land drain at low level behind the base of the wall. In all but one of the nine trial pits (dug to a depth of 1.37 metres) no water was found to accumulate in the base of the excavation.

Historic subsidence damage and the NCB's involvement

437. The Mulpan programme run for Mr Wilshaw estimated that the ground beneath the wall is likely to have subsided by between 0.2 metres and 1.4 metres at different places along its length. It is agreed that this subsidence occurred at or shortly after mining close to or beneath the wall in the Barnsley seam (1947 and 1953), the Swallow Wood seam (1961-62), the Top Fenton seam (1957-62), the Parkgate seam (1937) and the Thorncliffe seam (1945-1947). The mining in the Thorncliffe, Swallow Wood and Parkgate seams took place immediately below the eastern end of the wall where the greatest historic damage is evident. It is though likely that part of the western end of the wall was taken down to facilitate the open cast mining in the Barnsley seam in the 1940s.

438. There is no doubt that the wall, the terrace above it and the drainage in the field below it have all suffered damage as a result of this mining activity, but the experts agree that damage caused by the extraction phase of longwall mining (in the Swallow Wood, Top Fenton and Thorncliffe seams) ought to have occurred contemporaneously with the mining itself and thus ought to have been completed by the mid 1960s. This expectation is consistent with the early history of claims in respect of damage to the wall, the first of which was for damage around the western gate in 1961. Gaps in the wall are mentioned in 1963 and these were attributed to subsidence which was said not yet to be complete. Although these gaps may have been to the west of the gate and therefore beyond our area of interest, it is apparent from the exchanges of correspondence on the NCB's files that the effects of subsidence were distributed widely along

the length of the wall: the area close to the temple was said to have experienced “considerable damage” while it was reported that towards the eastern end “the junction of the wall appears to have sunk 4 ft.”

439. In a letter of 11 September 1963 the NCB’s representative assured the Wentworth Estate’s agent that repairs would be attended to as soon as the settlement was complete. Despite this assurance the work took many years. A tender was received in November 1966 for the rebuilding of the gate, the temple and two lengths of the wall at its western end totalling 44 yards, and the terrace walk itself was reinstated in the same area in 1969. No clear mention is made in the NCB’s claims file of the remediation of damage at other locations until 1976 when a manuscript note on the file (which we take to have been prepared by an NCB employee) suggests that stepped fractures had recently been re-pointed along 350 metres of the wall leaving a further 70 metres still to be re-pointed and 25 square metres to be taken out and “re-bonded”. The quality of this work appears not to have been terribly impressive, with the note recording that 120 square metres of wall had been rebuilt in the past by the NCB without courses, in a “non-matching style”, and that the current re-pointing was being done using non-matching mortar.

440. The work undertaken in 1976 does not seem to have been arranged by the NCB and it may be that the patience of the Estate was simply exhausted, prompting it to take its own remedial action. The NCB’s February file note proposed making an offer of £1,200 towards the cost of the work and a few months later a rather suppliant letter from the Estate’s agent inquired if the NCB had yet given consideration to “the possibility of a grant in aid ... towards the cost of the necessary repair and restoration”. This may have been simply diplomatic, or it may have reflected an appreciation that mining was not the only cause of problems with the wall so that the most that could be hoped for was a contribution. The NCB’s reply acknowledged that it had an outstanding liability and proposed an allowance towards the re-pointing of fractures which had become visible now that ivy had been removed; as it was understood to be the intention of the Estate to have the whole wall repaired one bay at a time the NCB offered a one-off payment of £1,200 in full and final settlement of the claim for the whole of the wall. The Estate preferred to wait until it had consulted an architect before considering the offer, but in April 1977 a further damage notice was served following the recent collapse of a 25ft length of the wall.

441. It appears that, once again, the NCB responded to the April 1977 damage notice at a leisurely pace. In November 1981 it invited tenders for what appears to have been a very extensive programme of re-pointing and fracture repairs along the whole length of the wall which included taking down and rebuilding 8 square metres of the wall at the central bastion and a further 40 square metres in each of bays 6 and 8.

442. This work was carried out by J. Utley & Sons Ltd in the summer of 1982, and was recalled by Mr Pearson, who has farmed the arable field on the south side of the wall since 1975 as tenant of the Wentworth Estate in succession to his father. He told us that parts of the wall had fallen down in different places, including some really bad falls where masonry had all dropped into the field in, perhaps, three bays; in those locations the wall had had to be rebuilt

from the ground up, and in other areas less severe cracking was repaired at the same time. Mr Pearson could not be precise about when this event had occurred, but we think it likely that he was recalling the collapse which led to the repairs and partial rebuilding of the wall at the expense of the NCB in 1982.

443. It is apparent from a letter of 26 July 1982 that the programme of work was undertaken in response to the 1977 damage notice, but comparing the description of the damage in the notice with the schedule of work attached to the tender documents it is also clear that the NCB had accepted liability for a more extensive catalogue of remedial works; these had quite possibly been outstanding since the 1960s (although the need for quite so much re-pointing may not have been obvious until the removal of ivy in 1976). The final account for the work came to £8,460, which included the cost of taking down and rebuilding an additional 50 square metres of the wall.

444. In July 1992 six timber shores or props were erected to support a section of the wall in bay 8 which was found to be leaning. The invoice for the work is not addressed either to the Board or to the Estate, and it is not clear which of them paid it. Mr Pearson told us that the propping had obstructed cultivation of part of his field, and that the timber had later appeared to him no longer to be in contact with the face of the wall. He pointed this out to Mr Newbold who therefore arranged to have the propping removed; again it was not clear precisely when this occurred, although it must have been after 1999.

445. The impression given by the claims file is that by 1976 the NCB was not in a terribly good position to dispute its liability to make good the existing damage to the terrace wall, having failed to deal comprehensively with the damage which first became apparent in the early 1960s. It also suggests more generally that, at least until 1982 (when the camellia house claims were rejected) the NCB took a fairly relaxed view of its responsibilities and did not require much persuasion that it should make a contribution to the cost of repairs. We surmise that a robust rejection of the 1976 claim in relation to the wall, on the grounds that there had been no mining in the vicinity since the early 1960s, may not have been open to the NCB because it had never fully discharged its liability for previous damage which clearly was mining related.

The recent collapse of bay 8

446. Bay 8, rebuilt in 1982 and propped for a period between 1992 and at least 1999, has recently collapsed to the ground in two places. The collapse occurred in stages. Photographs taken in September 2014 show a bulge towards the bottom of the wall west of its centre line, with cracking around the bulging stone work. By February 2015 the bulge has pushed out and the front face of the wall has slumped down. By January 2016 this western section of the bay had completely collapsed over a width of about 5 metres. On our site inspection we were able to observe the mortared mass of rubble lying on top of the facing stones at the foot of the wall with the soil of the terrace above beginning to slide into the field through the gap.

447. Photographs of bay 8 taken early in 2016 also show the second area of collapse, about 4 metres wide and in the same bay but a little to the east of its centre line. The facing stone has collapsed and part of the rubble core has followed it, but in this location the collapse has revealed an earlier repair. It is believed that this repair was part of the work undertaken in 1982 at the expense of the NCB. In this location modern concrete blocks had been used to build an inner skin at the rear of the wall before the masonry facing was restored, but no steps appear to have been taken to bond the masonry to the new inner skin. The concrete inner skin is not present behind the first area of bay 8 to have collapsed.

Possible causes of the current damage

448. Dr Beattie attributed the damage to the wall to a large scale event which had caused movement, which in context could only be further ground movement caused by mining subsidence. Mr Stevenson pointed also to the presence of a minor geological fault running beneath the wall which was shown on the abandonment plans for one of the coal seams and which coincided with one area of damage where a panel had sheared from its adjoining buttress.

449. Before any investigations of the ground conditions on either side of the wall had taken place Mr Richardson suggested a number of potential causes of the more recent damage, all of which he considered to be consistent with non-mining related mechanisms.

450. The first of these was simply that, by reason of its size, age and design, the wall is inherently unstable, unable to contain the pressure of the retained ground behind it, and has always been liable eventually to collapse; it is known that it collapsed shortly after construction in the eighteenth century, and a prolonged period of neglect following the shock of mining in the 1960s has seen further collapses. In areas where the wall's rubble core is un-bonded, the core is liable to slump, causing the face of the wall to bulge and eventually to fail; lateral thermal expansion (especially in the curved wall of the rotunda) would be exacerbated by the absence of adequate movement joints and would contribute to the bulging and cracking typified by the photographic records of the failure of bay 8. The taller the wall (i.e. at its eastern end) the more solar gain it would experience and the greater the expansion of its facing skin.

451. Mr Richardson considered that confirmation that mining was not responsible for the condition of the wall was provided by a comparison between the degree to which the wall would have tilted (in the estimation of Mr Wilshaw based on the location and extent of mining) and the degree of tilt actually measured by Obsurvus; no correlation existed between actual and predicted tilt, and Mr Richardson took this as an indication that some alternative cause must be responsible for driving the wall out of plumb to the random and varied extent now observed.

452. Mr Richardson initially considered that the wall's intrinsic instability may have been exacerbated by pressure from the rear caused either by the silting up of drains beneath the terrace, leading to a build up of water, or by expansion of the backfill behind the wall. Neither of these hypotheses was confirmed by the digging of the trial pits in 2015, which found no evidence of water accumulating behind the wall. A third possibility canvassed before the

excavations took place was that shrinkage of the ground at the foot of the wall might have encouraged it to tip forward in places, but once again that hypothesis has not been substantiated, and it is now common ground that the wall is founded on rock.

Terrace wall - conclusions

453. We are again faced with a choice between the views of well qualified experts who have reached radically different conclusions on the causes of the current condition of the wall. In resolving that disagreement we have necessarily considered the confidence which we are able to have in their respective opinions. We are influenced in our judgment by one general factor which we have already mentioned, that is that both Dr Beattie and Mr Stevenson have been recruited to the ranks of the claimants' advisers long after the advice of their Arup colleagues had been relied on by the claimants in deciding to commence these proceedings. We are quite satisfied that their true opinions have been faithfully conveyed to us in their evidence, but we are conscious of the pressure of expectation that each is likely to have been under when called in to prepare their evidence. We give weight to that factor, but it is certainly not the only ground on which we have concluded that Mr Richardson's evidence is to be preferred on these issues.

454. Dr Beattie deferred to Mr Stevenson's views in some quite surprising respects, not least over the behaviour of old masonry walls (a subject which we would have expected to be beyond Mr Stevenson's particular expertise). This may have been a simple issue of practicality, with Mr Stevenson having greater availability to respond to the Coal Authority's evidence than Dr Beattie. Whatever the explanation, the result was that evidence on aspects of structural engineering was given by an expert in engineering geology. In view of their relative expertise it implies no disrespect to Mr Stevenson for us to place much greater reliance on the opinions of Mr Richardson where their views diverge on the performance of historic structures. One particular example was their disagreement over the propensity of gravity walls to fail suddenly after standing, apparently without incident, for decades or centuries – an occurrence which Mr Stevenson considered inconceivable without some external trigger, but which Mr Richardson had encountered on a number of occasions.

455. The horizontal cracking and localised bulging at the base of the wall in bay 8 is not consistent with a large scale event triggering damage, such as was suggested by Dr Beattie and Mr Stevenson, and appears to us to support Mr Richardson's hypothesis that the core of the wall may be slumping as the face of the wall experiences thermal expansion. The zones of failure in bay 8 provided evidence of the variable nature of the core of the wall, with some areas well bonded and others more loosely arranged. Although in this location there is at least one tying stone between the bonded core and the face, this has sheared, and we think Mr Richardson was probably correct in attributing this to the differential expansion of the cooler backing material and the exposed masonry facing. We were persuaded by Mr Richardson that this was the most likely cause of the failure of bay 8, and also explained the bulging and much of the cracking in other locations. Other cracking is the result of the failure of historic repairs or the further deterioration of a structure which has been poorly maintained.

456. We also found it difficult to reconcile what is known of the performance of the wall with the claimants' general causation hypothesis. Parts of the wall collapsed in 1977 and larger areas were rebuilt in 1982 to an indifferent standard and using materials which were liable to contribute to future damage. 35 years later a further collapse has occurred in the same location. We cannot readily relate this chronology to the postulated effect of rebounding mine water on damaged pillars supporting the roof of the Parkgate seam. It is not suggested by the claimants that mine water recovery had begun to any significant extent in the 1970s or early 1980s. Only the need to prop the leaning face of bay 8 in 1992 fits Mr Stevenson's theory of causation (although it is equally suggestive of the 1982 rebuilding not having been well executed), yet the props were either absent or performing no useful function for at least a further 15 years before the most recent collapses.

457. If the longwall mining of the early 1960s caused or significantly contributed to the damage to the wall which was finally repaired in 1982, as the NCB was prepared to accept, it must mean that the wall was cracked and in need of repair or rebuilding in areas for almost 20 years with only poor quality stop gap work carried out in the meantime. The lapse in time between the original mining and the eventual remedial work is too great for the damage to have been caused only by mining. We think it more likely that the wall is a vulnerable structure which, having experienced major trauma in the 1960s, has been at greater risk of deterioration ever since. There is no evidence of further repairs between 1992 and 2014 and we consider that the current condition of the wall is a reflection of an extended period of neglect.

458. Nor is there evidence of subsidence at the wall after the major change in levels which was recorded in 1963. Mr Stevenson's re-presentation of the Obsurvus level monitoring data covering a period of only seven months, and his conclusion that its tiny variances demonstrated the residual effects of subsidence continuing as late as 2015, were the least persuasive elements of his evidence. We would also have found it extremely difficult to accept the hypothesis (which was never explicitly applied to the wall) that subsidence could have been matched by an equal and opposite regional uplift; no benchmark readings are available to provide a starting point of any sort for that theory and the wall is too long and too vulnerable for it to be plausible.

459. We do not consider that the presence of a minor geological fault is likely to explain the occurrence of damage in a number of bays all along the eastern section of the wall and on the face of the rotunda. No more persuasive, in the case of the wall, is the alternative proposition that the principal mechanism of damage may have been strain rather than subsidence; at the mansion the fault line and the absence of direct undermining might make strain a more relevant consideration, but the workings which Mr Stevenson considers must have collapsed are directly beneath the eastern section of the wall. Had they behaved in the way Mr Stevenson suggests we think the damage to the wall would have been greater and more immediate.

460. The localised recurrence of structural instability over an extended period of 35 years, without evidence of further subsidence, does not fit well with Mr Stevenson's hypothesis and satisfies us that Mr Richardson is more likely to be correct in attributing the leaning, bulging and cracking in the wall to its age, mode of construction and lack of maintenance.

461. We conclude, therefore, that the recent damage to the terrace wall is not subsidence damage.

Conclusions

462. Having now considered the evidence of damage relied on by the claimants in some detail we can briefly summarise our final conclusions.

463. Following the cessation of deep mining in South Yorkshire and the discontinuance of strategic pumping, the level of groundwater has recovered and the former workings, including those surrounding Wentworth Woodhouse, have become progressively inundated since the late 1980s. Ground or mine water rebound had the potential to cause a new phase of damage to surface structures long after the end of active mining either by the disruption of historic workings causing collapse or further consolidation or by the reactivation of geological faults.

464. Had we been satisfied that damage to the structures at Wentworth Woodhouse had been caused in either of these ways as a result of mine water rebound, we would not have had difficulty in accepting that the damage was subsidence damage within the meaning of section 1(1) of the 1991 Act. If deep mine workings collapsed, or the fractured overburden above them settled, causing vertical or horizontal displacement, the resulting damage could fairly be described as having been caused by the withdrawal of support from land in connection with coal mining operations. Neither the lapse of time between the mining operations and the withdrawal of support, nor the key role played by returning water (itself previously kept at bay as part of those mining operations), appear to us to take the damage so caused outside the scope of the statutory definition of subsidence damage. If the cause of damage was the reactivation of a fault because of the discontinuance of pumping and the general return of water, so as to cause differential movement and the withdrawal of support either vertically or laterally from ground along the line of the fault, we would equally have been prepared to accept that that was subsidence damage.

465. However, we are satisfied that the mechanism of damage relied on by the claimants in this reference does not explain the damage at Wentworth Woodhouse. We think it more likely than not that the critical Parkgate seam was damaged to a much greater extent in the 1940s than Mr Stevenson's hypothesis allowed for. Although the possibility of further consolidation, triggered by returning mine water, cannot be ruled out, there is no evidence to support it having occurred. All of the technical monitoring evidence available since 1995 suggests that, on the balance of probability, the house has been stable. In the face of that data the suggestion that further subsidence has occurred during the same period depends on a theory of equal but opposite regional uplift in the surface of the ground which, having reviewed all of the evidence, we find implausible. The sequence of benchmark evidence is incapable of differentiating between subsidence which undoubtedly occurred in the 1960s and any that may have occurred subsequently. The evidence of recent large scale movement given by Mr Newbold was unreliable, while that of Mr Pearson was imprecise. When evaluated in the light of the technical and expert evidence, the more careful observations of Mr Scholey and Mr McWilliams did not establish that such changes as have occurred since 1999 were as a result of mining subsidence.

466. We are satisfied that Wentworth Woodhouse has experienced mining subsidence on a substantial scale. We are also satisfied that damage occurred for longer than would ordinarily have been anticipated by the application of conventional rules of thumb. This was, in particular, due to the presence of the fault which remained active for perhaps as much as fifteen years after the cessation of mining. We are also satisfied that the impression that mining related damage continued long after the time it would usually be expected to have ended was contributed to by the NCB's dilatory approach to carrying out or paying for repairs, which may have made it difficult until the 1980s for it to resist some questionable claims (the clearest example of this being in relation to the terrace wall).

467. The preliminary issue we have been considering asks simply whether coal mining has caused subsidence damage in the four areas of investigation, which clearly it has to the extent we have identified. In their submissions and in the lay and expert evidence which they relied on, both parties addressed the more relevant question, namely whether coal mining caused a second phase of subsidence damage after the 1980s when mine water rebound began to occur. For the reasons we have given we are satisfied that it did not.

468. In the light of our conclusions we now invite the parties either to agree or to make further submissions on what, if anything, remains to be determined in this reference.

Martin Rodger QC
Deputy President



P R Francis FRICS
Member

4 October 2016