



OUTER HOUSE, COURT OF SESSION

[2018] CSOH 75

A400/16

OPINION OF LADY WOLFFE

In the cause

DAVID O'CONNOR AND SUSAN DOCHERTY

Pursuers

against

SCOTTISH WATER

Defender

**Pursuers: Gordon Balfour; Plexus Law
Defender: Christian Marney; BLM**

12 July 2018

Introduction

[1] The pursuers were formerly the heritable proprietors of the house at 202 Millroad Drive, Glasgow (“the property”). On about 18 December 2013 the first pursuer noticed that a paving slab at the front of the property had disappeared into the ground. A day or so later, six more paving slabs disappeared into a larger hole that had opened in front of the property. Shortly thereafter the pursuers required to evacuate the property, as the increasing size of the subsurface void had affected the structural integrity of the property’s foundations and rendered it unsafe.

[2] Subsequent investigation by Scottish Water, Glasgow City Council and others, disclosed that a manhole immediately to the west of the property boundary had collapsed. The cause of this is disputed, but it is not disputed that a substantial subsurface void had occurred in the immediate vicinity of the manhole and under the property (“the 2013 collapse”). Scottish Water are responsible for the manhole, and the sewer to which it was connected.

[3] The property was demolished. The pursuers required to move elsewhere.

Basis of liability

[4] By this action, the pursuers seek compensation from the defenders. They rely on section 10 of the Water (Scotland) Act 1980 (“the Act”). So far as material section 10 provides:

“(1) Subject to the provisions of this section, a local authority or Scottish Water shall make full compensation to any person who has sustained damage by reason of the exercise by them or it of any of their or its powers under this Act in relation to a matter as to which he has not himself been in default.

(1A) The escape of water, however caused, from one of Scottish Water’s communication or supply pipes or mains shall for the purposes of subsection (1) above be taken to have been brought about by the exercise by it of powers under this Act.”

[5] To succeed with the claim under section 10 of the Act, the pursuers must show that there was an “escape of water” from a structure for which Scottish Water are responsible, and which cause damage to the property.

Summary of the parties’ positions

[6] It is common ground that the manhole and the garden ground outside the property failed and resulted in the 2013 collapse and loss of the structural integrity of the property. It

is also common ground that this was probably consequent upon a leak from the nearby manhole which contributed to ground disturbance or erosion and the undermining of the property. The sharp dispute between the parties is as to what caused the manhole to leak.

The pursuers' position

[7] The pursuers' case is premised on a prior event, the rupture of a water main in December 2008 near the property, which the pursuers contend damaged the manhole in some way, causing it to leak and which caused or materially contributed to the ultimate collapse of the ground under and around the property in 2013. A large volume of water was discharged at high pressure from a broken water main in December 2008 below Millroad Drive opposite the property ("the 2008 event"). The pursuers contend that the 2008 event was causative of the 2013 collapse.

[8] On Record and in the first report (dated January 2015) of the pursuers' expert, Mr Smith, the contention was that the escape of water in 2008 created flow paths from the vicinity of the water main toward the north-most retaining wall of a railway cutting (following the very gentle fall away of the ground in that direction). It was posited that the escape of water, and the subsequent disturbance of the ground, would have caused loss of support for the sewer or the associated manhole. As a consequence, it is said, mortar joints in the sewer or manhole would have opened up. This would have allowed leakage from the sewer into the flow path created by the water main rupture. This leak caused more soil to erode with a consequent loss of support over time for the structures above ground, including the property.

[9] The position in the second report of the pursuers' expert (in the form of a letter with appendices dated June 2018 ("Mr Smith's second report")) and that generally spoken to by

Mr Smith in his evidence, was that the water from the burst water main caused settlement in the immediate vicinity of the manhole. The consequence of the settlement was to apply forces to the manhole: these forces could have been frictional forces with a downward drag on the outer vertical surface of the manhole, or they could have been additional forces bearing down on the stepped shoulders of the manhole where they widened out below its upper vertical shaft. These forces damaged the manhole and this damage led to the ultimate collapse in 2013.

[10] In advancing their case, the pursuers relied principally on the 2008 event, which created two sinkholes: one in the immediate vicinity of the manhole and a second further away across a nearby railway bridge. They also rely on evidence of a sinkhole in the immediate vicinity of the manhole noted in November 2013. It was also suggested that the property was on the site of a former public house (which was likely to have had a cellar), and the possible build-up of water in this cellar may also have contributed to the collapse in December 2013, although this feature was not critical to Mr Smith's opinion as to the cause of the 2013 collapse.

The defenders' position

[11] The defenders resist the pursuers' analysis. They contend that the 2008 event was unrelated to, and had no causal connection with, the 2013 collapse. They advance alternative explanations for the 2013 collapse, including heavy rainfall in the month or so preceding the 2013 collapse (although Mr Smith does not accept that the rainfall was heavy at the material time) and, it is said, the poor quality generally of the land in this area. In respect of the latter feature, the defenders relied on the results of earlier non-destructive investigations ("NDI") and intrusive ground investigation works carried out by Donaldson

Associates Ltd (“DAL”) as part of a factual investigation into the 2013 collapse agreed to by all the relevant stakeholders. There was also reference to a sinkhole in 2011 some distance away from the property (to the southeast, along the line of the railway cutting) and limited anecdotal evidence of another sinkhole in 1999, on Millroad Drive perhaps to a little north of the pursuers’ property.

[12] The physical process that both experts appeared to envisage was that damage or loss of support for the sewer caused it to lose its structural integrity, allowing a leak to develop. The water escaping from this leak would have caused further loosening and disturbance of ground. This would have accelerated over time, ultimately leading to a significant loss of material and the development of the sinkhole. What divides the parties is whether the 2008 event was causative of the 2013 collapse. It is not disputed that there was a rupture of a water main (for which Scottish Water were responsible) on Millroad Drive opposite the pursuers’ property in December 2008, and which caused some damage - although the extent and nature of the damage was disputed.

[13] Accordingly, the principal dispute in this proof was the question of causation. Apart from very brief evidence from the first pursuer, the rest of the 3 days of evidence was comprised of expert evidence of Mr Smith and Professor Cook.

The Joint Minute

[14] On the morning of the proof parties presented a joint minute agreeing quantum in the sum of £220,000. They agreed that the pursuers were the heritable proprietors of the property and that the property was uninhabitable as a result of the formation of a sinkhole. The terms of a factual report prepared by DAL (“the DAL report”) was agreed. This was

very helpful as both experts relied on the factual material in the DAL report, including its many appendices, as the basis for the expression of their own opinions.

Description of physical features of and structures on the land

[15] Before detailing the expert evidence, it is necessary to provide a description of the layout and physical features of the land in and around the property. None of this was disputed and I need not identify the relative witnesses or productions.

The property and manhole adjacent to the property

[16] The area had originally been developed in Victorian times. The area was substantially redeveloped in the 1980s. The property was part of an estate built at that time. The estate replaced whatever had previously stood on the ground. The front of the property was oriented to the south. The western boundary of the property was the outer face of a brick wall. Immediately beyond this, and broadly in line with the front of the house, was a small soft area or verge between the western boundary of the property and Millroad Drive. Located immediately adjacent to the western edge of the pursuers' boundary wall, and broadly in the southern part of this soft verge, was a manhole identified as "MH 4713" (and which I shall refer to as "the manhole"). As will be seen, a sinkhole developed in the immediate vicinity (ie to the west) of the manhole in December 2008 and again in November 2013.

[17] It is also necessary to describe the roadway, the line and features of an abandoned railway cutting immediately to the south of the property, and the sewer system near the property.

Millroad Drive and the earlier Victorian Street

[18] Millroad Drive is to the west of the property and runs in a north-south direction. An old ordnance survey map discloses that this was formerly a wider street, previously known as Tureen Drive, but had been renamed and become narrower at some unknown point in the past. The wider width of the earlier street is relevant to the potential location of a cellar which may have existed below a public house known previously to have existed on the approximate site of the property. The western edge of the housing built on the eastern side of Millroad Drive in the 1980s would have intruded onto the roadway of the wider Victorian road.

The railway cutting

[19] Immediately to the south of the property is a disused railway cutting running in a southeast to northwest direction. The surface bed of the railway cutting is approximately 9 m lower than the ground level of the property and of the adjacent road, Millroad Drive. There is a railway bridge (running in a north-south direction) carrying Millroad Drive over the railway cutting. One of the chapters of evidence concerned the transportation of soil through the retaining wall on the north side of the railway cutting, including the accumulation of silty spoil at the weep holes at the foot of the retaining wall, as well as significant damp staining on the wall and haunch on the underside of the northern span of the railway bridge. Millroad Drive slopes down gently in a southerly direction toward the railway cutting, as evidenced by the flow of water from the ruptured water main in December 2008 in a southerly direction over the railway bridge.

The north retaining wall of the railway cutting

[20] There was evidence about the state of the north-most retaining wall and the haunch (or underside) of the railway bridge at the side nearest to the property. There were, for example, photos dating from the 2008 event showing substantial water staining for the bottom two-thirds of the retaining wall. There were large weep holes at the foot of the retaining wall at ground level. It was not disputed that there were significant deposits of silty soil issuing from these weep holes after the 2013 collapse. It would appear that approximately 30 m³ in volume of this silty material was transported from the site of the 2013 collapse through the ground and out through these weep holes and deposited onto the disused railway platform. Some of this material was described as being in the form of slurry which oozed beyond the platform and onto the track bed, forming a covering of about 1 foot in depth.

The sewer and the upstream and downstream manholes

[21] Returning to the manhole, it is necessary to describe in a little more detail its location relative to the sewer it serves and other manholes upstream and downstream, as well as to describe its own physical structure. There is a Victorian sewer running north to south under the solum of, and in line with, Millroad Drive. This is constructed of brick and is of classic egg-shaped design characteristic of sewers built in the Victorian age. The dimensions of the sewer are approximately 860 mm wide and 640 mm high at its highest point. Just south of the point where the sewer meets the manhole, the sewer curves and heads in a south-easterly direction broadly in line with the railway cutting. There is a further manhole some distance away or downstream from the manhole, at an approximate distance of 50 m, and identified variously as MH 5616 or MH 5614. (I shall refer to this as the “downstream

manhole".) The sewer is intended to take surface rainwater and is not a foul sewer. The fall line, or flow of the water in the sewer, also runs from north to south. There is a manhole upstream from the manhole which I shall refer to as "the upstream manhole".

The curve in the sewer to the south of the manhole

[22] As just noted there is a curve in the shape and direction of the sewer just south of the manhole. This is significant because one of the matters disputed between the parties is whether or not a 2011 CCTV survey within the sewer, commencing at the downstream manhole, reached the manhole. The particular issue is whether the 2011 CCTV survey was able to confirm that the sewer and manhole were intact at that time, as the defenders contend, or whether the 2011 CCTV survey was several metres short of the manhole and was, by reason of the curve, thereby precluded from giving any useful information in relation to the state of the sewer or manhole, as the pursuers contend. The depth of the sewer was about 3 m below the surface of the ground and about 1.5 m below the level of the mains water pipe.

[23] At the time of the 2011 and 2013 CCTV surveys inside the sewer, there was water flowing through the sewer but only to a relatively shallow depth. There was some evidence that in periods of high rainfall the sewer would flow to full capacity (ie rising to fill the whole chamber of the sewer tunnel).

The 2008 event

[24] It was not disputed that there was a rupture of the water main in 2008 on Millroad Drive. The water main was located about 1.3 m below the ground surface and ran broadly in line with Millroad Drive. This was about 13 inches in diameter and carried mains water

at significant pressure. This is evidenced by the fact that in 2008 the escaping water burst through the tarmac on the eastern side of Millroad Drive, precipitating the 2008 event. The first pursuer described water flowing down the road toward the railway bridge. Photos confirm the flow of mains water, forced by pressure through the ground until it broke through the tarmac surface of Millroad Drive. In his view, the precise distance was of no materiality.

Location of the burst water main

[25] It is necessary to describe the location of the burst water main in relation to the manhole. The burst water main is on the eastern part of the road surface of Millroad Drive, broadly in line with, or a metre or so north of, the south-western corner of the pursuers' garden wall. The ruptured point for the burst water main was a little bit south and west of the manhole. There was no precise evidence about the distance between the point of rupture of the water main and the manhole. Professor Cook was of the view that the distance was 4.5 m, whereas Mr Smith thought it was a little less than that but still several metres.

The two sinkholes created by the 2008 event

The sinkhole adjacent to the manhole

[26] The water main failure created two significant sinkholes. The first was immediately to the left or west of the manhole ("the first sinkhole"). The first pursuer was asked about this but he had no recollection about the state of the ground around the manhole after the 2008 event. So far as he could recall, before the 2008 event the ground around the manhole and the soft verge was level. Mr Smith endeavoured to mark the extent of collapse

of the first sinkhole by annotations to a photograph taken at the time. The first sinkhole was broadly oval in shape, with the length of the oval oriented on a north-south axis, ie in line with the sewer. The dimensions were estimated to be about to 3 to 4 metres by 2 metres. The hole or depression at the centre of the first sinkhole was about .5m deep. A substantial shrub at the edge of the first sinkhole had fallen sideways into its centre. Professor Cook suggested that the sinkhole had slightly smaller dimensions. This sinkhole was above the north retaining wall of the railway cutting and in the north-west corner of the railway bridge where it passed over that cutting.

[27] Professor Cook was at pains to emphasise that, in his view, the majority of the flow from the burst water main would have been above ground or at surface level, ie not travelling through the ground. He was also at pains to emphasise that the manhole was upstream from the location of the burst water main. In part, this was because on his approach, water would not flow against gravity. Be that as it may, it is clear that the force and volume of water from the burst main resulted in a substantial sinkhole whose centre was within one-half of a metre or so of the manhole. The photo of the location of the burst water main also shows a large area of water on all sides, including "upstream" from the location of the burst.

The sinkhole above the south retaining wall of the railway cutting

[28] The second sinkhole was about 13 m south and slightly east of the first sinkhole. This was broadly above the south retaining wall of the railway cutting and in about the middle of the span of the railway bridge. The second sinkhole was, in terms of the photographic evidence, much more dramatic in that there was a gaping hole with a complete loss of soil and a dark void of unknown depth - no bottom was visible. In one

photograph, the whole of a large shrub was shown tilted onto its side and dangling precariously from a sunken outcrop of soil which had not yet fallen into the void. The extent of the remedial works to these two sinkholes is unknown. For what it is worth, on the notation of one of the plans there is reference to “infilling” at the point of the second sinkhole, but not the first. Both experts presumed there would be a degree of compaction of the ground around these two sinkholes. They differed as to the likely force that might have been applied, given that the sinkholes were above the railway bridge. Mr Smith presumed that there might have been some restraint in the force of any remedial compaction so as to protect this structure.

The sinkhole at the manhole in November 2013

[29] The first pursuer explained that in about mid-November 2013 he became aware of a new sinkhole adjacent to the manhole. It is not disputed that the sinkhole noted in November 2013 (“the November 2013 sinkhole”) was related to the 2013 collapse. The first pursuer spoke to this location and he estimated that the depth at the centre of the sinkhole was 3 or 4 feet.

The DAL report

[30] After the 2013 collapse, a report was commissioned by the stakeholders (including Scottish Water, Glasgow City Council, the loss adjusters of the pursuers’ insurers, Historic Railway Estate etc). It was agreed at the time that this would be a factual investigation with no view expressed as to causation or allocation of responsibility. The principal report extends to 30 pages together with 16 appendices totalling a further 390 pages. The appendices to the DAL report included photographs dating from 2008, 2011, 2013, and 2014;

structural inspection reports from the highways agency; CCTV surveys of the sewer in 2011 and 2013 (the extent of the sewer system surveyed is disputed); Met Office rainfall records; extracts from geological maps and historical maps; annotated condition survey maps; geophysical investigation report and data from trial pits and dynamic probe information. There were also still photographs produced from a camera probe inserted into the void that opened up in 2013 underneath the property as well as 3D computer generated images of the void and the manhole.

[31] As noted above, the DAL report was agreed by joint minute on the first morning of the proof. The parties' experts relied on these factual findings and these did not require to be spoken to by other witnesses. For his part, Professor Cook reproduced all of the appendices from the DAL report in his own report, and he effectively incorporated the factual findings into the body of his principal report (number 7/6 of process) ("COWI's second report"). COWI was a successor company of DAL.

The 2013 collapse

The damage to the manhole in 2013

[32] The survey information dating from the 2013 collapse disclosed that the manhole had dropped virtually by about one-half of a metre, and there was substantial cracking in the form of a jagged line along one of its vertical edges. In the executive summary to the DAL report it is narrated that:

"a site inspection by DAL on 9th January 2014 discovered that a substantial quantity of soil appears to have been washed through a bridge abutment and has been deposited into the disused railway cutting adjacent to the site."

Pre-2013 events identified in the DAL report: the 2011 event

[33] Section 2 of the DAL report narrated several events including the 2008 event, which I have already discussed above, and one in October 2011. This event was referred to by the defenders' expert, Professor Cook, but ultimately discounted as of any relevance by the pursuers' expert, Mr Smith. It is necessary therefore to say something about the 2011 event. This was described as a medium void developing on the footpath between the front of 208 Millroad Drive and the line of the railway cutting running immediately to the south. Subsequent inspection of the nearby sewer by CCTV cameras on 3 and 4 October 2011 ("the 2011 CCTV") disclosed it was in "reasonably good condition, with no damage or ruptures recorded". It was accepted that no cause or explanation for the 2011 event was even identified. It is reported that some 19 tonnes of stone material were required to infill this void. The 2011 sinkhole was approximately 30 m distant from, and to the southeast, of the first sinkhole (ie which developed adjacent to the manhole in 2008).

Transportation of soil through the retaining wall of the railway cutting

[34] The DAL report also noted that a survey undertaken in January 2014 of the railway cutting immediately to the south of the property, ie under the road bridge, disclosed that the volume of soil deposited onto the platform and track bed of the cutting was estimated to be 29.3 m³. It is agreed that this volume of material was transported through the ground, through the structure of the retaining wall and issued out through the large weep holes at the foot of the northern retaining wall where it met the railway platform.

Ground investigation works

[35] Other investigation work undertaken for the DAL report included non-destructive investigations (“NDI”) in the form of ground penetrating radar (“GPR”) and Microgravity (“MGRV”) testing, although the areas of these forms of testing did not entirely overlap.

There were also intrusive ground investigation works in the form of the digging of shallow trial pits to a depth of 1 m, heavy dynamic probing and handheld dynamic probing. While the outcome of these investigations support the observation that the ground “in the general locale of the event is of a very loose or very soft nature” (as stated at page 2 of the COWI report, number 7/6 of process), there was no evidence that these conditions obtained at the manhole or in the immediate vicinity of the property.

The pursuers’ expert evidence

[36] The pursuers instructed Mr Neil Smith of Applied Geotechnical Engineering Ltd, who produced a preliminary report in January 2015 (“Mr Smith’s first report”). In addition to the DAL report and a statement from the first pursuer, he also had regard to Met Office rainfall data from the Paisley weather station (for the period 1959 to 2014), historical maps and certain Scottish Water records.

Mr Smith’s first report

[37] This report, which was described as a preliminary one, had been instructed shortly after the 2013 collapse. In relation to the 2008 event, Mr Smith stated in his report (at section 4.1) that “one effect of the burst was the creation of water flow paths from the burst to the retaining wall and the underside of the bridge arch”. He went on to state that:

“backfilling was probably carried out using coarse granular soil and, as the hole was directly above the bridge arch, I think it unlikely that heavy compaction was used. The flow paths opened by the water leaking from the main will therefore have remained. ”

He also referred to the 2011 event, but I need not narrate his comments in his provisional report about this, as his final view in oral evidence was that the 2011 event was of no significance.

[38] He was asked to provide his expert opinion to two questions. The relevant part of his provisional report is as follows:

“8 SUMMARY OF MY CONCLUSIONS

On the basis of the information given to me, my opinion is that the most probable cause of the collapse was a defective sewer in the vicinity of [the manhole]. The fact that the ground movement was first seen in the verge on the other side of the sewer from the garden of No 202 [ie the property] I take to be strong evidence that the buried structure below the garden was not involved in causing the ground movement.

The evidence that I have seen does not indicate that SW investigated the effects of the 2008 water main burst to a sufficient degree. I have seen no evidence to suggest that GCC investigated the cause of the 2011 collapse, though I do not have information to confirm which party would have been responsible for the footpath where the collapse occurred. Apart from site inspections, the DAL report does not include any information which suggests activity on the part of either SW or GCC to find the cause of the initial subsidence seen on 12th November 2013 before movement was reported in the garden of No 202 Millroad Drive.”

Mr Smith's second report

[39] Mr Smith also commented on the defenders' expert report, intimated shortly before the proof. He did so by letter dated 4 June 2018 (with its several appendices) (“Mr Smith's June 2018 report”). The material parts of Mr Smith's June 2018 report are as follows:

“Firstly, I would like to deal with the location of the collapse. Cowi's report asserts that the water main burst in 2008 was too far from [the manhole] to cause damage to the sewer. It is also pointed out in the report that the sewer tunnel is at a substantially greater depth than the water main. Figure 1 is taken from Appendix G

of the Cowi report and shows the location Cowi deduces for the burst. The location is incorrect. Figure 2 shows two photographs from the BRB report of 3rd December 2008. The lower picture (BRB Photo 4) shows the location of the crack in the main. The upper picture (BRB Photo 3) shows the perimeter of the pit and the garden wall of 202 Millroad Drive. It is clear that the burst is located further away from the cutting than the corner of the garden wall. Figure 3, attached, is a Google Earth image from 2009 (dated 11 May) which I have annotated to show the location of the burst as determined from Figure 2, together with the line of the retaining wall of the cutting, the location of [the manhole] and the corner of the garden wall.

Figure 4 is another image taken from the Cowi report, Appendix A. This was taken shortly after the burst, when water was still flowing, but Herras fencing had been erected around the soft surfaced verge between the garden of 202 Millroad Drive and the road. The location at which the water appears at the surface is consistent with my Figures 2 and 3. The photo shows that the road surface had not subsided significantly at that time, but the Herras fencing suggests settlement of the soft verge had occurred by then. Note the position of the Herras fencing in relation to the low black rail, which I take to have been a barrier to prevent vehicles driving onto the verge.

Figure 5, also taken from Appendix A of the Cowi report, shows the area around [the manhole] shortly after the water main burst. I have included two copies of this photograph, so that my annotations do not obscure the basis on which I have made them. The photograph clearly shows an area of significant settlement close beside [the manhole]. From the positions of the Herras fencing and the low level rail, I believe it to be the case that this photograph was taken shortly after the burst and before excavation was started to expose the main for repair. It is clear from this image that the ground beside [the manhole] settled significantly as a result of the water main rupture.

Manholes typically have a narrow entrance at the surface and open out below ground to provide working space for sewer maintenance. I do not have a diagram giving a section through [the manhole], but the 3D scanning images in Cowi's Appendix M do provide confirmation that this was the case. I have used one of those images in Figure 6, which shows that the widening of the manhole was modest on the side nearest the water main and the collapse seen in the previous figures. In my opinion, this was, nonetheless, significant. The settlement of the ground beside the manhole could have imposed significant downward frictional and bearing forces on the manhole structure. If the soil movement local to the side of the manhole had included a horizontal component, then that side of the manhole would have lost support from the ground, with a void or loosened soil beside it. Whatever the precise detail of the direction of the ground movement, I consider it very probable that some damage was inflicted on [the manhole] in 2008. Leakage from the manhole would continue a process of erosion over time, maintaining the flow paths that were created in 2008 leading to the retaining wall of the cutting.

I consider it to be highly relevant that the first indication of ground movement on 12th November 2013 occurred between [the manhole] and the line of the water main, precisely at the location of the 2008 subsidence seen in Figure 5. I also believe that a cellar did previously exist under No 202 Millroad Drive and that it was constructed sometime between 1861 and 1893. It was then abandoned and built over in a redevelopment which took place between 1933 and 1967. The original construction would have resulted in some loosening of the ground around the excavation for the cellar and it is likely to have been poorly backfilled. Erosion of the ground between the manhole and the water main would have caused small lateral movements of the structure over the period following the 2008 burst. Such movements coupled with looser or softer ground between the manhole and the cellar would explain the migration of the subsidence that took place between mid-November and mid-December 2013.

I note that the BRB routine survey of the cutting, carried out on 6th December 2013, makes no mention of subsidence. It includes a photograph taken from the southwest side of the bridge looking up Millroad Drive towards the location of the subsidence.

If the cellar had contained significant amounts of water, accumulated over the decades since its abandonment, there would have been a sudden rush of water when the structure began to crack. An intense outflow of water from the cellar would have caused rapid erosion of the soil in its path. Such a progression would be consistent with Mr O'Connor's witness statement, in which he avers that Ms Doherty (his partner) first noticed subsidence in the garden of 202 Millroad Drive late on 18th December and that a significant void had opened up in the garden on 19th December. By 19th or 20th December, the hole had developed to the extent that the house was considered unsafe for habitation.

The Cowi report states, in Section 5 'Expert opinion', the final paragraph of Section 5.2 (Question 1)

'Further evidence to support this opinion [that the main rupture did not damage the sewer] is presented in the 2011 CCTV footage of the sewer, which was carried out following a ground subsidence event outside 214 Millroad Drive, approximately 30m south east of the 2013 event. The CCTV footage was carried out from MH5616 to MH4713 and indicates that the sewer was transporting water with no indication of major structural defects. While some surface degradation of the mortar joints is visible there is no indication of open joints or major structural defects. The CCTV survey terminates at the location of MH4713 and a laminar flow of water is visible. The lack of disturbance to the flow of water at the location of the manhole suggests that the sewer was in working order at the time of the 2011 survey.'

In the Cowi report, it appears that a distinction is drawn between the manhole and the sewer, so the statement in the first sentence of the passage quoted above would be true with that rider. However, in the quote above, it is also stated that the 2011 CCTV survey terminates at the location of [the manhole]. This directly conflicts with

the statement in the letter written by Mr Phillips of Cowi to SW in March 2017, in which he states 'it is apparent that the sewer deviates right after the end point of the survey'. Figure 7 shows two still images taken from the 2011 CCTV survey. Figure 7(a) is included because it provides a better view of the tunnel as a whole than the final image taken from 51.0m along the tunnel. It is clear that this survey provides no information as to the state of [the manhole] post the 2008 water main burst. The CCTV survey taken on 19th December 2013 of the collapsed manhole includes a view into the curved section of tunnel. I have reproduced the still image in Figure 8. It shows that that part of the sewer tunnel (the curve) is structurally intact, though it cannot be taken as evidence that no movement has taken place.

I will comment briefly on the 2011 collapse near 214 Millroad Drive. There is no evidence that the collapse was caused by any defect in the sewer between [the manhole] and [the downstream manhole]. The collapse at surface was about 2.5m from the line of the sewer (see my Preliminary Report, Figure 7). There was, however, a drain pipe seen in the excavation to repair the collapse (see my Preliminary Report, Figure 8) and this pipe may have contributed to the collapse if it had been leaking.

Time constraints prevent me from addressing other points from the Cowi report at this moment, but I will refer briefly to a suggestion that the ground in the Millroad Drive area includes zones with low strength and hence naturally poor ground may have been a factor in the collapse beside No 202. The area was developed in late Victorian times, so the sewer had existed for well over 100 years at the time the collapse occurred. It had been functioning satisfactorily for over 30 years following the major redevelopment of the area c1980. Therefore I do not believe this was a factor in the collapse.

To conclude this letter, it is my opinion that it is highly probably that the water main rupture in 2008 damaged the structure of [the manhole] and that the damage eventually led to the collapse of the ground in November – December 2013. I do not believe that the collapse would have occurred without the water main rupture. Given the photographic evidence from 2008 of significant ground movement immediately adjacent to [the manhole], I consider that SW was negligent in not carrying out at least an inspection of the manhole as part of the remediation of the rupture."

[40] In summary, in his second report Mr Smith challenged the defenders' report as to the location of the burst water main central to the 2013 event. He concluded that the sinkhole immediately adjacent to the manhole outside the property caused significant settlement as a result of the 2008 event and he also challenged the assertion that the 2011 CCTV survey

reached the manhole. In his view the 2011 CCTV survey provided no information as to the state of the manhole following the 2008 event.

[41] Addressing the manner in which the 2008 event operated as a cause of the 2013 collapse, Mr Smith posited in his second report, that “[t]he settlement of the ground beside the manhole could have imposed significant downward frictional and bearing forces on the manhole structure.” He also suggested that

“[i]f the soil movement local to the side of the manhole had included a horizontal component, then that side of the manhole would have lost support from the ground, with a void or loosened soil beside it.”

From this he concluded:

“[w]hatever the precise detail of the direction of the ground movement, I consider it very probable that some damage was inflicted on [the manhole] in 2008. Leakage from the manhole would continue a process of erosion over time, maintaining the flow paths that were created in 2008 leading to the retaining wall of the cutting.”

[42] He relied particularly on the fact that the first indication of ground movement on 12 November 2013, noted by the pursuers, and which occurred between the manhole and the water main, was at precisely the same location as the first sinkhole that developed as a consequence of the 2008 event (as shown in several photographs).

[43] As recorded in the extract of Mr Smith’s report, just quoted, he also posited the existence of a cellar and the role this might possibly have played in the 2013 collapse. He considered that there was probably a cellar, first, because the property was formerly the location of a public house (he had examined several historical Ordnance Survey maps which disclosed the existence of a public house) and, secondly, in his view the still images taken from the camera probe after the 2013 collapse disclosed brickwork which he interpreted as part of the cellar. From this, he surmised that there might have been the

accumulation of an substantial volume of water, which he considered was most likely contained within the area of a former cellar.

[44] In any event, his conclusion was that

“it is highly probable that the water main rupture in 2008 damaged the structure of [the manhole] and that that damage eventually led to the collapse of the ground in November-December 2013. I do not believe that the collapse would have occurred without the water main rupture.”

Mr Smith's oral evidence in chief

Flow paths

[45] Mr Smith was asked to explain about flow paths. A flow path was a preferential route which concentrated volumes of water that came into the vicinity of that path and resulted in a greater quantity of water flow than would otherwise have been the case in the absence of a flow path. In this case, the flow path was the route the water would have taken from a leak or hole in the manhole to get to the bottom of the arch of the bridge and retaining wall on the north side of the railway cutting.

[46] While the repair, including backfill (which was presumed to have been compacted), may have blocked the flow path to a depth of about one-half a metre, Mr Smith doubted whether the flow path would have been destroyed. He did not believe that the presence of a flow path itself would have played a part in initiating the damage, but it would have facilitated it once these events unfolded.

Presumed damage to the manhole caused by the 2008 event

[47] The evidence from the 2008 event clearly disclosed that the burst water main had resulted in quite a significant sinkhole or subsidence immediately beside the manhole. The sinkhole was about 3 to 4 metres wide by 2 metres and had a depth of about .5 of a metre.

The manhole had a relatively narrow vertical chamber at its top but this widened as it went deeper. In Mr Smith's view the effect of a large body of soil settling adjacent, ie at the side of the manhole, caused movement in the brickwork and possibly down to the base (or invert) of the manhole.

The November 2013 sinkhole

[48] On 12 November 2013 subsidence was noted in the same position as the sinkhole in 2008. Mr Smith surmised that between the 2008 event and the November 2013 sinkhole there was leakage from the manhole at that location. As a consequence, there was a path for water to run from the side of the manhole toward the point of the water main burst and flow paths towards the railway cutting. Quite possibly, there would have been slow erosion of the soil over this period but it did not develop sufficiently to be noticed. So a void probably would have formed in the region of the manhole and would have brought about the depression in November 2013.

The cellar

[49] Mr Smith suggested that there was a cellar on the site of the old public house, which was on the other side of the manhole than the sinkhole ie under the property. The construction of this cellar would have involved excavation to the side and filling up to the cellar's brick wall. There were some anomalous ground conditions at that location. Any movement in the manhole could have caused lateral movement of the ground and of this back fill material, and reduction in the support of the cellar wall.

Rainfall data

[50] After having examined the rainfall data from the Met Office for Paisley, Mr Smith discounted rainfall as a cause of the 2013 collapse. The data disclosed that rainfall in September 2013 was below average; in October it was above average but well below prior maxima; and rainfall for the month of December was below average. Overall, rainfall was not particularly excessive in the months preceding the 2013 collapse.

[51] Mr Smith modified the opinion expressed in his first report in the following respects:

- 1) While he had not previously distinguished between the sewer and the manhole (using the former word to include the latter), he now distinguished between these different parts of the defenders' structure. He remained of the opinion that the manhole had been damaged by the 2008 event, but he expressed this as a probability rather than as a possibility.
- 2) He considered the 2011 event of no relevance to the 2013 collapse. This was because it was quite different from the 2013 collapse. There was no relevant background to the 2011 event, in that there was no history of another disruptive event that preceded it. Little was known of what had happened. No cause for it had been identified.
- 3) He identified, and placed some emphasis on, the effect of frictional forces operating on the manhole as a consequence of the subsidence of the ground next to it. These frictional forces could have operated in two ways. The subsidence of the ground could have pushed directly onto the shoulder of the manhole where it stepped or broadened out beneath the vertical shaft. The other way friction could operate would be by a frictional drag between the vertical surfaces, pulling the brickwork down. On the hypothesis that there had been

earth all around the manhole before the 2008 event, this would have supported the manhole on all sides. One consequence of the subsidence or the development of the sinkhole was that a void opened up or resulted in looser material at one side of the manhole. This would lead to a tendency of the manhole to move laterally. These possible forces probably damaged the manhole in 2008, resulting in loosened brick work or cracking. The ground to the side of the manhole (ie at the site of the sinkhole) had moved substantially. This sinkhole evidenced this. While it was hard to say precisely how the manhole would have responded, it was very probable that the manhole had suffered some damage and the top may have been pushed down toward its base. The fact that the water from the burst main was at a shallow depth did not mean that the damage was confined to a shallow depth. Given the nature of the Victorian structure, any sort of damage would have resulted in leakage. This would likely have been where the manhole met the sewer tunnel. In his view, the 2008 event remained significant, because the erosion and ground movement in 2013 was as a result of the 2008 disturbance.

Comment on the non-destructive and destructive investigations

[52] Mr Smith was taken to sections of COWI's second report (which, as noted above, effectively incorporated the DAL report). He explained in detail the nature of the non-destructive investigations ("the NDI"). He also explained the nature of the intrusive investigations. These were relatively limited. The probes went no deeper than 1 m and they all terminated within made ground. None of these penetrated into the natural materials

which was the point of erosion into the railway cutting. One could not extrapolate the conditions found at a depth of 1 m to the conditions at greater depths.

[53] At most, these investigations disclosed that there were variations in the ground conditions, ie in the density of the ground. The NDI identified some areas of low density or voids, but when these were associated with intrusive ground investigations, which also provided evidence of poor or weak ground, the correlations between these areas was not good. It was a fair summary to say that there were areas of weak ground, but ground conditions were variable. In his view, this data did not support the conclusion that the ground was generally poor in this area, as was contended in COWI's second report. There was not much evidence. He had checked the British Geological Survey websites for the area but there were no specifics. There was no section on geology in COWI's second report. There had been no samples taken or tested of the materials being washed through the retaining wall into the railway cutting. Had there been, this could have helped to define what was being looked at.

Comment on COWI's second report

[54] Mr Smith also commented on other statements in COWI's second report as follows:

- 1) In relation to the contention (at page 12) that there had been "substantial rainfall", Mr Smith did not accept this. The 2013 collapse had started by 12 November 2013, the date that the sinkhole around the manhole had been reported. The rainfall peaks referred to by COWI all post-dated this date. Rainfall played no part in the initiation of this collapse.
- 2) In relation to the contention that the sewer had not been damaged by the 2008 event, Mr Smith agreed with this to the extent that the reference to "the sewer"

was to the sewer tunnel itself, but excluding the manhole. He disagreed with this statement, if it were intended to refer to the manhole. In his view, this had sustained damage as a result of the 2008 event.

- 3) In relation to COWI's statement that the 2011 CCTV survey had shown the state of the manhole, and their reliance on this as a basis to assert that the 2008 event had not damaged the sewer (including the manhole), Mr Smith was firm that the 2011 CCTV survey had not in fact reached the manhole. The 2011 CCTV survey was played and Mr Smith spoke to his interpretation of how far it reached and what it showed, and what it did not show (which was the entirety of the internal structure of the manhole). The 2011 CCTV survey had not extended beyond the curve, and therefore could give no evidence one way or the other as to the state of the manhole. As Mr Smith pithily put it: 'the absence of evidence was not the evidence of absence [of damage]'
- 4) In relation to the suggestion that one could ascertain the state of the ground generally (or the degree of disturbance caused by the 2008 event) by reference to the sides of the excavation pits dug around the mains water pipe for the purposes of its repair (or the photos thereof), Mr Smith did not accept this. Looking at photographs 3 and 4 in the last of the Highways Agency ("HA") reports contained in Appendix B to COWI's second report, these disclosed nothing about the depth of the disturbance caused by the 2008 event. None of the available photos showed this. The 2008 event had resulted in water and soil being transported through the retaining wall. The subsidence at the manhole also confirmed that the escape of water under high pressure had had an effect. Accordingly, these photos provided no support for the statements (at page 20 of

COWI's second report): (i) that these photos showed that the "deepest section of disturbance" were at 1.3 m; (ii) that the disturbance caused by the 2008 event "was confined to the location of the pipe rupture [ie the water main] itself" or (iii) that "the depth of disturbance is shallower than at the water main". The excavation pit had been dug to repair the water main, not to ascertain the extent of ground disturbance. In any event, strictly speaking, it was not correct that the sewer was 1.5 m below the water main. The manhole came to the surface. The disturbance to the upper part of the manhole could have disturbed the ground around the lower part of the manhole, too.

- 5) In relation to the propositions that the burst water main was downstream from the manhole and that the escaping water flowed downhill (only) over the surface of the road, and the inference that any disturbance was similarly confined to that area, Mr Smith did not accept these propositions. Not all of the water flowed along the surface of the ground. The HA report had referred to water coming through the retaining wall of the cutting and some of the photos (in Appendix B to COWI's second report) showed water dispersed all around the ruptured water main. There was also the evidence of the depression or sinkhole next to the manhole which was upstream from the burst main. It was not correct that the ground disturbance consequent upon the 2008 event was confined to a shallow depth or to an area in the immediate vicinity and only to the south of the water main.
- 6) In relation to the conclusion, based on some of the foregoing propositions, that the burst water main in 2008 was too far from the manhole to cause damage, Mr Smith firmly rejected this.

[55] It remained Mr Smith's position that the substantial amount of ground that settled next to the manhole in 2008 imposed sufficient frictional forces on the manhole so as to damage it.

Comments on COWI's first report

[56] In relation to the COWI's first report (no 7/4 of process), certain passages of this were put to Mr Smith for his comment:

- 1) He reiterated his analysis that the 2011 CCTV survey did not disclose the entirety of the interior of the manhole. The 2011 CCTV survey did not go beyond the known curve in the sewer immediately south of the manhole. Furthermore, having regard to the shorter length the CCTV camera had travelled (of 47 m) compared to the known length to that section of sewer between the manhole and the downstream manhole point (of c 51 m), it was unequivocally the case that the 2011 CCTV had not reached the manhole and its camera had not disclosed the entirety of the internal chamber of the manhole. Accordingly, in his view, COWI's first report overstated matters when it said that the 2011 CCTV had disclosed the state of the manhole or that it supported any positive conclusion that the manhole was at that stage undamaged. The 2011 CCTV survey provided no basis for COWI's conclusion that as at 2011 the manhole was undamaged. Nothing in what he observed from the 2011 CCTV was inconsistent with his own explanation. The fact that there was laminar (ie smooth) flow of the water after having passed the invert of the manhole did not necessarily support an inference that it was undamaged.

Mr Smith's oral evidence: cross-examination

[57] Mr Smith was cross-examined on a variety of topics. In particular,

- (1) On the issue of laminar flow, Mr Smith did not accept it was significant or conclusive that the 2011 CCTV footage showed smooth flowing (or a laminar flow) of water immediately downstream from the manhole. The fact that the flow was laminar was not strong evidence that the manhole was undamaged, as COWI assumed. It would depend on the flow rate of water which, in any event, could settle down after having been disturbed at an earlier point upstream. The existence of a laminar flow was not a strong consideration from which to draw any conclusion about state of the manhole in 2011.
- (2) In relation to the 2013 CCTV, this showed the damage to the manhole after the 2013 collapse. It showed a collapse of the manhole at its base. Debris was washed onto the floor of the manhole. Its integrity was breached, including on one of the vertical walls. Water was escaping from the bottom of the manhole, ie it was not going into the sewer tunnel but flowing out of the void created by the collapse. In other words, water was flowing or leaking into the ground and ultimately travelled through and came out of the retaining wall of the railway cutting.
- (3) In relation to the 2011 CCTV, in his view this did not show the entirety of the manhole. It did show that the sewer tunnel was intact, at least up to a point a little downstream from the manhole.
- (4) Mr Smith was also questioned about his use of the word "collapse". This simply meant a depression or settlement. He used settlement and collapse

interchangeably. He preferred the word “collapse” because what had happened, had happened quickly. Whereas the use of the word “settlement” did not have a connotation of that nature; it simply meant downward movement.

- (5) Mr Smith was challenged on the basis that, if he had wanted to produce the best report, he would have investigated the ground prior to 2008. Mr Smith stated that there was no information about the condition of the ground at that time. He was not aware of any significant movements or investigations in the vicinity prior to 2008. He rejected the suggestion that he should have asked the pursuer about this, his view being that the pursuer would have had no knowledge. In like vein, Mr Smith was also challenged on his use of the phrase “extent of collapse”, on the basis that this presumed some knowledge of the pre-collapse state of the ground (ie the use of the word ‘extent’ implying a comparator). While he accepted that that might be the case in the ideal circumstance, it remained his firm view that there had been significant settlement or collapse which occurred in 2008 immediately adjacent to the manhole. He believed it was a combination of the effects of this collapse, caused by the burst from the nearby water main, and the nature of the ground, which led to the 2013 collapse.
- (6) He was challenged on the basis that he had not measured the area of collapse shown in the 2008 photograph of the sinkhole adjacent to the manhole. Mr Smith was of the view that an estimate was sufficient. In any event, in his view the area was larger than 2 m by 1.5 m, which was Mr Smith’s own estimation.

- (7) He agreed with the proposition that Victorian manhole and sewer structures were substantial, reasonably robust and probably well-constructed. They were intended to take a degree of loading, although his own view was that the construction was based on experience rather than a specific design process.
- (8) Professor Cook's view that the ground settlement in 2008 did not add to the load on the manhole was put to Mr Smith, who did not agree with this view. In Mr Smith's view, the settlement had increased the loading on the structure of the manhole and some stress would have been applied to it. He was challenged on the basis that he had not produced any calculations to support this, which Mr Smith accepted. Mr Smith explained that there was insufficient information to make a calculation, or, at least to do so without making a number of assumptions. He also accepted that this particular observation, about the stress on the manhole structure, had first been identified in his second report. Certain passages of that report were put to Mr Smith, and he accepted that he suggested this was a "possibility" rather than that this had "definitely" happened. However, in his view, the ground had settled adjacent to the manhole and if there was movement at the interface of the ground and the manhole, or onto the stepped part of the brickwork, these movements would have posed the downward bearing forces which he had described. He accepted that it was not known precisely what had happened below the surface, but countered, it was known what had happened at the surface of the ground.
- (9) In relation to his observation about "horizontal soil movement", it was put to Mr Smith that we simply did not know what had happened. Mr Smith's position was that it was probable that there had been lateral movement as a

consequence of the settlement or collapse creating the sinkhole adjacent to the manhole. Particles of soil would flow into the tunnel at the bottom, so there was sideways as well as downward movement. If there had been a loosening of the material at one side of the manhole, it would not necessarily involve movement of the manhole but it would create an imbalance of forces as between one side of the manhole and the other.

(10) Under reference to a number of photographs showing the sinkhole beside the manhole in 2008, Mr Smith confirmed his view that this showed a considerable degree of ground disturbance. It was put to him that these photos showed the deepest level of disturbance and that this was confined or local to the manhole, a proposition which Mr Smith rejected. In his view, one could not tell from these photographs how deep the disturbance was at any particular point. The water escaping from the manhole would go in all directions including downwards. In other words, there would be water downwards from the burst water main which went directly into the ground. That water would have continued to travel downwards and ultimately to have escaped through the retaining wall. In his view, the sinkhole adjacent to the manhole was caused by the activity of water at some point below the ground, where the ground had settled. He accepted he could not be precise about this.

(11) In relation to the reinstatement works, Mr Smith accepted that there was no information about this but he doubted whether that work went beyond remediation of the sewer and the two sinkholes. While there was a difference of view between the experts as to whether or not there would have been light or normal compaction as part of those remediation works, Mr Smith confirmed

that even if there had been normal compaction this would not change his opinion. In his view, the effects even of normal compaction would have been limited and would not have extended below the level of the excavation at that time. In other words, any compaction of this type would still only have closed the flow paths for a limited depth or distance.

- (12) In relation to the topic of whether or not there was evidence from the NDI and the invasive investigations to support the contention that the ground was generally weak in this area, Mr Smith did not accept this. While he did not challenge the underlying data, the kind of statements found in the DAL appendices were simply the normal kind of statements found in a geophysical survey report. A number of sentences from section 4.3 of COWI's second report were put to Mr Smith, but he did not accept that the geophysical survey, as restated by COWI, was precisely true. In other words, the available data did not support the proposition that all of these areas had underground voids. A number of the appendices were gone through in detail with Mr Smith, but he maintained his position that this information was patchy and did not support a proposition that all of the land in the area had these qualities. He noted that the area had been developed more than 100 years ago. One did not know the extent of how human efforts had impacted on the ground. In relation to the NDI, the areas showing less dense ground could also be consistent with the ground relaxing during the construction of the railway cutting. It was notable from this data that the predominance of weaker or less competent areas of ground was close to the cutting. This was consistent with the construction of the cutting having caused some lateral movement to the ground in that locality. It was

possible that there were less sound areas local to and caused by the creation of the railway cutting.

- (13) In relation to further comments at section 4.5 of the COWI's second report, Mr Smith's view was, essentially, that, properly analysed, this data did not support the conclusions or interpretations the authors of COWI's second report purported to place upon it.
- (14) In relation to the cellar, Mr Smith accepted that this was purely a question of circumstantial evidence. Most Victorian public houses had cellars and there was a public house in the vicinity of the property. As he interpreted some of the probe photographs, some of the brickwork shown could be part of the cellar wall. If, after the construction of the cellar it had been poorly backfilled, and water penetrated thereafter, these factors may be indicated in the 2013 event. He believed that to be the case, but, ultimately, his view was that the presence of the cellar was not material.
- (15) Returning to the issue of whether or not the ground could be said "generally" to be good or poor, he noted that the area had been extensively redeveloped in the 1980s. Any disturbance of ground surfaces now seen was unlikely to have predated the 1980s development. This had involved a wholesale redevelopment and building of new houses everywhere. None of the old houses remained. The old road had been resurfaced and there were areas of soft landscaping. One could assume a good standard of construction work in the 1980s and the ground would have been in good condition. Features of the defenders' own survey of the area (showing mild settlement of cracking along garden walls), were put but Mr Smith did not accept that this supported the

proposition that the ground was “generally” poor. He had inspected the area in late 2014 and he did not get the impression that the state of the ground at that time was particularly poor. While a few walls were a little askew, he did not accept that this was particularly relevant. It could simply mean inadequate foundations for that particular wall. He reiterated his position that, while it could be said that in places the ground was of a loose or soft nature, he would not go so far as to say that the ground was generally very soft or very loose in this locality.

(16) It was put to him that there might be evidence of significant historic transportation of soil to the retaining wall of the cutting. So far as Mr Smith was aware there was no such evidence. While there was reference to water penetrating through the retaining wall, there was no evidence of significant soil being transported through the wall or silty spill onto the platforms of the railway cutting. Even if there were some evidence of some degree, this did not necessarily infer soil transported through the retaining wall. It could be debris or fly tipping.

(17) In relation to that part of COWI’s second report (at section 5.3), and its reference to a “history of soil build-up”, Mr Smith could not understand this passage of the report or what was being referred to. There was no description of a history of soil build-up. In relation to the anecdotal evidence and removal of material from the track bed, if that were the case, there was no evidence which showed where this material had actually come from. The report had referred to “debris and spoil”.

- (18) The proposition was put to Mr Smith that if soil had found its way down from Millroad Drive through the retaining wall, and through the weep holes of the retaining wall and if, historically, that had happened, would it change his opinion. Mr Smith accepted that if there were evidence to show substantial quantities of material being washed through the retaining wall in that way, then it would potentially affect his reasoning. However, there was no evidential basis for this.
- (19) The rainfall figures for Hamilton were put to Mr Smith. He noted that the higher or extreme rainfall relied on by COWI, post-dated the development of the November 2013 sinkhole. He was not crossed on the basis that the Hamilton rainfall figures were to be preferred to those from Paisley. He reiterated his position that any high rainfall brought out by the Hamilton data post-dated the initiation of events, which was from mid-November 2013. He believed that events were already in train by that point and which resulted in the 2013 collapse.
- (20) The final paragraph of COWI's second report was put to him, but Mr Smith observed that this was not really a statement that related to the cause of *this* particular event. While it was true to say that, by reason of development over time, the ground had been disturbed, there was no evidence that ground below the manhole had been disturbed unless by works to construct the railway cutting. He did not feel that the evidence was strong enough to show that the ground in the area was "generally" poor or weak; although there were some weak pockets. By and large, in his view, this area of ground was reasonably competent.

(21) Returning to the topic of the cellar, ultimately Mr Smith's view was that this did not impact materially on his view. Even if there were no cellar, it would not have changed the 2008 events and it did not affect his opinion that the manhole had been damaged by that event. In his view collapses such as that shown in the photograph of the sinkhole were almost always due to water flowing through the soil at a velocity sufficient to carry soil particles with it. He was certain that this was caused by the water flow which had come from the burst water main in 2008. While one could speculate on the precise route that the water took, it is clear that it took soil away from this area such as to create the sinkhole.

(22) Mr Smith accepted the proposition that Victorian sewers could degrade over time and that they need not be involved in a water main burst to degrade. However, it was Mr Smith's view that there was no evidence of any other event which caused the sinkhole.

(23) Mr Smith was challenged on the basis that there was no "physical evidence" to vouch for the proposition that the manhole was damaged in 2008. Mr Smith accepted that there was no direct evidence of damage. It was put to him that such physical evidence as did exist suggested that the manhole was not damaged by the 2008 event. Mr Smith profoundly disagreed with that proposition. The fact that there was no physical evidence did not demonstrate that the manhole was not damaged. The absence of physical evidence did not support a conclusion that there was no damage. He reiterated his position that the 2011 CCTV did not support the conclusion that the manhole was not damaged by the 2008 event.

The defenders' expert reports

[58] The defenders instructed the firm of COWI (successors to DAL) who produced a preliminary report in March 2017 and lodged as 7/4 of process ("the first COWI report").

This was authored by Chris Phillips, one of the co-authors of COWI's second report, dated May 2018 ("COWI's second report"). Professor Cook was the co-author of COWI's second report.

[59] Counsel for the defenders, Mr Marney, relied on the defenders' second expert report.

For his part, Mr Balfour put certain passages of the defenders' first expert report to

Professor Cook. Those passages included the following (I have inserted subparagraphs for ease of reference):

"(1) Appendix C – AGE comments that there is confusion over manhole numbers and length of sewer surveyed. An up to date GiS is attached to this letter to clarify manhole numbers. The CCTV survey information does clearly confirm that the sewer line between [the upstream manhole] and [the manhole] and onwards to [the downstream manhole] had been surveyed in 2011 and 2013.

(2) SW did inspect the sewer in 2011 and there was no evidence to suggest that the sewer was leaking or the manhole was in poor condition, three years after the 2008 event. The investigations in 2011 of the SW assets around the 2013 collapsed zone found no evidence of damage or leakage which could have contributed to the 2013 ground collapse.

(3) The report states that the 2008 burst water main damaged the sewer, causing it to leak in that area. This is a viable potential failure mechanism, however the 2011 CCTV surveys indicate that the sewer was in reasonable condition and there was no indication of leaks from the system. We have not been able to gain any evidence that the sewer was inspected immediately following the 2008 water main burst."

[60] COWI's second report is a substantial document, incorporating as it does effectively all the appendices of the DAL report, and also the sections of the DAL report dealing with the factual background and the different investigations. Professor Cook confirmed that, apart from the opinion section of COWI's second report, the only additional material (ie not

derived from the DAL report) was the brief reference to certain anecdotal material.

Accordingly, all that requires to be noted is this anecdotal material and the expert opinion expressed at the end of the report.

[61] The passages concerning anecdotal evidence are as follows:

“(1) Anecdotal information obtained from local residents during the course of the investigation works suggests that a ground subsidence event occurred in Millroad Drive adjacent to the railway bridge and opposite (the property) in circa 1999. The void was subsequently infilled by (Glasgow City Council), although no formal record of this event are available. (2) Further anecdotal information relating to material within the disused railway cutting was obtained from (Glasgow City Council) who commented on clearance works carried out by the contractor building the nearby Tesco supermarket. The GCC employee stated that the contractor had to remove debris and soil from the cutting to facilitate the use of the track as an access point.” (I have inserted subparagraphs for ease of reference.)

Professor Cook discounted the 2008 event as having any causative link to the 2013 collapse.

By way of alternative explanation, he relied on what he said was evidence of generally poor condition of the ground in the area, and also the effect of high levels of rainfall in the preceding months. Further, in order to refute the contention that the 2008 event caused damage, reliance was placed on the 2011 CCTV survey as showing the sewer and manhole intact. Certainly, this is the import of a number of passages in COWI’s first report (see para [59(3)], above.)

[62] The expert opinion and conclusions of the COWI’s second report are as follows:

“5.1 General

COWI has been requested to provide an opinion, based upon the available factual information, to each of the following questions raised by Counsel for SW. The questions are set out as follows:

1. Did the burst water main in December 2008 damage the sewer?
2. Did leakage from that damaged sewer undermine the house?

The following sections of the report set out our response to both questions.

5.2 Question 1

Based upon the review of factual information collated during the investigation of the ground subsidence event at 202 Millroad Drive we consider that there is no factual evidence to confirm that the 2008 water main rupture damaged the sewer.

Subsequently, any comments are based on engineering judgement, conjecture and opinion.

The factual information relating to the 2008 water main rupture is limited to:

- > SW incident report which officially records the water main burst and confirms SW intent to implement remedial works.
- > Photographs of the location of the burst.
- > Highways Agency (formerly BRB Residuary) inspection report of Bridge No. 3 on the Bridgeton Central – High Street route which references the water main repair works and includes photographs of the ground disturbance at the location of the rupture.

The incident report sheet simply records the occurrence of the rupture and the SW response. There is no record or comment on the condition of the surrounding assets.

Photographs of the 2008 water main rupture present the condition of the road surface at the time of the burst, with water clearly issuing from below ground and reaching the surface. The photographs also show excavation of the water main and more extensive shallow excavation of the surrounding area. It would appear from the photographic evidence that the soft verge area local to the SW sewer manhole, which is the asset related to the 2013 ground subsidence event, was impacted by the water main rupture. There are no internal photographs of the sewer or the manhole, and no record of damage to the sewer pipe or manhole. The photographs also indicate that ground subsidence occurred within the soft verge area on the bridge between parking bays above the southern abutment of the bridge. Refer to Photo 8 in Appendix A.

The HA report records the occurrence of the water main failure and states that the excavation is in line with the east abutment and haunch area. The photographs of the water main failure contained within the HA report highlight that the deepest section of disturbance is local to the water main and at a depth of approximately 1.3m, which is approximately 1.5m higher than the sewer manhole invert.

Considering the evidence that is available from the time of the water main failure in 2008, and with specific reference to the photographs, it would appear that the main area of ground disturbance was confined to the location of the pipe rupture itself (Refer to Photo 1 in Appendix A). While it is acknowledged that a greater extent of ground disturbance is clearly visible, local to the SW sewer manhole but also distant from it, it appears that the depth of disturbance is shallower than at the water main.

This is most apparent on the HA report photograph No.3. Given that the water main was at a shallower depth than the sewer manhole and that the general flow of water from the rupture appears to be towards the railway cutting and also over Bridge No. 3 (Refer to Photo 19 in Appendix A) it is considered unlikely that the water main rupture damaged the sewer.

Further evidence to support this opinion is presented in the 2011 CCTV footage of the sewer, which was carried out following a ground subsidence event outside 214 Millroad Drive, approximately 30m south east of the 2013 event. The CCTV footage was carried out from MH5616 to MH4713 and indicates that the sewer was transporting water with no indication of major structural defects. While some surface degradation of the mortar joints is visible there is no indication of open joints or major structural defects. The CCTV survey terminates at the location of MH4713 and a laminar flow of water is visible. The lack of disturbance to the flow of water at the location of the manhole suggests that the sewer was in working order at the time of the 2011 survey.

5.3 Question 2

As set out in Section 5.2 above we consider that based in the available factual information and our engineering judgement the water main failure did not damage the sewer directly. Therefore in the context of Question 2 leakage from 'that' damaged sewer could not have undermined the house as we consider the sewer was not damaged as a result of the water main rupture.

However, we do consider that leakage from the manhole sometime after 2011 likely contributed to the undermining of the house and ultimately exacerbated the ground disturbance. From the information available and presented within the Factual Report, there appears to be a history of ground movement and disruption in the specific and general area of the 2013 subsidence event. There also appears to be a history of soil build up in the railway cutting, most likely from transportation through the wall via weepholes, as a result of water flow or seepage. The historical problems at this site suggest that this is a longstanding phenomenon in the general area, such as numerous local zones of significant settlement (and void occurrence) which has never been suitably investigated or addressed. The ground investigation works carried out in 2014 suggests that the ground in the general locale of the event is of a very loose or very soft nature, and as such it is possible that there was insufficient or reduced support to the base of the manhole, causing the invert to drop slightly and allow water to discharge from the manhole. Subsequent egress from the manhole could cause further loosening and disturbance of the ground, allowing the invert to drop further and greater quantities of water to discharge into the surrounding ground, with subsequent transportation of soils into the adjacent cutting. Met office records obtained for the period of ground subsidence indicate high rainfall occurred suggesting that flows within the sewer could have been increased. The high rainfall occurrence may have caused a high level of flow within the sewer which discharged into the ground surrounding the manhole, and subsequently disturbed the ground to such an extent that it was forced or

transported through the weep joints of the adjacent railway overbridge and discharged into the railway cutting. The loss of material from below the manhole and its discharge into the railway cutting subsequently caused the global subsidence at ground level.

It is considered that the poor nature of the ground could be due to the weak nature of the natural soils, disturbance by and poor remediation of the ground during previous and or current (housing) developments or by gradual migration of soils through the openings in the adjacent bridge abutment weepholes; or a combination of same.”

Professor Cook’s oral evidence in chief

[63] After being taken through his CV, Professor Cook confirmed that COWI were the successors of DAL. He had been the senior project manager at the time and oversaw the completion of the DAL report. He confirmed that, apart from his CV, all of the appendices in COWI’s second report were derived from the appendices to the DAL report.

[64] He explained the genesis of the anecdotal evidence referred to in COWI’s second report (see para [61], above.)

[65] In relation to the cellar, Professor Cook gave detailed evidence about the camera survey in January 2014. This disclosed a horizontal concrete structure, which he called “a roof”, which was suggestive of the presence of a cellar. However, the photographs were poor and very difficult to interpret. They did show brickwork but no orientation was indicated on the photographs. In his view the brickwork was associated with the manhole and not, as Mr Smith had interpreted these same photos, part of the cellar. He accepted that there was the possibility of the existence of a cellar, based on historic maps, similar to those used by Mr Smith. The concrete slab he referred to could be the roof to the cellar. A further detailed and lengthy passage of evidence followed, under reference to the ordnance survey and other historic maps. The import of this was that the old road was wider than the present one; the line of the buildings on the old road would therefore have been set back

from the present line of the narrower modern road. Even if there were a cellar in the public house, which was likely, it was not adjacent to the manhole, as presumed by Mr Smith. In other words, if there were a cellar it was not the location Mr Smith suggested. In his view there was no evidence of a cellar in the area of the collapse of the garden to the property. In response to a series of questions from the bench Professor Cook confirmed that it was more likely than not that the public house had had a cellar. Most Victorian public houses did. Ultimately, however, in his view the cellar would have played no part in the 2013 collapse.

[66] Professor Cook spoke at length about a photograph taken after the 2013 collapse, in early 2014. This confirmed, among other things, that water was still penetrating through the retaining wall and forming channels through the soft mud of the slurry that had formed on top the platform and on the track bed. It was about a foot deep on the track bed itself. In his view the moss shown on the retaining wall was indicative of long-term damp penetration.

[67] He did not agree with Mr Smith's opinion about causation. In particular, he did not agree that there had been damage to the manhole in 2008. He referred to the 2011 CCTV survey which, in his view, showed that there is no deterioration of the sewer.

[68] On the question of the calculation of forces, Professor Cook was of the view that one could calculate the force, although this would involve making assumptions. Manholes were in his view strong structures and able to withstand downward drag forces on its vertical surface. The manhole should not suffer any distress because of a drag down force on one of its vertical walls. In terms of the stepped out or corbelling, there was already weight on the manhole and it could take this load. Only additional weight would be as a consequence of drag down forces. Further, he explained that the manhole was a chamber which was joined to the sewer. Victorian egg-shaped sewers were robust. Any movement of the soils would not have caused significant additional forces, whether horizontal or bearing forces. One

would expect a sheer at the point where the manhole met sewer. The 2011 CCTV survey did not disclose this.

[69] He reiterated his view that the manhole had not been damaged in 2008. This was based on the 2011 CCTV survey, although he now accepted (ultimately) that it did not go into the manhole. Nonetheless, it did not disclose any sheer. From the 2011 CCTV survey there was no turbulent flow in the water flowing south of the manhole, and no sign of debris on the floor. He repeated the conclusion that there was no “physical” evidence of damage consequent upon the 2008 event. While there was a water main failure, water would take the path of least resistance and, in his view, this meant coming to the surface and travelling along the road surface above ground as it fell away from the property toward the cutting.

[70] He also spoke to the possible gradual erosion of the ground behind the retaining wall. He gave a long explanation about the need to cut a slope into the ground to build a vertical wall and how the volume of ground used as infill might then be susceptible to transportation through the retaining wall and into the cutting from both sides. He suggested that this was evident historically. Surface water across the bridge inundated the ground because it was loosened and susceptible. When saturated it just fell away and caused the void.

[71] He suggested that there was anecdotal evidence emerging after the 2008 event that similar settlement had taken place in 1999. He summarised that this was saturation of the ground that led to a quick collapse, such as had occurred in the 2008 event. He could not understand how the water could flow backwards 4.5 m towards the manhole. So the only explanation had to be saturation of the ground around the manhole as causative of the sinkhole adjacent to the manhole.

[72] In response to a number of questions Professor Cook essentially repeated his evidence that, in his view, the water from the burst main flowed mostly over ground along the surface and did not permeate the ground underneath. The majority of the water would have come to the surface. He did not accept that the water had been pushed under great pressure underground and he did not accept that water had reached the area of the manhole or created flow paths. The 2008 event resulted simply in a general wetting of the area and in localised inundation and depression at the point of the two sinkholes. It was COWI's view that the 2008 event had no effect on the sewer or on the manhole. In relation to the 2011 sinkhole, there was no explanation of what had caused it.

[73] Professor Cook also spoke to what he regarded as excessive settlement, which he would not have expected in a housing estate. There were areas of significant settlement remote from the retaining wall. He believed that the upper surface settlement was as a result of a poor backfilling.

[74] Professor Cook accepted that the failure of the manhole and collapse had resulted in the loss of ground and undermining of the property. But his model of how this came about was based on the manhole having been constructed on natural, as opposed to man-made soils, at least from a depth of 1 m and below. It was built on natural soils which with time lost support and resulted in a loosening or a breakup at the top of the manhole. The top of the manhole stayed in place, even after major failure, but the bottom of the manhole dropped by about one-half a metre. From the 3-D computer images, there was also a diagonal crack break to the vertical structure. This allowed water from the manhole to exit from the manhole itself, ie not travelling into the sewer. In his view this phenomenon predated November 2013. This cracking occurred and permitted water to escape from the manhole, with the consequence of ultimately migrating toward the cutting. He referred to

the rainfall data which, although not excessive, was nonetheless a lot of water which went into the sewer. This increased the water in the sewer. If the sewer had a crack then there was an alternate water path allowing water to seep into the ground rather than to be conveyed through the sewer. This worsened over time until, eventually, there was a total loss of support from the sewer such that the bottom of the manhole dropped out. There was no concrete base and the water was flowing into the ground from that point. This exacerbated a flow path and resulted in the wall collapsing. When asked how he could assert that the manhole had been damaged before November 2013, Professor Cook explained that something must have happened to allow the ground in November 2013 to settle. There was evidence of damage to the manhole, as well as a large opening in the manhole on the vertical side nearest the road.

Professor Cook's oral evidence: cross-examination

[75] On the issue of the proximity of the burst water main to the manhole, Professor Cook maintained his position that this was a distance of 4.5 m. It was put to him that it would be a remarkable coincidence if the depression or November 2013 sinkhole formed in the very same place as the sinkhole shown in the 2008 photographs, but that it occurred without any causal connection. Professor Cook maintained, somewhat dogmatically, that the water main burst was not causative of the sinkhole the 2013 collapse. It was just a coincidence. Nor was the 2008 event the main reason for the collapse in 2013.

[76] Under reference to passages in COWI's first report, in particular the observation that the 2008 event could be "a viable failure mechanism", Professor Cook sought to distance himself from this observation. He maintained that any ground settlement as a consequence of the water main burst in 2008 resulted in no more than localised inundation and settlement

at the site of the two sinkholes. He was pressed to accept the proposition in this report, that the pursuer's explanation was a "viable failure mechanism", but he was willing only to accept that as "potentially theoretically" and one of only a low probability. He asserted that his mechanism was one of a high probability.

[77] It was also put to him that, on a fair reading of COWI's first report, the reason why the pursuers' explanation, which the defenders accepted was a "viable failure mechanism", was rejected at that time, was on the strength of the 2011 CCTV evidence. He resisted this reading of this passage. He was challenged as to the veracity of certain statements in COWI's report (at page 2) as to the extent of the 2011 CCTV survey or the extent of the 2013 survey. The point of the question was that these passages overstated the extent or reach of these surveys. As a matter of fact, there had not been a survey between the upstream and downstream manholes. Nor did the 2011 CCTV survey reach the manhole. Professor Cook was unwilling to accept this, but simply asserted that the report stated what it stated and that he had no knowledge of the 2011 CCTV survey or what it had surveyed. He attempted to explain these sentences on the basis that they were not meant to refer to both surveys as having achieved the extent described. Ultimately Professor Cook accepted that the 2011 CCTV survey had not entered into the manhole and he conceded that he could not say on the basis of the 2011 CCTV survey that the manhole was 100% intact as at 2011. It was put to him that this section of COWI's first report was misleading, to which he replied that the experts had to take a view on the information available. He maintained that there was no evidence of a crack found in the manhole in the 2011 CCTV survey.

[78] When it was put to him that the final screenshot of the 2011 CCTV survey did not show the entirety of the manhole's interior, he cavilled and fell back on his observation that

one could not see a crack at that point but which was subsequently disclosed in the 2013 data.

[79] When asked about what one could infer from laminar flow, Professor Cook instead gave a long description about leakage and permeability. He did not accept Mr Smith's hypothesis although he ultimately accepted that what was shown in the 2011 CCTV was consistent with that hypothesis. A passage in COWI's second report was put to him: this was the observation that

“[c]onsidering the evidence that is available from the time of the water main failure in 2008, and with specific reference to the photographs, it would appear that the main area of ground disturbance was confined to the location of the pipe rupture itself”.

It was put to him that it was simply not possible to determine from the photographs how deep the disturbance had been to the ground after the 2008 event. Again, he did not give a clear answer but cavilled, arguing that it depended as to how one defined “disturbance”.

He maintained his position that there was no subsurface disturbance, essentially on the basis that when excavation was undertaken to repair the water main, the wall of that excavation was intact. He interpreted the 2008 photographs as showing no worsening of the density. In his view the ground had not been disturbed as a consequence of the 2008 event.

[80] The appearance of the first sinkhole next to the manhole was put to him, but he maintained his explanation that this was caused by surface water saturating the ground and leading to the collapse. He also maintained his position that the appearance of the sinkhole in 2013 in precisely the same place as the sinkhole in 2008 was purely coincidence. He presumed that any remediation and backfill around the sinkhole would have left the ground in a stable condition after 2008.

[81] He was cross-examined on the assertion that there was poor ground and, as I understood his evidence, accepted that this did not relate to the area of the 2013 collapse. Under further questions about pressure forcing the water downwards, Professor Cook maintained his position that most of it went upwards and there was unlikely to be high pressure forcing the water downwards. He did not accept that the water might penetrate upwards or horizontally, maintaining the view that gravity would have militated against this. The water had come to the surface and saturated the ground to a depth but did not cause or precipitate the 2013 collapse.

[82] In relation to the cellar, he stated that there was "a high probability" that there was a cellar below a public house. However, in his view the public house was not in or near the garden of the property.

[83] In relation to the 2011 collapse, he accepted that no cause had been identified for it and that at that time the sewer itself was undamaged.

[84] He was also cross-examined under reference to that section of the second COWI report that referred to a "history of ground movement". The basis for this statement was simply the anecdotal evidence in 1999 which came from an unnamed local resident in relation to an unspecified area. This was recorded by an unnamed engineer. There was no documentation to support this. (See para [61(1)], above.)

[85] He was also cross-examined about the assertion that there was "a history of soil build-up at the railway cutting". He confirmed, again, that there was no documentary evidence to support this. This was based on further anecdotal evidence that, at the time the new Tesco had been constructed, the railway cutting had been used as an access point for construction vehicles and that some clearance of this was required before these vehicles could gain access to the Tesco site. The description was of "debris and soil" being removed.

He accepted there was no investigation as to what this soil or debris was. In his view, this provided evidence that transportation of the soil through the retaining wall of the railway cutting was not localised. He accepted that, apart from this anecdotal evidence, there was no other factual information to support the assertion that soil transportation was a longstanding phenomenon in this area. He also accepted that there was no mention of this in the text of COWI reports, but he said he knew it from his inspection of the site and from certain photos. He also accepted there was no information for the reader of the COWI reports as to the factual basis for this. He ultimately accepted that the photographs and elevations provided no information as to the timeframe when any soil might have been deposited. He suggested that vegetation shown in 2011 could have been growing in the medium of the soil deposited. He also accepted that there was only one photo relevant to this issue, it was of poor quality, and did not show a massive build-up of soil on the platform. On reviewing that, he accepted that it did not disclose a lot of soil on the platform.

[86] On the question of rainfall, he suggested that the heavy rainfall would involve a massive rush and that these very large events caused the sewer to run full and to create a large flow. So as a mechanism, he accepted that the preferential flow path and transportation of the soil, as described by Mr Smith, could explain how the soil got into the cutting. The rainfall concentrated the water flow. This would operate on any small distress to the manhole. This could explain how the sinkhole had opened up so quickly in November and December 2013.

[87] Finally, in relation to the 2008 event and whether it caused disturbance to the ground, Professor Cook maintained the view that it would be surprising for this to cause disturbance in the vicinity of the manhole because of the distance and direction. There was

a long explanation about Clyde alluvial soils and its susceptibility to softening. (This evidence was difficult to follow).

Professor Cook's oral evidence: re-examination

[88] A number of photographs were put to Professor Cook, as providing a basis for the observations in the report that deposits of soil which have been transported through the retaining wall were of an historic nature. Objection was taken to this line, because this had not been put to Mr Smith. I allowed this evidence under reservation. Professor Cook maintained his view that this provided support for the statement that there was historic soil build-up on the platform.

[89] He was also asked about the cellar, and his final position was that there was no cellar. This was because it was unlikely that the cellar would have been built underneath the Victorian roadway. After investigations, it was concluded that there was no cellar.

Parties' submissions

[90] Counsel prepared very helpful written submissions. I have taken full account of those submissions but need not record them in full in this Opinion.

Discussion

[91] The principal issue in this case is the question of what caused the 2013 collapse and whether the 2008 event was causative of, or contributed to, that event (as the pursuers contend) or whether those were unrelated events (as the defenders contend). This falls to be resolved upon a consideration of the opinion evidence of the parties' respective experts,

Mr Smith and Professor Cook, each of whom produced two reports and who gave oral evidence for about one and one-half days.

Credibility and liability

[92] Mr Smith and Professor Cook are both eminently qualified. No party suggested otherwise, although a brief passage in Mr Smith's evidence was suggestive that Professor Cook's specialism was principally in the engineering challenges of tunnelling. Mr Marney suggested in submissions that Professor Cook may have presented in a less polished fashion than Mr Smith, but this was readily explained by his relative lack of experience as an expert witness in court, and his natural inclinations as a scientist to look for evidence to support any proposition.

Mr Smith

[93] In my view, Mr Smith gave his evidence in a clear and straightforward manner. He was careful and he did not push for a conclusion or inference beyond what the available information might reasonably permit. He did his best to help the court. He was prepared to consider and comment on alternative hypotheses.

Professor Cook

[94] Professor Cook was less experienced in giving evidence in court as an expert witness, which may explain a tendency at times to produce very long answers, often with several digressions that were not obviously related to the subject matter of the question. He did not always answer the questions posed with clear answers. I do accept that there is some foundation to Mr Balfour's criticism of Professor Cook, in his inability at times to accept

reasonable propositions and that, at points, his evidence was, by reason of the length of his answers, a little difficult to follow. I do not accept that he was intentionally obfuscating, as Mr Balfour suggested. Professor Cook was more resistant to considering alternative hypotheses and, at times, he displayed a certain fixity of view or dogmatism. He was also prepared, on occasion, to express a rather firm view, without perhaps acknowledging the limitations of the material on which that view was based. Two examples from the evidence will suffice to illustrate these comments.

(i) *The statement in COWI's reports about the 2011 CCTV survey:*

[95] There are statements in COWI's first and second reports to the effect that the 2011 CCTV survey reached the manhole and disclosed that there was no damage to it. This is important, as COWI relied on this material in its first report as a basis to exclude the 2008 event as causative of any damage to the manhole. Professor Cook's evidence on this chapter of evidence was unsatisfactory in a number of respects. He began by assuming the truth of the statement (ie that the 2011 CCTV *had* reached the manhole and had enabled examination of the entirety of its interior). On viewing, it became clear that the 2011 CCTV survey did not reach the manhole and, by reason of the curve in the line of the sewer immediately to the south of the manhole, did not permit an examination of the whole of its interior. Even after this was apparent, and the question was put that, on a fair reading, the statements in the COWI reports overstated the position, Professor Cook resisted accepting this as a reasonable interpretation of these passages in the COWI reports. Instead of simply acknowledging the limitations of the 2011 CCTV survey, as now revealed, he became dogmatic and maintained that it provided a basis to exclude the question of damage to the manhole. His evidence

about that part of the interior of the manhole said to have been revealed at the end of the 2011 CCTV survey was strained and unconvincing.

[96] Mr Balfour submitted that in cross-examination, Professor Cook was not prepared to make even the most obvious of concessions regarding the misleading nature of the statements in the COWI reports regarding what the 2011 survey revealed. He would not accept that the statement regarding the 2011 survey extending from MH4708 and MH4713 and onwards to MH5616 was inaccurate. He obfuscated when pressed. He refused to accept that the statements were in any way misleading. Mr Balfour submitted that, ultimately, Professor Smith attempted to support his position by making a tenuous argument regarding the point at which the manhole structure starts despite the fact that the manhole chamber was not fully visible on the 2011 CCTV survey. There is some force in these comments.

(ii) *The 2008 photos and the question of disturbance:*

[97] Another factor relied upon by COWI to contend that there was no damage to the manhole following the 2008 event were some photos (referred to in COWI's second report). These were photos showing the excavation pit dug around the mains water pipe in order to repair it in 2008. In his oral evidence, Professor Cook was quite dogmatic that these positively excluded the question of disturbance of the ground at lower depths. However, upon examination, I find that the photographic evidence was minimal in quantity and very poor in quality. Nonetheless, Professor Cook was adamant in his opinion, notwithstanding that on any reasonable assessment the photos of the second sinkhole clearly showed that the degree of disturbance of the ground was very substantial. This was also borne out by the evidence of the volume of material required to infill this second sinkhole. This is an instance

where the documentary material Professor Cook relied on did not provide a sufficient basis for the conclusion he advanced.

[98] Mr Balfour submitted that Professor Cook's evidence on the 2011 CCTV survey suggested an inflexible approach and that he was unable to concede that a mistake had been made or that another explanation was possible, despite overwhelming evidence to the contrary. It undermined confidence that Professor Cook had approached the case with an open mind or would be prepared to modify his opinion in the face of competing information. It raised doubts over the evidence he had to give on other matters. It would, of itself, provide a strong reason for preferring the more measured and considered approach of Mr Smith.

[99] There is some force in this submission and I do approach other chapters of Professor Cook's evidence, when based essentially on his *ipse dixit*, with a degree of caution. That said, I stress that what follows is my consideration of the cogency of the experts' evidence, respectively, and is not based on their manner of presentation.

Mr Smith's mechanism for damage to the manhole following the 2008 event

[100] In Mr Smith's first report he posited a mechanism for how the 2008 event damaged the manhole. I have recorded this above. None of the evidence I have heard has persuaded me that this is an unfounded or unlikely scenario. Indeed, in COWI's first report, it is accepted that this is a viable mechanism for failure of the manhole but, as already noted, COWI relied on the 2011 CCTV survey as excluding this. Mr Smith challenged the correctness of that proposition. In COWI's second report, additional factors were advanced to explain the failure of the manhole and other features of the 2011 CCTV survey were referred to as supportive of COWI's conclusions.

[101] It is notable that none of these several factors was relied on as suggesting that Mr Smith's explanation was mistaken or not an available explanation. The thrust of COWI's approach was to provide an alternative mechanism to that proffered by Mr Smith. In light of the concession that the mechanism posited in Mr Smith's first report is viable, it is appropriate first to turn to the COWI reports and the several factors relied upon as providing an alternative mechanism or explanation of the 2013 collapse. I will return in due course to Mr Smith's evidence, including the development of his view in his second report.

The COWI Reports

[102] It is in my view significant that in COWI's first report, they relied on one factor to dismiss the analysis that the 2008 water main burst had initiated the development of the first sinkhole. In the first COWI report it was accepted that the 2008 event was a "viable potential failure mechanism". Having acknowledged that, it would not have been credible for COWI to retreat from that position. They did not seek to do so and I proceed on the basis that this is a viable mechanism to explain the 2013 collapse. In COWI's first report this explanation was nonetheless discounted because, it was said, "the 2011 CCTV survey indicate[s] that the sewer was in reasonable condition and there was no indication of leaks from the system". However, by the time of their second report, and after Mr Smith had argued that COWI had overstated the 2011 CCTV survey evidence, COWI appeared to rely on two other factors in support of their conclusion. The first was the photographic record from 2008, which was said to show that the area of ground disturbance was confined to the location of the water main rupture. The second was that the 2011 CCTV survey showed that the sewer was transporting water with no indication of major structural defects. This was

inferred from the laminar flow of the water. I turn to consider these chapters of evidence.

Before I do so, I return to the question of what may be inferred from the 2011 CCTV survey.

(i) *The extent of the 2011 CCTV survey and what may be inferred from it*

[103] The 2011 CCTV survey was undertaken following the sinkhole that appeared in 2011, which I have described above. No cause was ever identified for that event. However, the 2011 CCTV assumed critical importance in this case, from the defenders' perspective, because it was relied on as positively excluding any damage to the manhole as at that date and, accordingly, as excluding damage to the manhole consequent upon the 2008 event.

COWI otherwise acknowledged that Mr Smith's explanation in his first report was a "viable" mechanism for damage.

[104] So far as the CCTV survey from 2011 is concerned, in COWI's first report they stated:

"SW did inspect the sewer in 2011 and there was no evidence to suggest that the sewer was leaking or the manhole was in poor condition, three years after the 2008 event. The investigations in 2011 of the SW assets around the 2013 collapse zone found no evidence of damage or leakage...".

This was tied into COWI's earlier comment (at page 2) that:

"The CCTV survey information does clearly confirm that the sewer line between [the upstream manhole] and [the manhole] and onwards to [the downstream manhole] had been surveyed in 2011 and 2013."

A statement to similar effect was contained in COWI's second report:

"The CCTV footage was carried out from [the downstream manhole] to [the manhole] and indicates that the sewer was transporting water with no indication of major structural defects.... The CCTV survey terminates at the location of [the manhole]...".

Mr Balfour submitted that these statements were simply incorrect and that there was no survey in 2011 between the upstream manhole and the manhole, nor any survey onwards from [the manhole] to [the downstream manhole] (*per* Appendix C at page 1). Mr Balfour

had submitted that the fact that a section of sewer tunnel looked undamaged did not assist in informing one as to whether the manhole was. By way of illustration he referred to figure 8 to Mr Smith's letter (taken from the CCTV survey on 19 December 2013 after the manhole had collapsed).

[105] The 2011 CCTV survey was viewed several times in court. The video also recorded the length travelled, and that was shorter than the measured length between the manhole and the downstream manhole. Having regard to this evidence and to the other evidence about the curve in the line of the sewer between the manhole and the downstream manhole, I find that the 2011 CCTV did not reach, or show the whole interior of, the manhole. I accept as correct Mr Smith's statement that "It is clear that this survey provides no information as to the state of [the manhole] post the 2008 water main burst". The statements to the contrary in the COWI reports are incorrect. The closest that the 2011 CCTV survey reached was to show the sewer tunnel as it curved towards the manhole. It did not show the invert of the manhole nor did it disclose all of its interior aspects. Accordingly, it was not a basis positively to exclude that the manhole was undamaged at that time. The COWI report, and Professor Cook's evidence, are flawed in this respect.

(ii) *Laminar flow disclosed in the 2011 CCTV survey*

[106] COWI characterised the flow of water in the 2011 CCTV survey as laminar (or smooth flowing), and it thereby supported the inference that the manhole was undamaged. If the flow were passing over rubble, it would be turbulent in flow. Mr Smith rejected this suggestion. As he explained, the flow might have been disturbed at the manhole, but it could have returned to normal by the time it came into view on the 2011 CCTV survey. The fact that water continued to flow through the sewer in 2011 was entirely consistent with the

mode of failure suggested by Mr Smith and which would involve no more than a modest leak from the sewer, not any dramatic disruption to the flow of water through the sewer. I accept this evidence. The water level shown in the 2011 CCTV was shallow, of relatively low volume and was flowing at a sedate pace. These features, coupled with the distance that this water had to flow between the invert of the manhole to the point where it became visible downstream on the 2011 CCTV, make it difficult to draw any meaningful conclusion as to the presence or absence of damage. I also accept Mr Smith's evidence that what is shown on the 2011 CCTV is equally consistent with his explanation of the likely damage and subsequent failure of the manhole.

(iii) Photographs of the excavation pit to repair the water main

[107] The other additional factor relied on in COWI's second report were some photographs from 2008. In that report, COWI highlighted a few photographs taken after the water main rupture was excavated as purporting to show the extent of the ground disturbance caused by it, ie as effectively limited to the depth and area shown on these photographs. I accept Mr Balfour's submission that it was difficult to understand how such photographs could provide any clear indication of the limits of the area of disturbance. He also noted that in his evidence, Professor Cook did not take the court through these photographs to illustrate his point. Mr Smith rejected the suggestion that the depth of the ground disturbance could be identified from these photographs. I accept that evidence. COWI relied on the one or two photographs showing the excavation pit dug for the purpose of repairing the burst water main. On Mr Smith's evidence it was unlikely that the excavation was also undertaken with a view to determining the extent of ground

disturbance. Had that been one of the purposes of excavation, this would have produced a greater body of photographic evidence. I also accept this evidence.

[108] Furthermore, COWI's contention (that the degree of ground disturbance was limited to what was shown in these photographs) was advanced, but without reference to other photographs taken following the 2008 event. However, there are other photographs at the time relevant to this issue. I have in mind in particular the photographs showing the extent of the water flowing from the burst water main through the tarmac surface of the road, and which was wet for a not inconsiderable distance in all directions; and also the photographs showing the two sinkholes. It is patent from the photograph of the second sinkhole that the loss of soil and support was very significant. This is borne out by the considerable volume of infill that was required to repair this. The impression given from the photograph of the void under the second sinkhole was that its depth was not significantly less than the excavation pit. It is improbable that that amount of soil could be lost at this upper level by reason of the water escaping the burst main, but that this would otherwise have had no impact on the integrity of the ground at any lower level. Other uncontested evidence demonstrated that this water ultimately travelled down to the base of the retaining wall, a drop of some 8 to 9 m which was a short distance to the south of the first sinkhole and, indeed, transported soil with it (see para [32], above).

The shallower depth of the water main relative to the sewer & and the downward slope of the land

[109] COWI relied on several features to support their overall position that the 2008 event did not contribute to the 2013 collapse. One of these was the shallow depth of the water main relative to the sewer. This may be linked to COWI's argument that there was no

ground disturbance beyond the immediate area of the excavation pit at the point where the water main burst. As this argument went, COWI relied on the fact that the water main was at a shallower depth (of c 1.3 m) than the sewer (c 1.5 m below that), and also that the ground sloped slightly upwards from the site of the burst to the manhole. (As noted, the ground sloped at a very gentle decline from the area of the burst toward the railway cutting.) From this latter feature, COWI inferred that the water would not have reached the manhole and there would have been no appreciable disturbance of the ground below surface level. Professor Cook was categorical in his assertion that most of the water would have flowed above ground, over the surface of the road. I am not persuaded that the evidence supports this. I have already noted that the photograph of the burst water main showed water issuing from the hole in the tarmac in all directions for a reasonable distance. It must have required a considerable degree of force to penetrate through the hard core or sub-base of the road and its tarmac upper surface. As a matter of commonsense, it is more likely than not that as the water moved upwards it would have flowed in lateral directions when it met the resistance presented by the underside of the road surface or its sub-base. In any event, as I understood Mr Smith's evidence, the process he envisaged could have been initiated by damage to the manhole structure, which would then have caused damage to the lower structures. Mr Smith did not consider it to be necessary for the initial ground disturbance to extend all the way to the base of the manhole. The process of erosion caused by further leakage of water from the manhole and the consequent transfer of soil would have been a gradual process, initiated by the damage that was likely to have been sustained by the manhole as a result of the 2008 event.

[110] In any event, having regard to the location and size of the first sinkhole that formed in 2008 immediately adjacent to the manhole, it is patent that a very significant amount of

water had travelled up the very gentle slope to the manhole. It is also clear, on the evidence in relation to water penetrating through the retaining wall, that, as Mr Smith described, water escaping from the water main would have gone out in all directions available to it - including downwards. On the unchallenged evidence in this case, the water did travel downwards, escaping from the retaining wall.

[111] COWI also placed reliance on the general flow of water being towards the railway cutting and the bridge. The photographs do indeed suggest that this was the general direction of flow for the obvious reason that it is the direction in which the road sloped away from the water main rupture. However, Mr Smith's view was that, while the general direction of flow was towards the cutting and bridge, this did not exclude the possibility that the water could have disturbed the ground adjacent to the sewer. Mr Balfour submitted that the photograph in figure 5 of Mr Smith's second report amply demonstrated that there was disturbance of ground in the direction of the sewer, which Professor Cook had accepted. I accept that submission. I also accept as well founded his submission that on Mr Smith's evidence the general direction of flow offered no assistance in determining whether the rupture of the water main in 2008 damaged the sewer.

[112] It follows that I also accept Mr Balfour's submission that these features (the depth of the water main relative to the sewer, the slight decline of the land from the north to south toward the railway cutting) are of no assistance in determining whether the water main rupture damaged the sewer. In my view, they certainly afford no basis, individually or collectively, to displace the explanation advanced on behalf the pursuers. Nor do these factors, or the 2011 CCTV survey itself, afford a basis to make any positive conclusion that the manhole was not damaged by the 2008 event. For all of these reasons, I reject the defenders' reliance on the photographs of the excavation pit, the depth of the water main

relative to the sewer, or the general direction of flow as providing any basis to support their contention that the sewer was not damaged by the 2008 event.

[113] The defenders advanced other explanations. I turn to consider these.

Rainfall data

[114] In terms of rainfall, the parties' experts relied on the rainfall figures for slightly different areas. Professor Cook reproduced the Met Office figures for the Hamilton area from the DAL report, whereas Mr Smith's relied on the Met Office figures for Paisley. Neither was challenged as to the appropriateness of his selection of location of his dataset, nor was it put to either Mr Smith or Professor Cook that the other parties' data was from a preferable location. There were no questions posed to Mr Smith and no challenge to the conclusions that he drew from the data he had analysed (and which I have recorded above). By contrast, there was a challenge to the conclusions COWI sought to be drawn from the rainfall data analysed in the DAL report. The thrust of Mr Smith's evidence, and put to Professor Cook in cross, was that the peaks of rainfall noted in the Hamilton data had all post-dated mid-November 2013, and by which time the 2013 collapse had been initiated - as the development of the November 2013 sinkhole evidenced. Accordingly, there was no clear evidence that there was substantial or above-average rainfall at the material time. Overall, I found Mr Smith's analysis of this material more thorough and cogent. It is a small illustration of the more careful approach Mr Smith exhibited throughout his evidence. It also provides a further illustration of a categorical statement contained in the COWI report which, once the underlying data is examined with care, is found to be unsupported. I also found more persuasive Mr Smith's evidence that it was unlikely that this would be a significant factor, given how long the estate had been *in situ*.

The cellar

[115] I have not troubled to record in detail the considerable evidence regarding the possible existence of a cellar and its location. As noted above, neither expert attributed to it a material role in the events leading up to the 2013 collapse. Accordingly, I accept Mr Balfour's submission that the presence and location of the cellar was of limited relevance to the question which the court required to determine, namely whether the water main rupture of the 2008 event caused the sinkhole to develop. As Mr Balfour pointed out, even if there were no cellar, that would not alter Mr Smith's opinion that the sewer was damaged by the 2008 event, or that this damage ultimately caused the development of the sinkhole.

Ground conditions

[116] COWI also invoked ground conditions, which they suggested were generally poor, as a further alternative explanation for the 2013 collapse. The question of the quality of the ground disclosed a further difference between the experts and it centred around the correct interpretation of the results of the NDI and destructive investigations undertaken by DAL and contained in several appendices to that report. Although Mr Smith accepted that there were weak pockets of ground, he considered that by and large the ground was reasonably competent. He did not consider that the evidence showed that the ground in the area was "generally" weak as COWI contended.

[117] As I understood it, Professor Cook's position was that the ground was "generally" poor and that the poor nature of the ground caused the development of the sinkhole without any contribution from the water main rupture. He envisaged a process by which "there was insufficient or reduced support to the base of the manhole" (p 21 of COWI's second report),

but without any cause by or influence from the 2008 event. Reference was made to several events in the COWI reports to support this contention.

(i) *The 2011 sinkhole*

[118] Toward the end of COWI's second report, reliance was placed on what was said to be a "history of ground movement and disruption". I have already noted the 2011 event (ie the development of a sinkhole some 30 m distant from the manhole) and the absence of any identifiable cause. Mr Balfour had submitted that the 2011 event was caused by something different from the 2013 event: whereas the 2013 event clearly involved the sewer, the 2011 CCTV survey confirmed that there was no damage to the sewer in the vicinity of the subsidence. He referred to the finding in the DAL report that "the 2011 subsidence event was never linked to the sewer". Given this finding, I did not find it credible or persuasive for COWI nonetheless to invoke this as support for the specific contention they advanced. I accept Mr Smith's opinion that the 2011 incident was not particularly relevant to the question of causation at issue in this case. I accept Mr Balfour's submission that it would be unwise to place reliance on this event.

(ii) *Anecdotal information regarding 1999*

[119] In COWI's second report there was brief reference to "anecdotal information" (mentioned on page 7) regarding a possible subsidence event in around 1999. This had been reported by a resident at the time of the 2008 event. (The passage is quoted at para [61(1)] above, and Mr Balfour's cross of Professor Cook on this point is set out at para [84], above.)

[120] Mr Balfour criticised this evidence. He submitted that the quality of the evidence regarding this incident was very poor. He pointed out that there was no documentation

vouching that the incident had ever happened, far less whether there was an explanation for it. It seemed to be based on no more than what one unidentified person (who apparently turned out not to live at the house that they were thought to live at) had told another unknown person: neither individual gave evidence in this case, which is hardly surprising given that neither was identified. He submitted that this supposed incident did not form any sound basis upon which to base any conclusion regarding the circumstances of the present case. It was, he said, concerning that Professor Cook placed reliance on it and appeared to treat it as established fact. In my view, these criticisms have considerable force. I would not be prepared to place any reliance on this passage of COWI's second report to support the conclusion for which COWI contend.

[121] COWI's second report also referred to another matter for which there was only scant anecdotal material recorded. I turn to this matter.

(iii) Whether there was a history of transportation of soil through the retaining wall into the cutting

[122] It was stated at the end of COWI's second report that "there appears to be a history of soil build-up in the railway cutting". As I understood the purpose of this statement, it was to argue that if this were long-standing, it provided an alternative means by which a leak in the sewer or manhole could form (on which both parties agreed: see para [12], above), but which did not implicate the 2008 event. The apparent basis of this statement was a small amount of anecdotal evidence, which had come from a contractor to someone from the council: nobody with first-hand knowledge gave evidence. Professor Cook suggested that the circumstances were a matter of "inference". Mr Balfour's submission was that there was no documentation vouching what had happened. The precise location and timing of

the incident was unknown. The text referred to “debris and soil”, which, he argued, might suggest that the cause was something other than soil being washed through weep holes of the retaining wall. I accept that submission. Mr Balfour is correct when he stated there was no indication as to what the debris was. Mr Smith had explained that there was not sufficient information to say where the soil came from, and that it could have been from fly tipping or simply soft material from the surface of the cutting. Mr Balfour submitted that this information did not form a sound basis upon which to base any conclusion in the present case. I accept that submission.

[123] Professor Cook gave evidence regarding his own observations of soil within the cutting. He suggested that the soil had been there a long time, which he stated was “our understanding or hypothesis”. Under reference to photograph 8 in Appendix A to COWI’s second report, he had also described how the 2008 event had washed away large quantities of soil into the cutting causing the subsidence to the south of the bridge. Mr Balfour submitted that this would appear to offer an explanation for any historic soil found in the cutting (particularly the soil on the southern platform referred to at page 16 of COWI’s second report). However, there was no evidence of soil being deposited at any other time prior to the formation of the sinkhole in late 2013. Mr Balfour pointed out that, although Professor Cook referred to a photograph (at page 3 of Appendix H to COWI’s second report), in re-examination it emerged that this had been taken after the formation of the sink hole in December 2013. It did not vouch the proposition that there was any historic build-up of soil, other than anything deposited following the 2008 event. I agree.

[124] Mr Balfour submitted that, accordingly, there was limited evidence of a history of soil build-up in the railway cutting. In any event, whatever soil there was would be readily explicable as having been deposited in the cutting at the time of the 2008 event. I accept that

submission. I do not find it proved that there was a long-standing history of transfer of soil through the wall of the railway cutting.

(iv) Comment on ground conditions in the locality

[125] On the evidence presented, I am not persuaded that the patchy nature of some of the ground in this locality constituted a primary cause or an alternative explanation for the 2013 collapse. As noted above, this evidence supported a conclusion only that the locality had areas of poor ground condition; it did not support the conclusion (asserted by COWI) that this was generally the case. A closer consideration of DAL's NDI and destructive ground investigations, to the extent that they related the relevant ground, did not disclose weaknesses in the immediate vicinity of the property or the manhole. Certainly, there were no questions addressed to the experts with a view to eliciting such evidence. It may well be, as Mr Balfour contended, that the ground in this area was the equivalent of "eggshell" ground, comparable to the "eggshell" vulnerability of a person who is subject to a delictual act and whom the wrongdoer must take as he finds him. One therefore has to proceed in a relatively agnostic fashion as to the precise character of the ground in the vicinity of the manhole. I accept Mr Balfour's submission that the nature of the ground conditions might have made the area more susceptible to ground disturbance following an incident such as the 2008 event and that that in part explains how the 2008 event was able to set in train the process that led to the development of the sinkhole. For completeness, I record that I did not find the few photographs of cracked or slightly askew garden walls etc, relied on by COWI, to be of assistance. There was insufficient information to conclude that what they recorded was representative or indicative of a more widespread problem, or was attributed to ground conditions as opposed to other explanations (eg concerning their construction).

[126] It is convenient here to address the issue about compaction. Both experts presumed compaction as part of the remediation works to the two sinkholes created by the 2008 event, although there was no direct evidence about this. Professor Cook was adamant that compaction would have resolved any ground disturbance caused by the 2008 event. There is no documentary or other evidential basis for this assertion. While it is not clear that any significance is to be inferred from the difference in notation relative to the first and second sinkholes on figure 1 of Mr Smith's second report, an "infilling event" was recorded only in respect of the second sinkhole (not the first sinkhole). Furthermore, in order to undertake compaction of the first sinkhole, that is the one adjacent to the manhole, this would have necessitated removal of the fixed low-level horizontal metal bar structure in place to preclude cars impinging on the soft verge area. (This metal structure is visible on the photographs after the 2008 event.) Professor Cook did not address himself to the question of whether this would have posed an impediment to remedial works to the first sinkhole. Having regard to features of Professor Cook's evidence I have noted above, I am disinclined to accept Mr Smith's *ipse dixit* on this matter. I accept Mr Smith's position that the remedial works were unlikely to have extended as far down as the disturbance caused by the substantial volumes of water seeping into the ground and which created these two sinkholes consequent upon the 2008 event.

The extent of damage caused by the 2008 event

[127] What of Professor Cook's conclusion that it was unlikely that the water main rupture damaged the sewer (*per* p 20 of COWI's second report)? I have already dealt with the limitations in the photographic material which formed the basis for the statement in COWI's second report that, having regard to this material, the extent of any ground disturbance was

limited. There is otherwise no evidentiary basis to enable one positively to conclude that there was no ground disturbance at greater depths.

[128] The 2008 event was, as Mr Balfour described in submissions, a “dramatic event”. While Professor Cook sought to minimise the damage caused, for example by positively asserting that there was unlikely to be the low-level water migration or disturbance, on the basis that the excavation pit for repair of the burst water main seemed to be intact, I found this unpersuasive. The burst water main was under such pressure that it burst through the tarmac surface of the road. Water from the burst water main must have issued with such force to produce a significant volume of water sufficient to cause the sinkhole at the manhole. This is fortified by the even more dramatic degree of damage at the second sinkhole, to the south. Whether the water travelled laterally underground, as Mr Smith posits, or it travelled principally above ground, as Professor Cook contends, the unarguable fact remains that the burst water main resulted in very substantial damage in the form of the two sinkholes.

[129] Further, as I understood it, Professor Cook did accept that - whatever the precise mechanism – the 2008 event caused the first sinkhole and settlement in the vicinity of the manhole. I have already recorded the extent of the sinkhole’s depression. Mr Smith considered that the photographic material disclosed evidence of significant settlement of the ground beside the manhole following the 2008 event. It is obvious from the photograph that this area of settlement was very close to the manhole. Mr Smith described the forces that, in his opinion, would have been exerted on the manhole structure as a result of this settlement, with the possibility of drag frictional forces, downward bearing forces and a loss of support due to lateral movement of the ground. I also accept his conclusion that, whichever of these forces operated, it was “very probable” that some damage was inflicted on the sewer in the

vicinity of the manhole. It is likely that this damage would have resulted in leakage from the tunnel part of the sewer, which would have set in train the process that ultimately led to the development of the sinkhole. I accept this evidence and I find that on a balance of probabilities this most likely resulted in some damage to the manhole, allowing it to leak over time, and which precipitated the ultimate failure of the manhole in the form of the 2013 collapse.

[130] Mr Smith was challenged in cross for not having performed any calculations to support his opinion regarding the forces exerted on the manhole. I accept his explanation that there was not enough information to perform a realistic calculation and that it would have required a number of assumptions to be made. He could only work with the information available to him together with his own expertise. I accept Mr Balfour's submission that this question is not one of scientific certainty. It might also be observed that if calculations could have been readily performed, it is surprising none were produced by COWI to demonstrate the absence of the kind of forces Mr Smith spoke to. I accept Mr Balfour's submission that the fact that Mr Smith was unable to provide calculations in support of his opinion did not undermine his conclusion that the most probable explanation for the sinkhole, given the coincidence between the location of the 2008 event and the 2013 collapse, is that it was initiated by the water main rupture.

[131] I find on the evidence that the nature of the force and volume of the inundation of water from the 2008 event was sufficient to cause the two sinkholes, the first of which was substantial and the second of which was more dramatic in depth and aspect. As the second pursuer explained, this was in exactly the same location where the subsidence started to develop in November 2013. Mr Balfour submitted that it would be remarkable if these two events were purely coincidental, as Professor Cook insisted. The sewer had been in that

location, without any apparent problems, for over 100 years prior to the development of the first sinkhole. Mr Balfour submitted that the one thing that we know changed in the years prior to the development of the November 2013 sinkhole was the 2008 event. The two incidents occurred in very close proximity to each other. The 2008 water main burst caused settlement in precisely the same location that the initial settlement in November 2013 occurred. The obvious explanation for this is that the two incidents were related. Mr Smith considered the coincidence between these two locations to be highly significant in demonstrating a connection between the two incidents. I agree. I also accept Mr Smith's evidence that it would be a remarkable coincidence indeed for the first sinkhole in November 2013 to appear in precisely the same location as the sinkhole in 2008 but that there was no causal connection. Professor Cook's dismissal of this as mere coincidence was unpersuasive and inconsistent with the body of evidence I have accepted.

[132] It follows that the pursuers succeed in this case. I shall grant decree in their favour in terms of the first conclusion. I shall reserve meantime the question of expenses. It remains for me to thank Counsel for their able conduct of the case and their written submissions, which I found most helpful.