SCOTTISH HOSPITALS INQUIRY

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THE CHAIR: Good morning, everyone. Now, Mr Maciver, we have Dr Walker today.

Q We do.

THE CHAIR: Good morning, Dr Walker. As you appreciate, you're about to be asked questions by Mr Maciver----

DR JAMES WALKER: Thank you.

THE CHAIR: -- who's sitting opposite to you, but first I understand you're prepared to affirm.

DR JAMES WALKER: Yes.

Dr JAMES WALKER

Affirmed

THE CHAIR: Thank you very much Dr Walker. Can I encourage you, when answering questions from Mr Maciver, to perhaps keep your voice a little bit above the level that you would use in normal conversation.

A Okay.

THE CHAIR: You've got the microphones there, but there's quite a large space to fill, and it's important that I hear what you have to say. I think your evidence will take most of today. We've certainly scheduled it for today. We'll take a coffee break at about half past 11, but if at any stage you want to take a break for whatever reason, just give me an indication and we can always take a break. Now, Mr Maciver.

Q Obliged, my Lord.

Questioned by Mr MACIVER

Q Good morning.

A Good morning.

Q Good morning. Could you tell the Inquiry your full name, please?

A My name is James Taggart Walker.

Q And what's your occupation?

A Public health microbiologist.

Q For what organisation do you work?

A I work for Walker on Water.

Q Am I right in understanding that that's your own company, your own consultancy company?

A That's correct.

Q Now, you're aware that today we're interested in various matters to do with the Queen Elizabeth University Hospital in Glasgow. Is that right?

A Yes.

Q I understand you were involved in some work at that hospital in two capacities. Would that be correct?

A Yes.

Q Now, the principal one that I'm concerned with is in your role as the author of an expert report that you've put to this Inquiry. You recall that?

A Yes, I do.

Q I wonder if we could bring that up on screen, please? It's in the Experts Report Bundle 21, Volume 1, at page

180. So, when I refer to a document, it will come up on the screen in front of you and we'll be able to read together what it says. So, this is the title page from your report. Is that right?

A Yes.

Q You recognise that? And it's dated 21 January 2024. Do you adopt that report as your evidence----

A Yes.

Q -- for the Inquiry today? My questions to you will principally be about this report and about matters relating to that report as they might have arisen in evidence hitherto before the Inquiry, but I mentioned that you've been involved in two capacities, and as I understand it, your other involvement with the hospital occurred earlier, and you've alluded to that at section 10 of the report. If we go to page 340 of the bundle, section 10, it will be there.

Do we see at 10.4 onwards, halfway down the page, you make reference to having been invited as a representative, a PHE representative, to the hospital on 5 June 2014?

A That's correct. PHE being Public Health England.

Q That's what I was going to ask. What is Public Health England?

A Public Health England is a large-- very large organisation within England which deals with (inaudible) the

public health and, from my perspective, I was a research microbiologist within public health.

Q Okay, thank you. Could I ask you perhaps-- I'm also having trouble picking up the top end of what you're saying. While I've been involved in this Inquiry, I've managed to have a shell of microphones----

A Okay.

Q -- built up around me, and it helps me if I lean forwards slightly.

A Okay, I will. Thank you for your suggestion.

Q So, the same may help you.

A Thank you.

Q So, sorry, you mentioned what Public Health England was. What was your role with it?

A So, my role within Public Health England varied over a number of years, but to the latter part of my career I was a senior water expert within Public Health England dealing with, basically, problem shooting and research programmes related to water microbiology and the hazard and risk related to water within buildings.

Q I understand that around 2012 there was an incident in Northern Ireland relating to a pathogen, Pseudomonas, that occurred in taps and water systems there. You had involvement with that as a result of that during your time at Public

Health England. Is that correct?

A Yes, I did. Public Health England were approached by colleagues in Northern Ireland to provide assistance in a number of ways. There was that expert advice over telecoms and meetings but also providing research by the investigation of the tap components – and when I mean tap, I mean plumbing components – that were associated in the neonatal ward where the outbreaks had occurred and babies had become infected.

Q Now, on the page that's in front of you, do we see at 10.2 you have recorded certain concerns about that tap design?

A Yes.

Q Perhaps I'll read out, here, what's said in the guidance:

> "Owing to the high surface-area-to volume ratio and location at the tap outlet, certain designs of flow straightener may present a greater surface area for colonisation and support the growth of organisms. Therefore, when selecting new taps where possible flow straighteners should be avoided/not included."

And there was advice against using aerators in outlets. For the benefit to-- or in layman's terms, could you describe what that issue is?

A So, end of tap generally have a mechanism within them to control the flow of the water as it leaves the tap to prevent splashing and possibly even slow down the flow, and those components, generally, within a tap are plastic components of a very high surface area, extremely complex units, highly engineered that provide what's known as a high surface area for the growth of microorganisms, but they also retain debris, and any silt or sediment within the water will be basically encapsulated within that framework of the flow straightener and, within that, you will get what's called biofilm growth that is then dispersed as the tap is switched on, and that's dispersed into the basin and splashes out into the environment.

Q Okay, thank you. It's a matter I'm going to come back to----

A Okay.

Q -- later in my questions, but that is what led up to you having been involved in this other capacity with Queen Elizabeth----

A Yes.

Q -- in 2014. At 10.4, midway down the page, you record-- We've half read this already, but having been:

> "...invited as a PHE representative and water

microbiology expert to a meeting in the Labs... block at South Glasgow Hospital on 5 June 2014 to discuss the findings from the Northern Ireland outbreak to explain the issues and problems associated with microbial biofilm and waterborne pathogen colonisation of tap components."

That's essentially what you've just told us a moment ago.

A Yes.

Q At 10.5, you record a summary of what happened at the meeting, and I'll come back to that in more detail----

A Okay.

Q -- later. Moving on from that, you then go on to record some other work that you carried out with PHE. 10.6 at the bottom records publishing and writing. Is that right?

A Yes.

Q And then over the page, 10.7, you speak about co-authorising reviews, and 10.8, co-authoring a book on safe water.

A Yes.

Q 10.9, there's academic-type work, conferences and so on.

A Yes, so they're basically to explain that I publish widely and regularly within the expert area in which I work.

Q So that's a source of your expertise?

A Yes.

Q And that reflects your expertise in water microbiology?

A Yes, and it's about sharing that experience with the wider domain in a wider scientific community.

Q And just to be clear, it's that expertise that led to your involvement with Public Health England and to your involvement in the meeting in June 2014----

A Yes, very much so, yes.

Q Just before I step away from that, when you were at that meeting, were you working for Queen Elizabeth in any capacity?

A My attendance at the meeting was as a Public Health-- Public Health England----

Q Okay.

A -- water microbiology research expert who'd been involved in a major outbreak of Pseudomonas aeruginosa within neonates and the deaths of babies and the consequent investigations which occurred.

THE CHAIR: Again, Dr Walker, try not let your voice drop.

A Okay. My apologies.

THE CHAIR: I'm hard of hearing and I'm very conscious of that, but I think leaning forward into the microphones, I think, does help but also maybe be conscious that it's not just conversation,

it's production.

A Thank you. Yes, so, very much I was there as an expert.

MR MACIVER: Did you have any executive role?

A My role was to represent the work we carried out at Public Health England.

Q So, stepping away from that particular involvement, I'd like to ask you just a few questions about your career, your expertise and about limits to your expertise. Turning back to page 187, there's your introductory section. You begin introducing yourself there. You start at 1.1.1, obviously, with your studies, microbiology degree at Aberdeen?

A Yes.

Q And then over a number of paragraphs following that, you speak about 30 years at the Porton Down Centre----

A Correct.

Q -- of Applied Microbiology. Could you tell us a little bit about your career there?

A Interestingly, from my degree in Aberdeen where I set up laboratory models looking at the growth of what's called sulfate reducing bacteria on surfaces, which was my first investigation in biofilms, I then was able to apply for a job at Porton Down Salisbury as a junior

microbiologist, looking at the growth of bacteria on what was going to be copper surfaces related to a problem that actually occurred in Scotland hospitals in the 1980s, and from there, I spent many years working as a research microbiologist, and then through a series of advancements in my career and working on a different range of microorganisms, became an expert through time and gained my PhD through my work and that led to further management roles and then the final expert role in water microbiology as a PHE expert.

Q Indeed, on this page and the next page, going down to around section 1.1.10, you've given details of a number of projects you were involved in, and I don't need to go to those individually.

A Okay.

Q Over the page, again, at 1.1.11 to 14 you mention professional groups, professional bodies that you were part of.

A Yes, and many of those groups led to writing of government guidance, or at the time would have been Department of Health for England but also British standards and European guidance related to waterborne microorganisms and outbreaks and prevention of those outbreaks within buildings.

Q I don't think I asked you

specifically the question earlier on, but when you mentioned having written guidance, among that guidance was-- Am I correct in understanding that that included guidance relating to the Northern Ireland outbreak?

A It did, yes, which was specifically for Department of Health England.

Q Thank you. Just to complete that page, 15 and 16, you're mentioning some teaching roles again, and again in the two paragraphs at the bottom more authorship.

A Yes.

Q Before, over the page at 1.1.19, you describe the-- having formed your consultancy-- or having taken a career break and having formed your consultancy Walker on Water----

A Yes.

Q -- and, effectively, does that take us up to now? That's----

A It does, yes.

Q -- yes, that's the role you're in now. Paragraphs 20 and 21 there are mentioning your involvement with the Inquiry, and if I may just read 1.1.21 to you. You say, as a water microbiologist:

> "I've used my expertise and experience to assist the Inquiry by assessing the microbiological status of the water and wastewater system the QH and RHC from the point at which the patient's occupation took place. This included assessing and understanding transmission routes through which the patients were exposed through the water and wastewater systems. I understand my duty to be impartial in presenting and assessing that evidence and that my expert opinion would help the 'court' with its task."

Can you confirm that that remains-- that continues to be your position today?

A That does continue to be my position. Thank you.

Q Paragraph below that, that's the key questions that you were asked to assist the Inquiry on. First of those was, "From the point at which there were patients in the hospital, was the water system in an unsafe condition in the sense it presented an additional risk of avoidable infection to patients?"

A Yes.

Q And two was a similar question but relating to the present: "Is the water distribution system no longer in an unsafe condition in the sense that it now presents no additional avoidable risk of infection?"

A That's correct. That is the questions which I set out to answer.

Q So, broadly speaking, that's two questions. One is past looking and

one is present looking?

A Correct.

Q And does that determine, in broad terms, the structure of the later part of your report?

A It does.

Q At section 6, you're looking at how the system was, at section 7 you're considering how it is now?

A It does, yes.

Q There are some ancillary questions mentioned before-- below, and then over the page, again, it's paragraph 24 onwards, you set out your other duties as the expert as regards impartiality, candour, not exceeding your expertise and so on. Again, does that remain your position today?

A It does, yes, thank you.

Q Now, before I conclude on this part of the report, it's important to be clear about your expertise, where it begins and where it ends. So your expertise, as you've told us, is a water microbiologist, is that correct?

A That's correct, yes.

Q But there are some other areas that the report may or may not touch upon, and where I would have to ask you as to your view as to whether you have expertise in these areas. So I would put these to you, and you can tell me if you agree or disagree with the suggestion.

A Okay.

Q The first would be in relation to molecular strain typing. Is that a matter in which you have expertise?

A It's an area in which I've been involved in a number of outbreaks where other experts have undertaken the speciality involved in the typing of strains from the environment and from the patient and, using their own expertise, they have judged that it's similar or not. So it's outwith my own expertise.

Q Sorry, that was-- I didn't quite catch the last bit.

A Outwith my expertise.

Q That's outwith your expertise, thank you. The second area would be the application of whole genome sequencing. Is that a matter that's inside or outside your expertise?

A That's outside my expertise in terms of the detail of how it's done.

Q The third is the identification of genetic linking of organisms?

A Again, that's similar to the whole genome sequencing question. It's outwith the expertise which I have in terms of the detail of the mechanism and technologies used to achieve those outcomes.

Q And the fourth is the assessment of clinical risk?

A I would leave that to the clinical teams involved to determine that

for the safety of the patients who they are looking after, but very much aware from my own expertise in terms of water how the risk happens from the water system.

Q Okay, thank you. So to summarise that, there are matters you have some familiarity with, but you wouldn't go so far as to claim expertise in those four matters?

A Correct.

Q Right, thank you. As I mentioned, I'm going to principally refer you to this expert report. Where there's another document I'd like you to have a look at that will come up on the screen in front of you.

A Thank you.

Q The report is fairly lengthy, as you're no doubt well aware, nearly 200 pages. For reasons of time alone, it's not my intention to attempt to take you to all of it. It would simply be impossible to do so. Instead, I'm going-- I'm principally interested in the two sections that I mentioned, 6 and 7, which were the past and present assessments.

A Okay.

Q To some extent, I'll ask you questions also about section 4 which would be the description of the system as installed, and section 5, which I understand to be your description of what might be described as hypothetical water systems or unsafe features that one

might see in a water system generally. Have I got that right?

A Yes, we can discuss that when we get to those points. So, again, I'll just-- The word hypothetical, that section is based on experience over very, very many years for myself and with colleagues and understanding the implications where systems are either not managed or become a risk to patients.

Q Okay, thank you. Well, that's an important point where-- You have the expertise, I don't, where I-- Where I may slip in terms of words choice or so on, I'm grateful to you for picking me up on those.

A Okay, that's fine.

Q So I'll try to be quite focused in my questions and grateful if you could do the same with the answers.

A Thank you.

Q So, section 4 was the earliest of those I mentioned, and it begins at page 208, and there you're setting out an introduction and applicable standards used in the system. First reference I'd like to take you to is page 211 and section 4.3, which is supply of wholesome water. Do you see that?

A Yes, I do.

Q You've started out there by giving us a description of wholesome water. “Water delivered in Scotland” at paragraph 4.3.1:

"Water delivered in Scotland by the water supplier was considered as 'wholesome water' which is fit to use for drinking, cooking, food preparation or washing without any potential danger to human health. "

A Yes.

Q Now, am I correct in thinking that that is your paraphrasing of a statutory definition?

A That is correct.

Q And you've given a-- at footnote 80, there at the bottom, we can see it's the 2001 Regulations.

A Yes.

Q Now, one point worth taking from that is that the regulations, as I read it, aren't presupposing that the water needs to be sterile in order to be wholesome. Would that be correct?

A Wholesome and sterile are very, very different terms in terms of the outcome of the water. Sterile would be where there's no bacteria in the water. Wholesome is where it applies-- the definition that's there in front of you, 4.3.1, applies to the water. It will have bacteria within it or it must meet certain definitions once it enters a building and once it exits the tap where the patients are going to be. But we have to consider that water may not be appropriate for all the patients within the hospital, maybe

patients who are at high risk, and if you have a clinical decision that that water may have to be of a higher standard for those patients.

Q Okay. So the key test would be the potential danger to human health?

A Yes.

Q And that's completely different from thinking in terms of sterility, which is about the content, an absolute test in terms of the content?

A Very absolute, yes.

Q So, in fact, the presence of microorganisms in the water is not incompatible with wholesomeness?

A No, it's not.

Q And, indeed, if we look at the bottom of the page of-- at 4.3.4, you're perhaps setting that out in better terms than than I asked you there, where you're saying that,"Wholesome water is not sterile and will contain microorganisms," and then:

"Whilst wholesome water may be safe for most patients, the provision of the supply of this water in areas where vulnerable patients are present should be risk assessed to prevent infection in susceptible patient groups. "

And that, I think, is what you were describing to me a moment ago?

A Yes.

Q Does it follow from that that water that's found in a hospital will inevitably have microorganisms within it?

A Yes, because the water-- it only needs to be wholesome, but where a clinical decision is made that the water needs to be sterile for certain patient groups, then that water will be sterile.

THE CHAIR: Dr Walker, I'm continuing to find difficulty----

A You are? Okay.

THE CHAIR: -- in hearing what you're saying.

A Can I move this?

THE CHAIR: I don't know if our technical people can----

A Or can you----

THE CHAIR: -- as it were, ramp up the system.

UNKNOWN SPEAKER: I think they're on as high as it can.

A They are? Okay.

THE CHAIR: Right.

A I will try and project more.

THE CHAIR: Yes, I mean, it's not straightforward. You know, we don't often find ourselves giving evidence, but I'm just not hearing enough.

A Okay.

MR MACIVER: Apologies, my Lord. The best I could do-- best thing we could do, I'm afraid, is the leaning forward trick.

A Yes, I've----

Q Not great for the back, but it is

an encouragement to speak fast.

A I'll cope.

Q So if it follows that water in the system will inevitably have microorganisms within it, then does it follow that for water safety it's not so much a question of keeping microorganisms out of the system? Is that right?

A You do not have to keep them out of the system for the majority of the patient groups within the hospital.

Q What therefore are the important things to have regards to when running a water system?

A As the water is delivered to the hospital is wholesome, then the water leaving the taps should be wholesome, and therefore that water has to be managed from the point at which it enters a building, passes through all the various water equipment and components and is then delivered to the outlets where the patients would be. The importance in general terms, from a microbiological perspective, are to keep the hot water hot, the cold water cold, and keep the water moving. They're very simple layman's terms, but they fulfil basic requirements in order to prevent opportunities for microbial growth in the water system.

Q Okay, thank you, and I'll come on, I think, to each of those in turn, but

that's a very pithy description, and I'll just ask you about the importance of those three elements.

A Okay.

Q Why is keeping hot water hot important?

A So, in terms of the hot water, the regulations for health care are the water in the calorifier, the hot water cylinder that provides the hot water for all of the hospital, the water should be heated to 60 degrees centigrade. That hot water is then flowed round the hospital and it should return at 55, and that will reduce and control, to the best of its ability, the microorganisms within the hot water system. In terms of the cold----

Q How does-- Sorry, just in one sentence if you can, how does keeping hot water hot reduce the amount of----

A It prevents the microorganisms from multiplying.

Q Thank you, so, that was the first, keeping hot water hot. Second was keep cold water cold. How does that work?

A So, again, that's keeping the temperature below 20 degrees or lower and reducing the opportunities for microbial growth to multiply.

Q So, again, that's about proliferation. Is that right?

A Yes.

Q The third element was keep it moving. How does that work?

A So, keeping it moving means you're flushing the microorganisms that are in the water through the water system and out of the taps, so you're removing the microorganisms from the water system by keeping the water moving.

Q Thank you. The next section I'd like to look at is a few pages further on, 224, and I should say that this-- I'm moving at speed through this part of the report----

A Okay.

Q -- but in this part of the report you are-- In summary, you're looking element by element at the water system. I'm afraid for reasons of time I'm picking out parts that seem to me to be interesting or important. The first of those is at the foot of the page, 4.15 on pipework. Now, the first thing you do there is refer to the employer's requirements governing the build, where it stated that:

> "In respect to water systems and filtration, pipework shall be stainless steel with compatible accessories. [Then you note] However, the photographic evidence [you give a reference to that, and I'll go to that in a moment] only indicates the presence of copper for the main domestic hot

and cold water system."

So, you're putting your finger on an incompatibility here between the requirements for the general pipe work in stainless steel and what you've seen in terms of a copper fitting. Is that correct?

A Correct.

Q Now, I will take you to a photograph or two. First one is within the same report at page 390. It's not at page 390. Sorry, give me a moment. I'll see if I can identify what I should've referred to. We may have to do without the picture, I'm afraid. That's my mistake. I apologise. The picture that I'd intended to take you to, I think you'd be familiar with it. It was a picture of a copper tail. Was that correct?

A Correct.

Q You recall what I'm talking about here?

A Yes, a hard fixed copper tail.

Q Could you tell me what a tail is, please?

A So, for example, you have your hot water system which has a flow and a return, and we know that those ran in the ceiling voids, and from the flow and return you'll have a spur going down to an outlet, such as a hand wash basin. It looks like those spurs or tails ended up in copper, whereas the system specification was for stainless steel.

Q Okay, thank you. So, you're

drawing a distinction between the main pipework in the hospital and I think what you described as a spur----

A Yes.

Q -- which was a length taking us from the main pipework to the fitting, in this case perhaps a tap, perhaps a shower, something like that.

A Correct.

Q Am I right in understanding that it was that spur that is what you refer to you talk about a tail?

A Yes.

Q You identified the tail that you saw as having been made of copper?

A Correct.

Q What's the problem with making a tail out of copper?

A The problem in terms of the Scottish technical guidance relates back to problems in 1980s where there was debris and sediment within the Scottish hospitals, which led to failure of the copper pipework, and this was an extensive, very expensive problem related to replacement of miles of copper pipe within the hospitals, and because of those problems, the Scottish guidance was rewritten to ensure that there was filtration to prevent debris and sediment entering the pipework, but also that the pipework should then be in stainless steel so it has a longer life, because the sediment and debris reduced the lifespan

of the copper pipework.

Q Am I correct in understanding that this was a problem specific to Scotland?

A No, it was specific to areas in the world which had soft water, quite often with upland water with a lot of humic and fulvic acids within it, which was a debris which would flow, which flowed through into the water systems and sedimented onto the pipes.

Q So a combination of soft water plus debris plus copper?

A Plus bacteria.

Q Plus bacteria, equals?

A What we refer to as pepper-pot pitting and failure of vast quantities of the copper pipework within the hospitals.

Q The pipes started to disintegrate. Is that too strong a word?

A Yes, basically they started to leak and fail and had to be replaced.

Q Okay, thank you. I think I've found where I went wrong with the photo reference a moment ago. The copper tail that you were picking up I think was from a reference from a report by DMA Canyon in 2015. Do you recall that?

A Okay, yes.

Q That DMA report is at bundle 6, page 122. Is that the report-- You recall seeing this?

A Yes.

Q In general terms, that's a

report into Legionella but reporting on the state of the water system as it stood at April May 2015. Is that correct?

A Yes, it was a Legionella risk assessment of the entire water system.

Q If we move on to page 390 of this document, then with luck there should be a photograph here. If we see----

THE CHAIR: Just before we do that, Dr Walker, you refer to Scottish guidance. I'm assuming, unless you tell me differently, that that's SHTM 04-01, Is that right?

A Yes, correct.

THE CHAIR: Thank you.

MR MACIVER: So, of these six photographs, the lefthand side, the middle photograph, it's marked, "Small copper tails visible," and it refers to, "Infra Red taps and Armitage Shanks taps in endoscopy washroom." Is that the copper tail that you-- of the type----

A Yes, it's one of them, yes.

Q Did you see many of this sort of thing when you visited the hospital?

A When I visited, the majority of the units which I looked at were actually behind the wall panels, so you have very little visibility of the pipework.

Q Okay. We have this photograph because here's a bit of the pipe poking out of the wall.

A Yes.

Q You can see here because it's the brown line in the middle of the photograph.

A Yes.

Q Is that the copper tail?

A And the one in the middle on the lefthand side, yes.

Q Thank you.

A So we know there was copper within the system.

Q Thank you, and this particular copper tail is not very large. Is that correct?

A That one looks relatively short, yes.

Q I think in fairness, you don't know for other copper tails.

A We don't, correct.

Q Thank you. The next section I'm interested in – and this is going back to your report – would be at paragraph 4.16, which ought to be in page 225, and here at 4.16 you're discussing supply of filtered cold water to different departments. Now, why I'm interested in this is, here, you are talking about-- You're defining cold water by reference to temperature parameters.

A Okay.

Q I'll perhaps just read the first paragraph:

> "Cold water is supplied to various departments and wards for use at the point of use… [you give some examples of that. You talk about] end-of-line dump valves to discharge the water into the drain when the water temperature increases above 23 degrees, as there is a reasonably foreseeable Legionella risk in water systems if the water temperature in all or some part of the system is greater than 20 degrees centigrade. "

Then again in the paragraph under at 4.16.2, you talk about:

> "The warmer the cold water, then the greater likelihood of microbial growth [which is what you told us earlier]. Therefore, dumping cold water when the temperature reaches 23 degrees serves several purposes [and you list three of them], removal of microorganisms, reduction of water temperature and replenishing any chemical disinfection."

My question is that you mentioned two different temperatures here, 23 degrees for the dump valves but 20 degrees for the Legionella risk. If we skip forward 40 pages to 265, at 5.12.3 you're discussing what you'll probably tell us about in a moment about waterborne pathogens growing in temperature range of 25 to 45 degrees.

A Yes.

Q "Hence guidance encourages the following [first bullet]:

"Keep the cold water cold at or below 20 degrees, preventing heat gain…"

Then for hot water, 60 degrees, 55 degrees, as you told us earlier, and you mention again the growth range, 25 to 45.

A Yes.

Q Then if we look over the page, there's a diagram of (inaudible) thermometer graphic, Legionella and a sort of vertical bell curve on the righthand side, with parameters 70 degrees, 60, 49, 25 and 0 degrees. Now, my question to you is really can you help me by explaining those numbers? I'm particularly interested in the lower 20, 23, 25 boundary and why there isn't-- or why you haven't used a single number for all three.

A Thank you. So, in terms of the cold water, we know that the regulation's to try and keep it below 20 degrees centigrade, and if the water starts to increase above 20 degrees, you will get more microbial growth. So the microbial growth may be in stasis below 20, but the more you go above 20 degrees centigrade, the more opportunity there will be for the potential growth of the microorganisms. You have to have a cut-

off somewhere in terms of-- For example, you were just mentioning those dump valves. You could've chose 25, but you would have more growth, so we brought it down to 23, and it doesn't mean the bacteria are not growing at 23, but what you're doing when you operate a dump valve is you're moving that water at 23 and reducing the temperature back down, so you're reducing the opportunity for microbial growth as the cold water increases in temperature.

Q Okay thank you, number of questions I can think of as a result of that, and perhaps the first of them is answered by the bell curve graphic you've got in front of you. Can you describe how growth occurs, increases and so on as the temperature rises above 20?

A So, microorganisms will grow better as the temperature increases, and as you get to 25/30 degrees, you will get more bacteria growing more quickly, and as you increase above 30 to 37 to 40, you'll hit the sweet spot that the bacteria will actually grow exponentially at. So, by removing the temperature profiles from where-- You talked about that optimal growth range. When you have it lower, then you have reduced microbial growth, and if you keep it much higher, in a higher temperature range, 55 to 60, then you will reduce the potential for the bacteria to multiply within the water.

Q Okay, thank you. So, am I correct in understanding, then, that there is a sweet spot or a peak which is the thickest part of the bulge here, and that's between, I think you said, around 37 to 40 degrees. Is that right?

A Yes.

Q But as we are moving towards that, am I correct in understanding you had stasis below 20, and then as you move above 20 you start to get some growth, but it doesn't become exponential until you get considerably above 20. Is that right?

A Correct.

Q So does it follow from that, then, that when we're talking about 20 or 23 or 25 for the functions that I referred you to a moment ago, the choice of number there is essentially a pragmatic solution as to when is it best to have the, for example, dump valves come into operation?

A It's about reducing the opportunity for microbial growth. It's about controlling that growth, and one of the methods of doing that, as you talked about, is temperature and keeping the water moving, and those dump valves basically satisfy both of those requirements by-- When you operate the dump valve, then you keep the water flowing, you remove any water with bacteria in it, but also you then replace it

with water that is below 20 degrees centigrade.

Q In that case, then, is temperature and movement inherently linked?

A They need to be linked. They need to be part of the control strategy for reducing the opportunities for microbial growth in the water system.

Q And keeping the water moving is part of keeping the temperature down, or perhaps I'll put the other end of it----

A Correct.

Q And you've said the mechanisms by which this occurs is replenishment with new, colder water.

A Correct.

Q And is there any other means by which movement assists in managing temperature?

A So, when the water is delivered to the hospital, it will have a residual chemical, chlorine, within it, and as that water passes through the hospital, through the miles and miles of pipe which each hospital has, that chlorine concentration will reduce, and therefore when you have a dead-end pipe, for example with those areas where you want to purge the water, then when you purge it, you move it, you remove the water which may be at 23. You're removing that potential for microbial growth, but you're replacing it with water

with a potentially higher chlorine concentration.

Q Okay. Thank you, and is that because chlorine gets used up? Is that how it dissipates as it makes its way down the system?

That's correct. Any biocide which is entering a building will be challenged by the organic carbon within that building – organic carbon being debris, sediment, microorganisms – and as the water passes through the building, the more sediment, the more debris, the more microorganisms present, the more quenching and reduction of the biocide you will have as the water passes through the building.

Q So new water is helpful, in summary, in two ways: it provides fresh biocide, and it also is colder, so it reduces the temperature.

A Yes.

Q Thank you. Now, I took you quite far forward in the report there. Could we move back to page 231, please? This is the soil, waste and drain system at the bottom of the page. If we go two pages further on to 233, there is a picture. The top picture is-- In fact, I think it may be the same picture with a copper tail, in fact, now that I look at it. It's the left-hand side of this picture I'm interested in at this point. We have a figure marked, "Trap below sink unit."

Can you see that?

A Yes, I do see it.

Q Can you explain what that item is, please?

A So, basically, that is a bottle trap that's attached to waste sinks, hand-washing sinks or drains, and it's a bottle trap which basically contains the water, and the bottle trap contains the water to prevent foul odours coming back up the water system.

Q Does this fulfil a similar function to what a U-bend might in your house?

A It does, yes, and bottle traps are used quite often where there is not the space or capacity for a U-bend.

Q Okay. One function that I have when I'm asking you questions is to gather together questions from other participants, and there are references in one or two places in the report to U-bends, and a suggestion I've had is that in actual fact there aren't U -Bends present at the hospital, and instead traps are universally used. Now, you've visited to the hospital, and you've viewed at least some of the apparatus. Does that tally with your recollection?

A It does, in that there weren't U-bends, but there were bottle traps. Bottle traps, as we've just discussed, provide a similar control scenario to prevent odours coming back into the ward environment

by having that bottle of water, hence a bottle trap, from the drains, and it also acts as a receptacle to collect any material that's poured down the basin or sink.

Q Okay, thank you.

THE CHAIR: Sorry, can I just make sure I understand the answer there? The proposition that was put to you-- You've explained what a trap is under reference to the illustrations.

A Yes.

THE CHAIR: Now, the proposition that was put to you, if I understood it, was that if you look at the hospital overall, I think it was suggested by Mr Maciver there are no U-bends. It's always traps that you find. Now, first of all, did I get the question right?

MR MACIVER: That's essentially it, my Lord. The point was whether that's conformed with Dr Walker's----

THE CHAIR: So, what's the answer to that?

A Well, from what I observed and what I have in my photographs, there were only bottle traps. I can't categorically say there are no U-bends throughout the hospital whatsoever.

THE CHAIR: But from your observation----

A From my observation within the wards----

THE CHAIR: You agree with the

proposition?

A Yes.

THE CHAIR: Right, thank you.

MR MACIVER: So, there are, on occasion, references in the reports to U-bends, and there's certainly one later on where you are talking about a kind of hypothetical or potential section 5 features that one sees in water systems generally. There's a heading there that refers to U-bends. Where we come across that, we shouldn't understand that as a specific reference to any U-bend that you'd seen at the Queen Elizabeth. Is that correct?

A Correct, because the U-bend and the bottle trap perform the same function, and some hospitals will have U-bends and some will have bottle traps.

Q Thank you. The next passage I'm interested in is three pages further on at 236. Now, 4.26, flexible hoses and tails in the bottom part of that page. 4.26.1, you are making reference to an early document in the tender process, "Invitation to participate in competitive dialogue," which stated that, reading from it, "Flexible hoses were prohibited in the build. However, these were found to have been fitted in the water system." At 4.26.2, you mentioned what they are for: “Flexible hoses, also known as tails…” Is that in distinction to, or is it just another type of the tails that we've already spoken

about, copper tails?

A So, in real terms, these would be called flexible tails.

Q Do they fulfil the same function, essentially?

They do, yes, generally for connecting equipment to the hard copper – or hard stainless steel, as may be in some cases – water system.

Q So, two points from this page. One, they were prohibited, but they've found to have been installed anyway. Is that correct?

A Yes.

Q And, two, they essentially serve the function of taking water from the main pipework to the outlet.

A An outlet being a piece of equipment, or historically many flexible hoses-- flexible tails were used to connect to sinks and basins.

Q Okay. So, I don't know whether the word "spur" would be appropriate to refer to----

A It would be, yes.

Q So, spur, tail; these are examples of where one finds flexible hoses. Thank you.

A Are you going to touch on at some point why they're prohibited?

Q Over the page at 4.26.3, you mention what they are typically made of. "The outer casing of flexible hoses is typically braided steel or stainless steel

with a synthetic rubber inner lining such as EPDM," and you give the chemical name for that. This may be the question that you're looking for. What's the problem with that?

A So, the problem there is that, again, historically microbiologists have demonstrated that this material, the EPDM, is a black rubberised carbon material, and it has various gaps and holes within it, allowing niche environments for the bacteria to grow on as a biofilm, but also that this rubberised material provides nutrients for the growth of bacteria, and these basically flexible tails, EPDM material, have been demonstrated to provide opportunities for microbial growth and resulting in a number of waterborne outbreaks.

Q So you're referring to two distinct problems with having an EPDM material in your flexible hose. Is that right?

A Yes, that's correct.

Q Are they both serious problems?

A They are issues which, when carrying out a risk assessment, one needs to be aware that if they're present, you're increasing the risk and opportunities for microbial growth within the water system.

Q It may be worth dwelling upon them for a couple of minutes. The first

thing you mentioned, as I understood it, was the actual surface or constitution of the hose. You mentioned, I think, holes, perhaps cracking. Can you tell me about that constitution, please, and why that's a problem?

A Basically, you'll have-- Water supplied to a building, as we've discussed, has bacteria within it. Those bacteria will initially be in the water phase. However, over time, those bacteria will become attracted to surfaces where there may be sediment and debris because they're going to use that sediment and debris as a nutrient source and then grow as a biofilm, and within the flexible hose where you have a large surface area to volume ratio because you have the inner lining of the flexible hose-- but you also have niche holes within it into which the bacteria can enter and grow and, therefore, when you are using a biocide or increasing the flow rate to try and remove bacteria, you have a problem because you cannot access the holes in which the bacteria are actually growing as a biofilm. And the flexible hoses, because of their nature, will enable the bacteria to at a greater rate and a greater density than a normal pipe within a water system.

Q Is that a function that's inherent to its flexibility?

A That's a good question. No,

because we have EPDM washers which are also used within plumbing systems, and those washers will provide the same surface on which a bacteria can grow; but flexible hoses need to be made of a flexible material because of the way they are used to connect one piece of equipment back to the plumbing system.

Q Is it too simple, then, for me to say that the stretchiness of the material is what causes these nooks and crannies, these holes, to open up?

A That's an interesting question, but it's the surface material, regardless of whether it's stretchable or not, that provides a high surface area to volume ratio and provides nutrients for the bacteria to grow, but it is designed to be compressible, if that's the word, or stretchable.

Q Okay, so, in actual fact, do I follow correctly that even if they weren't bent, twisted, stretched and so on, EPDM hoses would still present a risk because of what you've told us before?

A Yes.

Q And that is essentially-- the first part is from the surface area itself, which is rough, pitted holes in it and so on. Is that right?

A Yes.

Q And then the second big issue that you mentioned was the material itself. Can you tell us about that? Why is

that a problem?

A The material itself is designed because it needs to be stretchable and flexible, and within it, it will have additives and hardeners, and those additives and hardeners within the rubber material provide nutrients for the growth of the microorganisms. They're attracted to the surface. They'll grow on the surface as a biofilm. They'll produce a polysaccharide, and they'll take nutrients from the surface of the rubber and grow, and it provides a greater opportunity for a greater density and more biofilm than, say, a hard steel or copper surface.

Q Okay, thank you. So, to summarise that then, the double problem is that the material provides refuge where the organisms can get to, to harbour the organisms, and then the second problem is that that refuge itself is a food source.

A Yes.

Q And that's why EPDM is a bad thing and is not to be used?

A There's been many materials developed over many years, and it takes time for these materials to be recognised whether they provide opportunities for microbial growth or not, and that is one of the materials which has been demonstrated to be a risk for microbial growth.

Q Thank you. The final part that I want to look at this section 4 of the

report is the section immediately below that, "Wash Hand Basin Taps." Over the page, at 4.27.2, you record that the specification called for pillar taps or Armitage Shanks taps. Do you see that?

A Yes, I do.

Q At 4.27.3, you record that, "In and around July 2012 the Contractor proposed the Horne Optitherm thermostatic bib tap" instead, and that they were fitted. Is that right?

A Correct.

Q And that-- If we move over the page one more again, we'll see two pictures of-- is that the Horne Optitherm taps?

A That is the Horne tap, yes.

Q And these are the types of taps that prompted your meeting in 2014 Is that right?

A Yes.

Q Now, I'll take that meeting at this point in the evidence. You've provided separately a witness statement as opposed to your expert witness report, and if we bring that up on screen? It's at Bundle 11, page 161. We see here this is your witness statement----

A Yes.

Q -- of Dr James Walker. Are you content to adopt that statement as your evidence to the Inquiry?

A I am, yes. Yes.

Q Now, it's not my intention to

take you through this witness statement just now because-- and correct me if you have a different understanding from what I have, but my reading is that this witness statement is essentially setting out details around that meeting, what happened, how you came to be invited and so on.

A Yes.

Q But you've also made reference to that process in another document before the Inquiry. If you recall when you submitted your reports, there was some follow up Direction 5, questions put to you, and you submitted what might be termed a supplementary report.

A Correct, yes.

Q And in part of that report do you recall that you also dealt with that meeting and with the Horne taps?

A I did, yes. There were questions related to that.

Q For reasons of convenience, it seems to me easier if I take you through that meeting from the perspective of a Direction 5 response. So, set the witness statement to one side for the moment. I'd ask you have Bundle 21, Volume 6, before you. Page 3 is where your Direction 5 response begins or the letter instructing your response begins.

A Okay.

Q Do you see that, and do you recall that letter?

A I do, yes.

Q If we move over one page we see a series of questions in bold and then your response below them. Do you recall this document first of all?

A I do, yes.

Q Are you content to adopt also this as part of your evidence before the Inquiry?

A Yes, I am content to adopt it.

Q Now, the one we have before us, section 1, on page 4, is discussing the Horne taps, and the question at the top of the page also makes reference to the meeting in June 2014. Do you see that?

A I do.

Q If you move over a few pages to page 8 at paragraph 1.21, hitherto you've been describing the Northern Ireland incident. At paragraph 1.21 you begin to make reference to what we talked about at the start of evidence, which was your involvement and awareness of the outbreaks in Northern Ireland and having been invited to attend the meeting in June 2014. Do you see that?

A I do.

Q Again, you mention here that your invitation was, in the last two lines, "...to present on the PHE findings and further PHE investigative research."

A Yes.

Q Did you do that at the

meeting?

A I did, yes, via a PowerPoint presentation.

Q PowerPoint presentation. Thank you, and indeed, you described that at 1.22 at the very----

A Okay.

Q -- bottom of the page, "During the meeting, I presented on the findings..." What was the gist of your presentation, please?

A The presentation was to demonstrate the work which Public Health England had carried out on a wide range of plumbing materials which we'd received from Northern Ireland, as well as the meetings which we'd been involved in with Northern Ireland colleagues. The materials which we'd received, the plumbing components, were shown to be contaminated. Many of them were Pseudomonas aeruginosa. For example, the flow straightener, in some cases, were over 60 per cent of them contaminated.

Q Can I just interrupt there. Your volume's starting to drop.

A Again? Okay.

Q An inch forwards, please.

A So, the presentation was to look at our involvement within the Northern Ireland outbreak, and much of that, from our perspective at Porton Down Salisbury, was where we investigated

many many plumbing components in terms of directly recovering bacteria from the plumbing components and looking at these from a microscopy perspective. But the overall work we did demonstrated that over 60 per cent of the flow straighteners were contaminated with Pseudomonas aeruginosa, and from the work which we carried out, we then worked with the Department of Health to provide an input into guidance which they later produced as an addendum for advice to reduce the risks from Pseudomonas aeruginosa within what was to be called augmented care units----

Q Can you----

A -- where patients were at a higher risk to microorganisms.

Q You mentioned, as part of that, flow straighteners. Am I right in understanding that flow straighteners----

A I did mention flow straighteners, yes.

Q -- flow straighteners are part of the Horne taps?

A Flow straighteners are part of a number of taps, and at that time they were part of basically all taps. The flow straightener, as I later found out, was also present within the taps which Horne Engineering were producing, because they presented at that meeting on their taps.

Q Okay. Now, we've mentioned

the taps twice now, and I think the discussion begins to get quite technical quite quickly about the constitution of the taps. So, rather than risk discussing flow straighteners at length without giving you an opportunity to tell us what those are, I wonder if you could take a minute to describe the role of a flow straightener and problems with it.

A It's interesting to note that we focus very much on the flow straightener, which is a plastic insert at the end of the outlet of the tap, and this plastic outlet is a multi-layered, highly engineered piece of plastic. It is used to provide a uniform flow from the tap to reduce the potential for splashing and potentially, in some cases, reduce the flow of the water as well. So, it provides a uniform flow rather than a dispersed flow that may splash into the ward environment.

Q How does it do that? Is it part of the structure of the design of that particular implement?

A These were, or are, highly engineered pieces of plastic designed to provide those particular functions of uniform flow and reduction of splashing----

Q When you----

A -- with multiple layers of plastic within them and highly technical.

THE CHAIR: What does highly engineered mean?

A I guess you'd have to ask an engineer who----

THE CHAIR: Sorry?

A You'd have to ask an engineer who designed these units. They----

THE CHAIR: Well, it's your expression, and (inaudible) Dr Walker.

A It's my expression. So, when I was involved with the outbreaks in Northern Ireland, we took some of the flow straighteners apart because we had to investigate them and recover the microorganisms, and these were composed of six, seven, eight layers of plastic with many multitude of probes and specific parts of plastic that were designed for a particular reason within those different layers. So, it's not just a little bit of plastic stuck in the end of the tap with a little hole in it. These are multi-layered. I think there's an image somewhere, Mr Maciver, of one of these flow straighteners demonstrating the complexity, and that's why I say highly engineered.

THE CHAIR: Maybe at risk of jumping around. I mean, I think I've got an answer which helps me there. At the risk of just jumping around----

A Yes.

THE CHAIR: -- did I note you as saying earlier that all taps, or all modern taps, have flow straighteners, or is this something specific-- or is there something

specific about the flow straightener in the taps produced by the Horne company? So, back to my critical question. Would you expect to find flow straighteners in all modern taps?

A When the outbreak in Northern Ireland occurred, the taps we investigated all had flow straighteners.

THE CHAIR: Yes.

A And to our knowledge, the majority of the taps supplied to hospitals at that time contained flow straighteners.

THE CHAIR: Right.

A Northern Ireland re-engineered all their taps after their outbreak such that they did not have flow straighteners.

THE CHAIR: All right.

A And it was partly based on our own work and our own investigations that demonstrated that the flow straightener was highly contaminated----

THE CHAIR: Yes.

A -- and therefore it was one of the components within the area of the last-- we call it the last two meters which were contaminated. Therefore, we worked with the industry during the writing of the English guidance because we, as microbiologists and the Department of Health, felt that the removal of the flow straightener----

THE CHAIR: All right.

A -- would reduce the risk of water borne microorganisms from

growing within the outlet where the organisms that have got oxygen, have got lots of nutrients.

THE CHAIR: Now, does that mean that by the time we get to June 2014, if I was wishing to buy a tap, I would have the option of buying a tap without a flow straightener?

A Yes.

THE CHAIR: Yes, right.

A You would have-- If you'd been aware of the work which had been going on at the time, if one had an interest in that area, one would have known from the press----

THE CHAIR: Mm-hmm.

A -- from the RQIA, which was the Irish Investigation.

THE CHAIR: Sorry, you missed----

A The Irish Investigation publication, RQIA.

THE CHAIR: Yes.

A The publication which Public Health England published in journals, and the Department of Health guidance which the addendum had been basically written very rapidly because of the concerns of the flow straighteners and the potential for the growth in outlets, demonstrating and indicating that flow straighteners should not be used within taps because of the risk of Pseudomonas aeruginosa growth within that area.

THE CHAIR: Right. So, these are

the sources of knowledge, and by 2014, there are such things as taps without flow straighteners?

A Correct, yes.

THE CHAIR: Right. Thank you. Sorry, Mr Maciver.

MR MACIVER: No. Thank you, my Lord. (To the witness) You mentioned that there were a picture of a flow straighteners somewhere. The description of them got quite technical quite fast and so I'm going to-- I wasn't going to take you to a picture, but I'm going to attempt to do so, and do let me know if I've got this wrong.

If we move forward-- Sorry, it won't be this document, it would be back to your principal expert report. If we can look at page 273 of that? Now, this is the context of a discussion of outlet fittings, and if you see at the top of that page, 5.20.3, you mention some of the purposes that outlet fittings are for. That includes one flow regulator to reduce flow, two flow straighteners to provide smooth flow, and three something called “aerators”. There's a picture of outlet fittings with some contamination in the middle of the page.

A Correct.

Q And then over the page, there is a banner picture across the top which has either deconstruction of one or more outlet fittings. Are these the types of

fittings that you have in mind when you're talking about flow straighteners?

A That's correct, and that's why, Lord Brodie, I used the expression "highly engineered" because it's extremely complex. In fact, you can see in the one in the image and the item second from the right, it also has a small rubber washer within it and, again, that small rubber washer will have contributed to a microbial growth, and the item which is second from the left has hundreds of little probes within it, and in an investigation which we carried out, each of those little probes serve the purpose as a biofilm, generator-- biofilm growth, and so you have a huge surface area to volume ratio within these components for microbial growth, increasing the risk of waterborne microorganisms at the end of the taps, and the potential for waterborne pathogens such as Pseudomonas aeruginosa growing on those components.

If you go back one image, one page, to 273, those components-- that flow straightener which you can see in the middle of the page was one which was taken from the work in Northern Ireland, and it's important to note that these components had only been in place for four months after a refurbishment. That is a highly, highly filed component from which Pseudomonas aeruginosa was

recovered.

Q The caption there is, "Biofilms and outlook fittings," and the-- if we look at the right-hand one and we see (inaudible) the right hand picture within that image, the right-hand item within that image, we see brown stains or debris or something.

A You do, yes.

Q Is that the biofilm that you're referring to?

A Yes.

Q What we don't have on those two images is a scale. How large are these things?

A They fit in the end of a tap, so there'll be anything from 15 to 20 millimetres in diameter.

Q Size of a thumbnail perhaps?

A Yes.

Q But nevertheless, when we look at the second image, on 274, that's as close as we've got to a folded out image within it. So, immediately, just from this image alone, we've got five thumbnails or, say, fingernails for area. But you mentioned also, by reference to the second of the images, that that is covered in probes. By probes, do I actually understand that to mean raised areas?

A Correct, yes, that's a better description.

Q So each of those will have

extra horizontal and vertical surfaces----

A Correct.

Q -- within it, and I don't suppose you'll be able to answer this except in the most general terms, but if one were to take the flow straightener and to fold it out, would it follow that we were dealing with a much larger surface area than would be indicated by looking at one's thumbnail?

A Very, very much so, and that's where the particular inherent risk from these components come from, and consequently why the guidance was written relatively rapidly by the Department of Health with the co-authors to raise the alert that these components can be a risk and to provide advice for hospitals to try to alleviate that risk.

Q We mentioned-- In the context of the flexible hoses, you gave me quite a useful description of what the mechanisms were by which the risk of proliferation profusion could occur. Can you do the same for these items?

A Okay. So, as you've washed your hands in a tap, the water will be flowing. You'll have turned the tap on, your water will be flowing. After you turn the tap off, that water will be retained within the flow straightener, so you have stasis or stagnation. The water which will have flowed through that flow straightener will have been approximately

41/42 degrees centigrade, so if you----

Q Why is that the case?

A Within hospitals, we have a component for the combination of the hot and the cold water called a thermostatic mixer valve. So, we talked earlier about the essentials of the control of the hot system being calorifier, 60-- leave the calorifier at 60, return at 55. So, one of the risks within buildings is scalding if people are exposed to water at 55 degrees centigrade. So, to alleviate that and control that, the water is combined within a thermostatic mixer valve, so you combine the hot and the cold water and bring the temperature down to 42 degrees centigrade.

Q This is before it reaches the tap?

A In the case of QEUH, it was at the tap----

Q Okay.

A -- because the thermostatic mixer valve was built within the tap component. So you combine the hot and the cold and the water leaves the tap at 42 degrees centigrade at a comfortable temperature for hand washing.

Q For the purposes of this question, it's going through the flow straightener at 41/42 degrees?

A So it's going through the flow straightener at that temperature, and you remember the curve we looked at for

temperature growth, and so your sweet point is going to be that 35/40 degrees centigrade, and so for a time period you're going to have that temperature within the flow straightener, and then it's going to go towards ambient temperature.

But the flow straighteners are also going to collect any debris or small sediment/dirt coming through the water and, therefore, that will become a nutrient source for the bacteria. Many of these bacteria also use oxygen and acquire oxygen for growth, and so at the outlet fitting in the flow straightener, you will have maximum oxygen growth potential, maximum nutrient potential because of the collection of the debris in those components and you have that high surface area and those multi complex horizontal vertical components.

Q Does that mean more nooks and crannies?

A Many, many more nooks and crannies and, potentially, with where they have the little washers within them, the rubberised material will also provide nutrients and surface area again for the growth of the microorganisms.

Q So, to summarise that, there's a coincidence of a large number of risk factors within this small item of equipment?

A Correct, and this was recognised through the Northern Ireland

investigation and written into guidance and the publications by Public England and by RQIA in Ireland to highlight these concerns and risks and the recommendations that flow straighteners be removed from taps to reduce the risk to vulnerable patients.

Q Thank you. That's extremely helpful. In a way, we got onto that as a digression from the point about the presentation that you gave at the meeting, but I should perhaps have asked one question before that which was, really, to take the focus away from one particular item within the taps and to the taps themselves. Lest we focus on flow straighteners when flow straighteners aren't the only issue with the taps, I should ask you the question of whether there were any other particular issues with these taps that cause you concern?

A Yes, these taps outlets are placed in the last two metres, and you have that situation where they're fed by spurs either from the hot or the cold water system, and so the spurs basically-- for the hot water system, where you have your flow and return circulating system, you have a spur from, for example, the ceiling down to the tap. When that tap's not been----

Q That's because-- just to mention the ceiling, that's because the

main pipe work runs in the ceiling----

A Correct.

Q -- and the tap isn't in the ceiling?

A Yes, and it could be in the walls or the ceiling, but you've got to then run from the hot water recirculating system through the tap, and you do that by using a spur, and the cold water system is fed singly through the whole building, and there's no return. So, basically, that becomes all of a dead leg, but it's also fed by a spur to the individual outlet. So you have a hot spur and a cold spur, and when you're flowing those-- when the water has flowed through the tap, then you-- We talked earlier on about replenishing that water, but as soon as the tap is switched off, you have no flow, you have stagnation.

And, interestingly, the Horne taps have two levers and, therefore, because you predominantly use the left-hand hot lever to deliver the water at 42 degrees centigrade to wash your hands, then it's been suggested through some of the reports that the right-hand lever may not be used so often. So you could have a small area within the tap where the water through the cold section is not flowing as often as it would be through the hot section, so you could have a higher risk within that.

And the Horne taps obviously have

flow straighteners within them, and we talked about these. You've seen the pictures: the high complex engineering that goes into these units. They're multi-layered. They're high surface area to volume ratio, the nooks and the crannies that are provided by these flow straighteners.

THE CHAIR: Am I getting the picture correctly? The source of both hot and cold water is the pipe work in the ceiling. You've described hot and cold spurs. Now, thinking about the cold spur, you point out that that's likely to be used less because people are principally using the taps to wash their hands. Now, as I say, have I got the picture correctly? You switch off the cold tap using one-- the right-hand lever, and does that leave a column of water filling the spur?

A It will depend on how it was plumbed into the cold water system. In some instances, it's not unusual for a separate cold spur to go to the TMV, the thermostatic mixer valve, and then a separate cold spur to go to the cold outlet.

THE CHAIR: Right. So, I'm wrong in thinking that it's necessarily-- Well, let me ask the question in the other way. Once the cold tap is switched off, would you expect any water to be left stagnant above the tap in the cold water spur?

A Regardless of the length of

that spur, you-- as soon as the cold is switched off, you will have stagnated water that will sit.

THE CHAIR: Sorry, say that again?

A Regardless of the volume, you will have stagnated water.

THE CHAIR: Right.

A So, once the cold has switched off-- and that will be a separate volume from what is flowing through the thermostatic mixer valve.

THE CHAIR: Right.

A So you do have-- You will have that area within the cold lever operating where you have water that is not moving.

THE CHAIR: Right, and that quantity of water, would it surround-- if there is a flow straightener in the-- Will that water surround the flow straightener? Should I be thinking of a flow straightener which has water surrounding it, or have I got that wrong?

A In terms of the water surrounding the flow straightener, the flow straightener will retain water once the water flow has ceased.

THE CHAIR: Right. I think that was my question. Right. So, you have a component which, for the reasons you've explained, is likely to be a site for the development of biofilm. Have I got that right?

A Absolutely, yes.

THE CHAIR: Right, and that-- Well, that's probably enough but-- and will also be wet with the stagnant water?

A Yes.

THE CHAIR: Right.

A That's very correct, but to complicate it, when you have your cold spur and your hot spur-- So, when the tap has not been operated, they become dead legs. Dead legs being stagnant water being opportunities for microbial growth. So when you then operate the tap, you then flush the water out of the spurs, reducing the microbial content in the water.

Biofilm is a different issue, you will still retain biofilm, but the outlet fitting becomes like a focal point of where you will collect sediment, debris, equaling nutrients, assimilable organic carbon for the growth of the bacteria, providing a warm, comfortable environment and temperature for microbial growth opportunities.

And you also have – we haven't talked about it yet – the exogenous-- or contamination from outside the tap, which we may touch on later. So there's other complications going on rather than just at tap, but at this point the flow straightener is enough of a focal point for microbial growth to occur in the water coming through the water system.

THE CHAIR: Right, thank you.

MR MACIVER: I may dwell on this for a minute or two longer but from a different perspective, which is if we skip back to page 239, which was the pictures of the Horne taps themselves.

A Yes.

Q Now, they look quite different from the mixer tap I've got in my kitchen sink at home. Without looking inside it, as I understand that tap to work, there's the hot tap on one side; there's a cold tap on the other. I flick the levers, and eventually after too long I get a flow through that I feel comfortable putting my hands under. That's how it works in my kitchen. My understanding is the Horne taps don't work like that at all, that the two levers are not doing those functions. Is that correct?

A The hot lever will deliver water which has been passed through a thermostatic mixer valve, yes.

Q It's been pre-mixed.

A Pre-mixed. Therefore, you'll only get 42 degrees centigrade water coming out of it to prevent scalding, so it's reduced that risk, and your cold lever will deliver cold water only.

Q So if we have pictured in our mind of everything you've told us beforehand, we have-- say, in the ceiling or in the walls we have the main cold water and hot water----

A Correct.

Q -- passing through stainless steel pipes. We then have a spur dropping down towards the tap, and you mentioned that if the tap were not used, or when the tap is not used, that acts as a dead leg, and that may or may not be a problem.

A Correct.

Q The spur reaches the tap. Does it follow from what I've said before that there are, in effect, two routes or two channels through the tap?

A Yes, because you've got to deliver either water for washing your hands from the hot side or cold water coming through, but it comes out through the same outlet. So it's designed within the tap to deliver the water through the same outlet.

Q And the flow straightener sits within that outlet. Is that correct?

A Yes, at the very periphery of the tap, so all the rest of the engineering is behind the body in the tap, which you can see.

A So the type of water that is getting retained by this flow straightener at any time will depend upon which lever was turned on last.

A Yes.

Q If that lever is the lefthand one, the red one, on our picture, then that would be 41/42 degrees water.

A Yes.

Q And that's the risk that you've described to us beforehand. If it's the righthand one, the blue lever, then that will be cold water. That starts out at 20 degrees, or below 20 degrees, say.

A Depends on the length of the spur----

Q Yes.

A -- and the last time the tap was used. So, if it's within a nice warm ward, then the water may actually have increased in temperature, and it may also depend on insulation between the hot pipe and the cold pipe. If there's no insulation, then you'll get heat gain in the cold dead leg from the hot dead leg, and so you may get potentially, as we've noticed within some of the reports, which we may talk about later, cold water examples being 30 degrees centigrade.

Q Okay, thank you. Well, maybe setting that to one side, it's the two channels through the pipe, two channels through the tap point that I'm interested in. What's your understanding as to how these taps are actually used in practice?

A From what I've seen written down, then there's a great potential in observation that the hot lever is used more often than the cold lever.

Q Why is that?

A Because staff naturally-- One's natural approach to these taps would be to operate the hot lever to

deliver hot water at 42 to wash your hands. Why would you operate a cold lever?

Q We know one of the problems posed thereby because that means that what is in, say, the flow straightener is often within the sweet spot. What are the problems that arise from disuse of the righthand lever, the cold lever?

A So, you will then provide a scenario where you have water which is stagnant and sitting in the pipework for a longer period of time.

Q You say within the pipework. Is that within the tap itself or within the spur? Where?

A There will be water within the tap body at that point behind the cold lever valve, and then that will then lead to the spur back to your cold water system.

Q What's the risk of having cold water lying within that channel within the tap itself?

A The problems are similar to the scenarios we talked about earlier where you have stagnation because that cold lever is not operated. You have the bacteria which will grow in the water phase but also grow predominantly as a biofilm on the components of the tap within the body of the tap and then further back in the cold spur because it's not being used.

Q Does that mean that there

should be special instruction for how to use these taps?

A One would have considered that training of these taps and instructions for the staff who use these taps, clinical staff, staff working within wards, as in how to use these taps so they can understand that they can help alleviate the build-up of microorganisms in the water system and therefore how to operate the tap to reduce those issues biofilm growth and reduce the potential for waterborne pathogens.

Q Okay, thank you. I think that's probably all I want to ask you about the internal workings of the taps themselves, but as I said, we got on to that from my initially having asked you about the gist of your presentation that you gave at the meeting in June 2014. I don't think I let you finish that answer. I wonder if you could tell us what you said at the presentation.

A I didn't. So, I was able to present on the findings from the outbreak in Northern Ireland, the Public Health England involvement and the identification of strains being present on the flow straighteners, the exact strains as was present on the flow straighteners and recovered from the patients who had acquired infections within those wards. From our work, it demonstrated that tap components and, as we talk about-- One

of the areas we haven't talked about is the strainers which are used as the spurs lead from the hot and cold water system to the expensive tap----

Q Can you just tell us what a strainer is in----

A A strainer is a little metal crisscross grid that is inserted before the tap is connected to the pipe, and that strainer will retain debris or any material which is larger than the crisscross hairs and stop it from entering the thermostatic mixer valves, because you don't want the valves to fail because you don't want people to be exposed to water at 55 degrees centigrade. So the strainer retains debris, but it also then becomes a focal point for microbial growth and particularly biofilm growth and, as we found again, Pseudomonas Aeruginosa.

So we need to take the tap and the tap body as an entity, rather that just always focusing on the outlet fitting. So it's reducing the risk overall with taps.

So, this is what I was able to present at the meeting, and then back up that scientific evidence which we had, which we published with RQIA, the Irish investigation had taken on board, taking that forward with the Department of Health and writing the guidance to prevent other incidents where vulnerable patients have been exposed to Pseudomonas Aeruginosa, by

recommending that flow straighteners were removed from taps.

Q Thank you. You say that's a recommendation. Was that advice that you gave in your presentation?

A Yes, highlighting the risk from retaining flow straighteners.

Q What was the specific advice? Was it to remove the or remove the taps, or what?

A The specific advice would be to remove flow straighteners, as per the Department of Health guidance, but it always comes with risk assessing what you're doing and being aware and educating and training of staff, so they're aware of what the problems are and they can put their own practices and policies into place to reduce other opportunities and reduce a lot of patients being affected.

Q Okay, so you concluded your presentation. What happened next?

A There was then a presentation from Horne Engineering, who presented some videos and demonstrations and countered the argument, that they needed to retain the flow straightener within their tap for its operability.

Q What was the outcome?

A Following the discussions where Horne Engineering tried to demonstrate that they needed to retain the flow straightener, which retained the

water phase within the tap. If you didn't have that water phase, then they were suggesting the bacteria would enter into the body of the tap.

Q What do you mean the water phase within the tap?

A So, Lord Brodie mentioned earlier on about the outlet fitting retaining water after the tap's flow has stopped, and that's what they do; they retain the water phase. Horne Engineering was suggesting that if they take the flow straightener out, then the water, which otherwise would've been retained in the body of the tap, would flow out, and therefore they were suggesting that that would result in an increased risk of microbial contamination of the outlet fitting in the tap.

Q Were you convinced by that?

A I see no evidence whatsoever that it's related to microbiology----

THE CHAIR: I may have misunderstood. When I was reading your statement, I may have misunderstood this, and what I'm about to say may be a gross simplification. What it seems to me that you've been highlighting up to this point is the risk of microorganisms having their source within the supply to the tap, including the tap itself and the flow straightener.

A Yes.

THE CHAIR: In other words, the

risk is coming down into and through the tap. If I've understood your summary of the Horne Engineering counterargument and the use of smoke testing, if I've understood it, they seem to be talking about a risk coming from the opposite direction. In other words, they were drawing attention to the fact that the retention of water within the tap provides, sort of, a seal to prevent microorganisms exterior to the water system coming into the water system through the tap outlet. Now, that's how I've read your statement. Have I understood your statement?

A Yes, that's very nicely put.

THE CHAIR: Right, so Horne Engineering, if you are accurately repeating their counter argument, are not answering your argument at all. Now, have I got that wrong?

A No, I think you're correct in that principle.

THE CHAIR: Right.

A But what I was there to demonstrate was the potential for microbial growth occurring in the flow straighteners, and I was there to attend the meeting on behalf of Public Health England to present to NHS GGC on what we had found were the risks inherent in the flow straighteners, the thermostatic mixer valve, and the strainer.

THE CHAIR: Did Horne Engineering really answer that point?

A I don't remember that part of a discussion----

THE CHAIR: Right, okay.

A -- took place.

MR MACIVER: Having had the two presentations, what was the outcome?

A Those present representing NHS GGC and the Scottish hospitals decided that they would proceed with retention of the Horne Engineering taps with the flow straighteners.

Q Now, you mentioned the way you described that decision was it was taken by those present on behalf of NHS GGC. If it was suggested to you that you were also part of that decision-making process, what would you say about that?

A I was there as a Public Health England representative. I was not in a position to make a decision on behalf of NHS GGC.

Q Now, one point that you make in the report – I don't think perhaps we need to go to it, but you may just simply recall this – or rather the Direction 5 response is that the decision was based upon the ability to risk manage use of the taps. Can you tell us about that aspect and how content you were with that outcome?

A Having been involved in the Northern Ireland outbreak where there were deaths of patients due to the dissemination, transmission and

exposure of Pseudomonas aeruginosa, and from our work where we demonstrated that flow straighteners were an inherent risk in that example, having been involved with the Department of Health in England, who wrote an addendum that flow straighteners should be removed, I have to say I was disappointed about the decision, which NHS GGC decided that they would proceed with a risk-based approach because, as a microbiologist who'd been involved in biofilms and water systems for very, very many, many years, the first principle should be to prevent the occurrence of situations where the microorganisms will be provided with an opportunity to grow and proliferate, particularly where patients are vulnerable and high risk.

Q Would it have been a scenario that could have been risk managed?

A Yes.

Q What discussion was there of risk management at the meeting?

A I don't remember that there was much detail at all about how that risk would be managed.

Q Can you describe for us what sort of risk measures we would be talking about?

A Many of the risk measures which we'd be talking about are demonstrated within many of the

guideline documents from the Health and Safety Executive contained within the HTM, contained within the SHTMs, where you would carry out either Legionella risk assessment or a Pseudomonas risk assessment to assess the water distribution system to look at what the hazards are in that water system – for example, the potential for microbial growth – and look at the risks in terms of transmission and exposure to patients such that you can put in place personnel who are well trained and understand water microbiology and water engineering. You can put in communication between your engineering teams and your clinical nursing teams, your Infection Control teams, and put in strategies to remediate the risks and protect the patients, without going into any detail, sorry.

Q Do I take it from that that the answer to the question is complicated? It's not as simple as "Flush them once a day"?

A That's very correct. You would take a bundle approach, a water safety group approach who would write a water safety plan and back that up with a written scheme where you have-- When I say a bundle, I mean a multitude of approach where you try to reduce the opportunities throughout the whole system by having a system that is well

managed through planned preventative maintenance work through the Estates, through the Facilities, right through to staff who are working in the wards who understand the waterborne risks.

Q And when you left that meeting, the decision having been taken, did you have an understanding of whether or not that sort of approach was going to be carried out?

A That was what was recorded in the minutes, that a risk assessment approach would be used, and that would included implementing all the control strategies as well as using microbial monitoring to assess whether your control strategies have actually remediated that risk.

Q Final question, is that the sort of thing that was discussed at the meeting?

A I don't remember the detail of it, but it is contained within the minutes. They decided to retain the taps, and therefore they would have had to implement some form of control strategy.

Q Okay, thank you. That's the end of that section about those particular taps and that meeting. My Lord, that might be a convenient moment to break.

THE CHAIR: It might be a moment for a coffee break. Could I ask you to be back for five past?

A Five past.

THE CHAIR: Thank you. You'll be taken to the witness room.

(Short break)

THE CHAIR: Mr Maciver?

MR MACIVER: My Lord. Now, Dr Walker, to return to a favourite theme from this morning, it's been mentioned to me a times during the break that there are people within the room who are still having trouble picking you up. So, I'm leaning forward as best I can just now. If you could do the same, it would be much appreciated.

I mentioned before we finished off for the break that I'd intended to finish off with the discussion of the meeting in June 2014. In actual fact, I need to return to it for a couple of points just now. First of those relates to the recording of that meeting, and you've mentioned a couple of times of things being mentioned in the minutes.

A Yes.

Q I wasn't going to take you to the minutes, but it occurred to me we do have them to hand. Bundle 15, page 692, ought to be-- in fact, here we are, ought be those-- We see it's recorded, "Minutes of special meeting held in the Labs... Block..." as you mentioned. Date – 5 June 2014, time – 11 a.m... to discuss and resolve issues with Optitherm taps installed in the Hospital." Do you see that?

A Yes.

Q So, chaired by Ian Stewart, and present there's a list of attendees. There are perhaps a dozen names there, and you're about eight or nine on the list. Do you see that?

A Correct, yes.

Q Now, I'm not going to take you through the contents of them, which, as far as I can tell, generally records the presentation and counter-presentation, but on the third page, at 694, we have the dispositive part of the meeting, action arising from the presentation, and then decisions made. It's 5.3 that I'm interested in here because this is the decision to retain the taps. Now, if I read it out to you:

> "The South Glasgow Hospital: it was unanimously agreed that as the taps installed within the new build development had complied with guidance current at the time of its specification and briefing and that the hospital was in the process being commissioned, it should be regarded as being in the 'retrospective' category, not 'new build'... no need to apply additional flow control facilities or remove flow straighteners, and any residual

perceived or potential risks would form part of the routine management process. ”

First question, does that broadly correspond to what you were telling us about the actual content of the decision before lunch?

A Correct.

Q The second point is, first line of it, "it was unanimously agreed" is what stated there. We saw that there were a dozen attendees of which you were one.

A Correct.

Q A decision is recorded here as being unanimous. I put it to you again that the suggestion is that you were part of that unanimous decision to retain the taps. Is that correct?

A I would still retain I was a Public Health England representative, and therefore I was not part of the decision making process for which those representing the Scottish hospitals decided.

Q Was there a vote cast or anything like that at the meeting?

A I wouldn't have thought it was a vote as such. I can't remember.

Q Did you cast----

THE CHAIR: Right, you make the point that you were there in a Public Health England role----

A Yes.

THE CHAIR: -- by reason of your

particular expertise. You say-- and that would seem to follow that you're not a decision maker at that meeting, and then if we look at the particular decision that is recorded:

“…it was unanimously agreed that… the taps installed… had complied with the guidance current at the time of its specification and briefing.”

Now, that might have been true. Was it----

A Which it was, because----

THE CHAIR: If we're talking about-- At least if we're talking about the Scottish guidance----

A The Scottish guidance, yes.

THE CHAIR: "...it should therefore be regarded in the 'retrospective' category, not 'new build'." Right, I've lost the text, but the decision seems to be as to whether it falls within one category or another, and it does go on to say:

"There was no need to apply additional flow control facilities or remove flow straighteners..."

Now, you've told us that what you had done was put forward an argument to the effect that there was a need to remove a flow straightener.

A From a Public Health England perspective----

THE CHAIR: Yes. I mean----

A -- and, having been involved in

writing the addendum for the Department of Health, with the Department of Health in England, that was the approach which we were taking.

THE CHAIR: All right:

> "...and any residual received or potential risks would form part of the routine management process."

So, seems to be no reference to additional-- I mean, according to the minute, no additional measures beyond routine management process. Right. Sorry, Mr Maciver. I've maybe----

MR MACIVER: At the risk of labouring----

THE CHAIR: -- (inaudible).

MR MACIVER: -- the point did you have any involvement in the decision to retain the taps?

A With my experience and my expertise and my involvement with the Department of Health Guidance writing that flow straighteners should be removed, then I would not have been party to a decision that I believe would have put people at risk.

Q You see why I'm labouring the point, which is because of the words "unanimously"----

A Yes.

Q -- "agreed" in the first line. Do you agree that it was unanimously agreed to retain the taps?

A I believe and understand that it

was unanimously agreed by those present representing Scottish hospitals.

Q If we go back two pages and we see the list of attendees, and we see designations after the names. We have Health Protection Scotland twice, NHS Greater Glasgow & Clyde three times, Golden Jubilee which is a hospital in Clyde Bank as I understand it, NHS Ayrshire & Arran. Then you with Public Health England, then Health Facilities Scotland and then two representatives from Horne Engineering. Which of those should I-- Which of those individuals should I understand as being part of the unanimous decision?

A I would have thought all but myself and those representing the commercial company.

Q Just to be clear, your position is you were not involved in the unanimous decision?

A I would like to state again that, representing Public Health England, I would not have been in a position to make a decision for Scottish hospitals.

Q Thank you. The second point coming out, in part, from the minutes is that there's reference to what measures would be taken to manage the taps, and there's a reference towards the end of what I read out, "a routine management process."

A Yes.

Q Do you recall that? Who owned that responsibility, that risk?

A Can you bring it up on the page?

Q Two pages on, 694. What I had in mind was the three lines, again, of 5.3, but in actual fact, the question is broader than that. It's in relation to everything you said before about having decided to retain the taps, but to risk management----

A Mm-hmm.

Q -- to risk manage that fact.

A Yes.

Q What was your understanding as to whose responsibility that was?

A Only those present representing NHS GGC and Scottish hospitals made that decision, and it would have been for them to communicate that decision. I realise I'm not answering your question specifically, because it may not have been those present who had to undertake the actual process of reducing the risk or putting measures in place to remediate the risks, but they would have had to communicate it to colleagues, who would then have used their water safety plans and their written schemes in order to ensure that the risk was reduced from the presence of the flow straighteners because of what we've described this morning, the inherent risk----

THE CHAIR: Dr Walker, if you want

me to hear what you're saying, I'm afraid you'll have to up the volume a bit.

A Okay.

THE CHAIR: It's-- If you could do that, it would mean that I can hear what you're saying.

A Okay.

THE CHAIR: Sorry. Mr Maciver.

A Apologies.

MR MACIVER: Yes, thank you. You mentioned the word "communication" there. Another aspect of communication is-- that I might have asked about was, to go back to the recording of the minutes, did you get a copy of these minutes following the meeting?

A I did, yes.

Q Did you communicate back to NHS Scotland any feedback----

A I did.

Q -- regarding those minutes? What did you communicate back?

A There was a couple of minor comments which I added to put more context into the issue of flow straighteners and contamination and maybe a few other minor additions to the minutes which I sent back.

Q Did you say anything about the words, "unanimously decided"?

A I did not.

Q Thank you. I'm just going to move onto the next section of my questions. Before I do that, I'm going to

return to a matter that I think I covered adequately this morning, but it was to do with adoption of the various statements reports and so on that you've had before the Inquiry. I think you've covered it already, but just for completeness, could I ask you to confirm, perhaps once again, that you adopt your expert report as your evidence to the Inquiry?

A Yes, I do.

Q Can I ask you to confirm that you adopt your witness statement as part of your evidence to the Inquiry?

A Yes, I am happy adopt the witness statement.

Q And can I ask you to confirm again that you adopt the Direction 5 response document that you gave in June or July of this year?

A Yes, I'm happy to adopt the Direction 5 document. Thank you.

Q Thank you. At this point, could we turn back to the main report, please? My questions before the break took us up to everything I wanted to say about section 4. So, if we move on to section 5, which begins at page 245, please. This section is the, "Description of 'unsafe' water and wastewater (drains) system." I think I described it to you at the very start of your evidence as – the word was wrong, but as a “hypothetical”, but perhaps “general” would be the better word – a general discussion of

features/unsafe features that one might see in water systems----

A Yes.

Q -- in general. Is that correct?

A Yes.

Q The first section here is an introduction. 5.1.2 discusses how one goes about assessing whether a system is safe or not. Here you've mentioned four bullets, four parameters that you would take into account, and they are:

“- Physical water and wastewater system
- The manner which it is operated
- Evidence of microbial contamination
- Mitigation and control measures. ”

Do you see that?

A I do.

Q I wonder if you could just expand upon that a little bit. What I have in mind is that you're describing there a system whereby you can't look at one factor and, from that, draw a conclusion about safety or unsafety. In actual fact, you're taking a more holistic view. Is that correct, and I wonder if you can describe how those four things interact?

A That's correct, yes, you are correct. Yes, so it's very much about-- We talked earlier on about wholesome water and how that's delivered to the hospital. By the regulations, wholesome

water should be delivered at the tap, and that's determined by how that system has been designed, built, commissioned, handed over, and then how it's managed from that point going forward. All of this is contained within documents such as a written scheme, and risk assessments are such an important point of this whole process where you identify the risks inherent within the water system and where those risks are identified, remediation measures are then implemented to reduce those risks.

Q So, coming back to the four main parameters, does it follow from that that to take-- for example, one might have two or three aspects-- two or three parameters that were perfect in terms of physical water, manner of operation, but still be brought down by failings in a third or fourth aspect, contamination or mitigation measures?

A That's a very interesting expression that you've just used, but it's very apparent that if all of these parameters and systems are not put in place, then you will have a failure or could have the potential for failure. It's a bit like the Swiss cheese model with holes in the cheese. If they're all lined up with the hole going through, then you have a greater potential for risk, and if you put them out of a juxtaposition, then you have a control at each stage. But if a

number of them are still weak in terms of protection, then you have the potential for exposure, transmission and risk to vulnerable patients.

Q But the only way you can assess that is by undertaking a holistic assessment, taking everything into account?

A That would be correct. So that would not just be your plumbing system, but it would be your staff as well.

Q So there are more parameters than simply the four in the bullet point?

A Correct.

Q But it would be too-- it would certainly be too simple, in my understanding, for-- to point at one-- a failing in one parameter and say, "This leads to a system that's unsafe," just as it would be too simple to point to perfection in half a dozen parameters and say, "This equals a system that is safe," is that correct?

A Correct.

Q So a failure in one parameter can be compensated for by work in another parameter.

A Yes.

Q Is that a----

A Sorry, say that again?

Q Sorry. One might feel a failing or something less than desirable in one of the parameters might be compensated for by work carried out in respect of

another parameter.

A But that failure should still be addressed as part of the risk assessment and part of the mitigation strategy because, at some point, it's a weakness in the system and could lead to risk.

Q Okay, I understand that. Does that amount, then, to a pragmatic approach towards the question of safety? In two respects, I suppose, firstly, in that one has to look at-- one has not to be over-focused on one particular feature, whether that be good or bad, and secondly, that one has to always be in a position of seeking to improve things.

A You used a good word earlier on when you said "holistic", and so when you use those other expressions, you do have to look at it overall. You do have to use different bundles and different mechanisms of ensuring that you're reducing those risks, and it brings in those four parameters as well as the staff, as well as the equipment, as well as the operation to ensure that you're not leaving risks that would then cause harm to patients.

Q If we move on a couple of pages, we see here on this page where there are references to an institution and one or two documents that you've already mentioned. 5.1.13 is where you describe water safety group, and 5.1.14 you introduced the idea of a water safety

plan. I think you also mentioned a written scheme, though I'm not sure it's referenced on that particular page. Could you take a minute or two, please, to explain the significance of those three things in terms of maintaining a safe water system?

A Yes, so your water safety group is an amalgamation of people taken from within your hospital who all have an interaction with the water and responsibility for ensuring that there is safe water for patients. You would select staff. You would appoint them into positions within the water safety group. You would train those staff and they will represent the different disciplines from within the hospital.

That will then enable them to assist in the writing of the water safety plan, which is partly where you're implementing risk assessments. Some people may-- some hospitals, some institutes may appoint a third party to carry out the actual risk assessment or do it themselves, but they need to be able to understand what the risk assessment is about, such that someone risk assesses the whole system to recognise where there's weaknesses and potential for risk and opportunities for microbial growth, and then to look at what the remedial actions could be to try and control that growth.

Q Thank you. The written scheme, is that different again?

A So, the written scheme takes all of this written material but goes into much, much more detail, including the members of staff as an appointed person, the responsible person, itemising who those are, and also possibly being-- looking at how the training of those staff-- what training they've undergone. But it also includes the risks, includes the water system, includes schematic diagrams to the detail of someone going into identifying the water systems. When they're looking at risks, if they're identifying risk, then they're identifying what the actual remedial strategy should be and detailing what the remedial strategy is.

So it's a lot, lot more depth, detail and substantial information in the written scheme.

Q Thank you.

A But what you do have to remember is all of these documents when they're written need to be live, they need to be updated because personnel change, hospitals change, parts of hospitals change and the risk assessment itself has to be an iterative process that is ongoing on a regular basis.

Q The idea of planned preventative maintenance, where does

that fit into those documents?

A That would be a feature of all of the documents where you're looking at your risk assessments and part of that risk assessment would be identifying your asset list. Your asset list tells you what equipment you have in your system and what parts of those equipments need maintenance, and then within your written scheme would be who's going to carry that out, how frequently it's going to be carried out.

Q One theme that has come up from time to time in the evidence has been the extent to which the hospital had in place those documents at particular times. In your understanding, did Queen Elizabeth have these institutions and documents in place at the correct times?

A My interpretation of the evidence which the Inquiry has provided to me through the DMA risk assessments was that the documentation was not sufficient at the time of the first Legionella risk assessment and subsequent risk assessments which were carried out in following years.

A You mentioned a specific matter in relation to the PPM, which was the asset list or asset register. If there was a period when the hospital did not have an asset register in place, what would be the consequences for carrying out PPM?

A In order to carry out servicing of equipment, you need to know where it is. You need to know where all your taps are, your thermostatic mixer valves, your expansion vessels, your water coolers, your ice machines, anything that you have within the hospital.

Q Yes.

A You need to be able to know that you have these to put them onto a list, such that they can then be serviced and maintained appropriately according to either the manufacturer's instructions and/or through your written scheme, such that you're following the guidance which should've be put in place by the HSC or Scottish Health Technical Memorandums.

Q Thank you. Moving on four pages to 251, you're discussing here healthcare associated infections. At 552, you start to describe in general terms how these are multifactorial, and you mentioned factors including susceptibility of the host of the patient, presence of bacteria, concentration of contamination and exposure to the source of the pathogen. In fact, we see you expand upon that in the following paragraphs to look at the circumstance of the patient, the pathogen involved and the environment. Does it follow from that that in a hospital the size of Queen Elizabeth, with different patient cohorts, different buildings, different conditions within those

buildings, does it follow that the risk of HAIs would vary from place to place and from time to time?

A The patients who are most at risk are going to be the most vulnerable patients and, therefore, there may be a certain amount of organisms in the water which will not create a risk to a patient in a general ward. So the risk would not be the same for those patients.

Q Again, to use the word "pragmatism", does that suggest that an approach might-- would be-- an appropriate approach would be to give more care to certain locations over others?

A So, that is very much an approach that the guidance takes in being able to identify your high risk patients, your vulnerable patients, and one of the terms which is used is "augmented care", and clinical decisions are taken based on where those patients are placed depending on the clinical vulnerability and the speciality required. Therefore, yes, it's an issue which has to be addressed within the hospital because they're more susceptible.

Q If we go over to 253, 5.6.2, you're talking about the risk of microbial proliferation:

"To maintain a wholesome supply throughout, the hospital

water system needs to be risk and managed. Where issues have been identified that would lead to microbial proliferation, then mitigated measures needed to be implemented."

And you discuss that little bit before arriving at the bottom of the page, 5.6.7, "General mitigation strategies for microbial control and healthcare water systems are considered to be..." and there's lots of bullets. Top two we've touched on before, temperature control then cleanliness, and third, removal of debris and sediment. Fourth is movement, keeping water flowing, and then implementation of a water safety plan and water safety group, as you've described to us a moment ago. Does all of that-- Is all of that part and parcel of the kind of pragmatic approach that we discussed a couple of minutes ago? Would that be a fair way to describe how one goes about assessing, managing, keeping on top of a water system?

A The short answer is yes, all of them.

Q Thank you. Over the page, there's the beginnings of a table, quite a long table. It's a list of pathogens, most of which we're not interested in just now, but I wonder-- I'll give you ten seconds with this-- five seconds with this page to remind yourself of what pathogens you

addressed here. Then 255 has five others. Over the page, thank you. At the page further on, we have six or seven pathogens, and then the end of the table is at 257, closing off with another five or six. Now, I won't read out all 20 or so to you, but some of them have been mentioned as being present at this particular hospital, but I think your list was, in general, pathogens identified in water systems generally. Was that correct?

A This was a general section of the report. We're dealing with potentially what is identified as an unsafe system, and these microorganisms have been identified as those which have been identified as causing outbreaks in hospitals related to the water system, or particular equipment with which water is associated with. Therefore, it was using other people's historical records and the scientific, peer-reviewed published data to identify that there's a very, very wide range of either gram-negative microorganisms or acid fasts, such as Mycobacteria, which can create infections within hospitals.

Q Without wishing to dig any deeper into any particular organisms, you mentioned that of them are gram-negatives. Out of the 20 or so organisms, are some of them more common than others?

A Yes.

Q Are some of them very rare indeed?

A Some of them are relatively rare in hospitals, but some are more common, and it's going to be dependent on how good the surveillance system is within the hospital, and surveillance being a microbiological surveillance based on when a patient's ill-- samples will be taken. You then have an accumulation of data, depending on the type of organisms and number of organisms that have been identified.

Q The reason I ask the question in that way-- approached from that angle is that we know that some of the microorganisms are subject to specific guidance. You've spoken about Legionella----

A Yes.

Q -- in particular, I think, has particularly stringent or particularly extensive guidance. Would that be correct?

A Legionella has been identified for very many years now as a waterborne organism which grows within the water system transmitted. What we have to understand is it's Legionella and other bacteria within a water system. So where you identify that Legionella has a capability of growing or the opportunity of growing, then other gram-negative

microorganisms will also grow.

Q Okay. I understand there's also specific guidance about Pseudomonas. Is that correct?

A Correct.

Q And Pseudomonas is a gram-negative bacteria. Is that correct?

A Correct.

Q The specific question that I have to you that where, say, a rarer gram-negative was identified, for which there was no specific guidance, would it be an appropriate approach to apply the Pseudomonas guidance as a means of tackling that issue?

A I would go broader than that in terms of what you're looking at. If I understand the question correctly, it's identifying where the risk is within the water system, and the guidance which has been written for Legionella and for Pseudomonas provides you with a framework in order to try to address the opportunities within the system where the bacteria are grow, and put in remediation strategies to control the growth of those microorganisms.

Q So insofar as you can give me a yes or no to that: you're confronted with a gram-negative for which there is no specific guidance; would a sensible means of approaching it to be to apply, say, Pseudomonas guidance?

A Yes.

Q Two pages further on is the next section I'm interested in, 5.8, "Where are pathogens and biofilms located in water systems?" Now, we've already spoken a little bit about biofilm, and there's been plenty of discussion about it in other evidence, but it's clearly a concern of yours. Can I ask you to explain in relatively brief terms what's the significance of biofilm within your work?

A So, we've talked about the water system, the flowing water system and the strategies for control: keep hot water hot, cold water cold, keep the water flowing. Bacteria will arrive in your water system within the water phase. Those same bacteria, when given the opportunity, will start to become attached to the surfaces either through gravity, sedimentation or attraction to a surface for nutrients. That biofilm will then grow on a surface, and as it grows it will produce products like polysaccharides, which will then encase the bacteria. As biofilm develops, it will encompass other bacteria, other microorganisms, other sediment and debris to become a niche environment where those bacteria will grow and multiply.

The important point is, as the water flows through the system, when you operate a tap, you will remove the bacteria from the water phase. The biofilm will still be resident on the

pipework after you've switched the tap off. You will not remove biofilm from a surface just by flowing water through it, because the water at the edge of the pipework, if you think about the radius, is slower at the outer edges. So you have the biofilm growth on the surface and it is retained within the surface and within the water system.

Q So there's a step change in nature between the risks posed by free-floating organisms on the one hand, and on the other hand between organisms that become attached?

A Correct, and it's not just a physical attachment. It's the tolerance of those bacteria within a meshwork of the biofilm, tolerance to biocides, to temperature. The retention of it and the viability of the material will be retained even where biocides and sometimes where higher temperatures are developed.

Q And is that a product of the-- I think you described it as products that are grown from or ooze out of the substance once it becomes attached?

A Once a biofilm is attached, you will then get also removal of biofilm bacteria from the surface, either through natural removal, sloughing, and/or pressure fluctuations within the hot and cold water system. So you will then get dispersal biofilm clumps from within the

water system through the rest of the water system. Depending where that happens in the water system, those clumps may still be viable many, many meters away, at outlets, at pieces of equipment. The scenario is if you have decontaminated an outlet using a chemical, if you have biofilms further upstream, then they will recontaminate that outlet.

Q Is it possible to tell how much biofilm there is within the system?

A It's a very good question. You can. There are different strategies you can use to do that. You can take out sections of pipework and plumbing components and analyse them using microbiological methods, either microscopy, counting, visual soiling, or more modern technologies that have been around for a little while now are using devices in order to determine whether biofilm is growing on a surface using an electrical differential.

Q If you have biofilm or a suspicion of biofilm within the system, what should you do to keep the system safe?

A When carrying out any risk assessments, you have to be aware that there will be opportunities within water systems for microbial growth within the water phase. Allowing biofilms to develop will exacerbate the volume, the

density of bacteria within the water system. Therefore, like any risk assessment, you have to put mitigation properties in place to try and reduce the volume of biofilm.

Q We've heard evidence about the introduction of chemical dosing. Would that be an example of a mitigation measure?

A Yes, absolutely. In fact, even temperature would also be another mitigation effect, but you have to consider that if you're using temperature, that you will kill the biofilm but you won't necessarily remove it, so you could be leaving dead biofilm behind, which will leave nutrients available for other bacteria coming through the system.

Q There are measures that can be taken, such that a system with biofilm can nevertheless be made safe. Is that right?

A You can reduce-- For example, if you are using a chemical, you can reduce the volume and viability of biofilms within a water system, but we had the discussion earlier on round about chlorine, but it would apply to chlorine dioxide as well, which is applied at the introduction of the water to the hospital. But as that chlorine dioxide passes through the hospital water system, the concentration of it will reduce because it's being exposed to organics and other

properties. It will degrade, such that you do not have the same concentration at the outlet as you had when you put it in, and therefore it will not be as effective at biocide further away from the point at which the chemical was introduced.

Q Okay, that's a helpful----

A So basically, it's not a panacea.

Q No, that's----

A Just because you've introduced a chemical does not mean your entire system is safe. It may be safer, but unless you're carrying out your risk assessments, your plan preventive maintenance, and everything in your water safety planning written scheme, then there could be the weaknesses which you discussed earlier on occurring.

Q Okay, that's a helpful answer. What I had in mind was not so specific as dealing with dosing particularly, but it was the general principle that-- I suppose relating back to the four parameters and to the pragmatic approach that we suggested earlier on. Presence of biofilm would be an example of one of those parameters having gone wrong. Would that be fair to say?

A Yes.

Q But that one could nevertheless render the system still safe by making sure that, for example, the fourth parameter, the mitigating

measures were in place, and the third parameter, the system was properly maintained or operated, plus other parameters, and it would be on a assessment of all of those together that one would have to come the view of whether or not we were dealing with the safe system or not.

A I think I would prefer the word "safer" rather than "safe." You're reducing the risk. You cannot remove the risk completely, and we have to be aware of that, and that's partly where the guidance always comes from, making the system safer.

Q I understand the point, and maybe just move on four pages to 263, 5.11, "What are the foreseeable risks that result in unsafe water?" Now, you've listed in this section a number, as we go through it onto the next page, back one page-- Perhaps probably shouldn't go through, try to pick through any points from this, but in general you're listing aspects of risk, physical infrastructure, management of the system, and then over the page the presence of microbial contamination. Again, the question may be the same one as I've just asked you, but are those the parameters that you're looking at when deciding whether or not you're dealing with a safe or an unsafe or safer system?

A There would be a number of

components which you would include, yes.

Q The specific point that I'm interested in here is the phrasing at the very bottom of the page, 5.11.6:

> "Thirdly and perhaps most fundamentally, microbial contamination of the water system."

The word "contamination" here is something I'm interested in. Do you recall that you were asked about that in your Direction 5 response?

A I do, yes.

Q If we can maybe bring that up, which was Bundle 21 Volume 6, and it was the first document there. It started at page 3, but the question dealing with contamination should be at page 36 of that document. Now, I'm interested in exploring a bit further what you mean by contamination, and I'm going to take you to that question by looking at one or two points from this passage. At 7.2 here you are acknowledging a point we've touched on two or three times before:

> "As discussed in my report, water delivered to hospitals must be wholesome. The water will still contain bacteria, and there are prescribed tests that must be undertaken to prove that the water is wholesome."

Correct?

A Correct.

Q 7.6 at the foot of the page, you give an opinion that the hospital water system from the tanks, calorifiers, expansion vessels, associated pipework and flow straighteners were contaminated with a high level of sediment and detritus as a result of the bypass hose. So, that's contamination with foreign material: sand, organic matter.

A Yes.

Q Things like that.

A Because it bypassed the ultrafiltration unit.

Q Yes.

A Therefore the ultrafiltration unit is there to take out sediment debris and infect bacteria as well. So, if you bypass the ultrafiltration, then you're basically contaminating with material that otherwise should have been removed----

Q Thank you.

A -- from one perspective.

Q So, that's contamination with that type of material, debris. 7.7, over the page, you talk about this again, but slightly different:

> "After the bypass has been removed, the water system was already contaminated by sediment and water-borne bacteria."

Now, am I correct in reading this that you're talking about the type of contamination that we spoke about a

moment ago, sediment debris, but also here you're introducing the idea of contamination by bacteria?

A Yes.

Q And at 7.8 you see this extensive contamination was presented in the Intertek microbiology reports, which were two or three reports that you footnoted, and you return to the idea of microbial contamination at 7.10. The evidence presented to you:

> "…by the Inquiry demonstrated there was inadequate management, lack of training, poor communication, which resulted in microbial contamination of the water system with a range of gram-negative bacteria."

My question is that you're describing what seem to me to be two different types or two different sources of contamination. One is debris or sediment; the other is microbes. Are those completely distinct types? Should I understand them in the same way, or are they different things?

A They are components which would have been delivered within the water phase, because it bypassed the ultrafiltration units. The sediment, the debris and organic material will provide nutrients for the growth of the microorganisms. The water which would have been delivered would have been wholesome as defined by the requirements, so it would not have been

sterile.

Q Okay, that last point is-- perhaps encapsulates why I'm interested in the distinction because debris-- I think I understand, because debris is stuff that isn't water and shouldn't be within the water, so if it's contaminated by debris, that would seem to be relatively straightforward. What's less clear to me is contamination by bacteria.

As you say, wholesome water will have microorganisms within it. My question, then, is where-- Is there a line? Where does one cross from wholesome water with the presence of bacteria into contaminated water because it's contaminated with bacteria?

A Where the line crosses is where you provide opportunities for growth of those organisms which have been delivered as wholesome water. As that water is within the building where you provide nutrient sources which otherwise would not have been there and you provide temperatures for the optimal growth of those micro-organisms, you will raise the level of number and concentration of bacteria to a level that would be considered unsafe.

Q Are you equating contamination with unsafeness?

A I am trying to draw the distinction that wholesome water will contain a certain amount of bacteria

within it. Where you're then providing nutrients and opportunities for growth, you will have more bacteria, and that will then lead to further numbers, proliferation and growth of those microorganisms.

Q I think I'm on top of that process, but it's the specific word "contamination", and perhaps because I'm a lawyer-- but it's that specific word that is of interest to me, particularly because this section is about contamination, in part about contamination with microorganisms/with bacteria.

A Yes.

Q What should one understand by "contaminated with microorganisms or bacteria"?

A We have to put this in context of the ultrafiltration unit. The ultrafiltration unit would have removed the organisms from the water, but because it was bypassed, then you're actually contaminating the system, because otherwise it would not have had those microorganisms within the water phase. It would have been taken and removed by the ultrafiltration unit, which is why I've used the word "contamination" at that point.

Q We haven't touched upon the ultrafiltration unit before, but are you telling me that the ultrafiltration unit ought to have led to the water coming into the

hospital being sterile?

A Fundamentally, the output from the ultrafiltration unit would have been a bacterial-free water. What you have to take into consideration was, when the hospital was built, that the practice is used at the time through the lack of ENDO caps, the system being filled with water and the water being retained or flushed and then retained. At that point in time, there will have been microorganisms within that water because it didn't go through the ultrafiltration unit, is my understanding.

Q You started out by making it quite clear that wholesome water will nevertheless still contain microorganisms.

A Yes.

Q It seems to follow from what you told me that where there's wholesome water circulating, if there are dead legs, debris, wrong temperatures, then the wholesome water can turn into water where the organisms already present begin proliferate and there's a problem?

A Yes.

Q Is there a set point where the wholesome water becomes contaminated water?

A Where it's not managed, where the risk assessments are not implemented, where the planned preventive maintenance is not

undertaken, where the staff are not trained, where there's a lack of communication between staff, then the risks which have been identified in the system are not addressed.

Q So where you've used the word "contaminated" and its derivatives here, should I perhaps understand that as being less an adjective to describe the water and more a description of the management of the system?

A Yes.

Q Contamination or contaminated water isn't a term of art, is it? It's not a-- It doesn't have a specific definition, does it?

A Not that I'm aware of, no.

THE CHAIR: Just before I lose this point, there was an exchange, Mr Maciver, in relation to ultrafiltration. Now, this is not a topic I have picked up on and I'm not really sure that I understood what was the point arising. First of all, does your report talk about ultrafiltration at any stage?

A Yes.

THE CHAIR: It does?

A It does.

THE CHAIR: Right, can you point me?

A Oh, Mr Maciver?

MR MACIVER: It may be----

A I don't have it in front of me, sorry.

Q It may be we get on to it probably shortly after lunch, because there was a discussion about the bypass that Dr Walker also mentioned.

THE CHAIR: Right, okay, because I'm taking from Dr Walker's answer that ultrafiltration achieves sterility. Now, if this is relevant, I need to follow that, and at risk of maybe pre-empting matter that you're going to deal with in greater detail, is it practical to install and maintain a water system which entirely excludes the possibility of an environment which promotes microbial growth following the input into the system from the public supply?

A Yes.

THE CHAIR: Right. That's----

A For very specific and particular reasons.

THE CHAIR: Sorry?

A For very specific and particular reasons.

THE CHAIR: Right. You may or may-- want to develop on that in the afternoon.

A I mean, this-- yes.

THE CHAIR: That is sufficient for my purposes at the moment.

MR MACIVER: I noticed we've ticked past one o'clock. I wonder if I might take the opportunity to reflect upon that at lunchtime.

THE CHAIR: Right. Could I ask

you to be back for two o'clock, Dr Walker?

A Yes. Thank you.

(Short break)

THE CHAIR: Good afternoon, Dr Walker.

A Good afternoon, Lord Brodie.

THE CHAIR: Now, Mr Maciver.

MR MACIVER: Thank you, my Lord. I'm going to continue with looking at aspects of the system, but before I do that, could I-- Just a quick hatching of one point that arose from a discussion that we had before lunchtime.

A Okay.

Q You recall that we spent quite a bit of time looking at the minutes of the Horne tap----

A Yes.

Q -- meeting in June 2014, and as part of that we looked at the list of attendees. I think you said, at one point, your position was that it was representatives of Scottish hospitals that were involved in the unanimous decision as you saw from your perspective. Do you recall-- and we may as well have this up on screen I think, Bundle 15, page 692, was the start of the minutes. Back two pages, please. Thank you. Do you recall I took you at speed through the list of attendees and----

A Correct.

Q -- their designations.

A Yes.

Q Some of them were hospitals, some of them weren't, one was you and two of them were representatives of Horne engineering.

A Yes.

Q My question related to the representatives from Health Protection Scotland and from Health Facilities Scotland. Are you familiar with those bodies?

A Kind of, yes. Yes.

Q Their position will be that they, perhaps like yourselves, were advice giving bodies----

A Okay.

Q -- and were not, in themselves----

A Right.

Q -- hospital practitioners. Would you agree with that?

A I would thank you for that clarification, but I'm not sure I would know the nuances of where they were involved, how they were involved and how they were distinctly different.

Q As I understand it, their position will be that they also tendered some advice that wasn't followed----

A Okay.

Q -- in regards to the Horne taps.

A Okay.

Q They specific----

THE CHAIR: Can I just make sure I've got that? What you're doing-- Reasonably enough, Dr Walker's not necessarily *au fait* with the----

MR MACIVER: Of course.

THE CHAIR: -- not always easy to follow arrangements of the NHS in Scotland, but the position that you have been advised that NSS would take is that they tendered advice. That advice was taken/was not taken?

MR MACIVER: Was not taken.

THE CHAIR: Not taken.

MR MACIVER: Yes.

THE CHAIR: And I take it that they were not part of the decision making process?

MR MACIVER: That is the ambiguity that I'm seeking to clarify----

THE CHAIR: Right, okay.

MR MACIVER: -- because Dr Walker, at one point, said that it was representatives of the hospitals, from his perspective, who were involved in the unanimous decision, and at another point he said, when asked the question perhaps slightly differently, he said it was the people present except for him and the representatives of the commercial organisation, which I take to be Horne Engineering Limited. My question for him is whether he's able to give any clarification as to whether he considers

Health Facilities Scotland and Health Protection Scotland to have been part of the unanimous decision process?

A I'm not able to split them out in terms of which organisations or who they're representing as to whether they could or could not have provided a decision on that at the end of the day.

Q Okay, thank you. Now, at this point, I think we can set that minute finally to one side and return to your original report, which was Bundle 21, I think. Yes. Page 276 is the next part that I'm interested in. It's where you get onto showers at 5.23 at the bottom of that page. Now, here you are describing a risk-- a selection of risks that might arise from showers, and I think there are quite a few of them. You talk about water temperatures. You talk about aerosolisation. You talk about the components used and so on. Do you see that?

A Yes.

Q Now, I don't have any questions about those, but I do have a specific hypothetical question that you may or may not be able to help me with. It relates to whether showers would pose a risk to particular patients where there was water contaminated at a relatively low level. Now, approaching with this, firstly, are you aware of such thing as a Hickman line?

A In general, yes.

Q Could you explain to me what your understanding of that is?

A As far as I know, it's a line that's inserted into a vein or artery on the outside of the skin.

Q Are you aware of what it's for?

A It's to help administer drugs or take blood.

Q Okay, thank you. I understand it can also be inserted into into chests, but you may or may not----

A Okay.

Q -- be aware of that.

A No.

Q The specific scenario that I'd like to put to you is if you had an immunocompromised patient with a Hickman line who was showering in water that was contaminated to a relatively low level of bacteria – and this would be perhaps less than 10 colony-forming units per 100 millilitres – are you able, on the basis of that-- the bones of that hypothesis that I'm putting towards you, are you able to say whether such a patient would be at risk of infection as a result of showering in water like that?

A Such a patient, if they're a high risk patient, may be at risk because you're saying it's less than 10 microorganisms. You're not telling me what microorganisms those are. So, there may be two or three or four of those

microorganisms which could be a particular risk to this patient. But because they have a Hickman line in, they may only be colonised by a few bacteria, but because the Hickman line is breaching the mucosa layer going into the chest, then you have the potential for even just a few bacteria to enter that area, and then because it's a rich nutrient source area, potentially multiply, proliferate, colonise, grow and possibly infect the patient. Not entirely safe, but safer possibly than if there were more bacteria present.

Q Thank you for that. I appreciate I'm putting to you another skeletal set of circumstances.

A And you may be better also involving a clinician in these discussions in terms of the vulnerability of the patient.

Q Thank you. I think that's all I have to put to you as regards the general components of a water system. I move on to page 284 where section begins-- where you start considering the QEUH water system specifically.

A Okay.

Q So unsafe aspects of the QEUH RHC water system begins here. Here, you're starting with a summary of the guidance, do you see that, including the SHTM documents and things that we've heard about over and over again, and over the page, you are-- There's a

passage at the top of the page, where you consider, at 6.1.5, Legionella risks, and there you mentioned counts greater than 100 CFU per litre. Now CFU, I alluded to them a moment ago, but I wonder can you explain what CFU are please?

A Yes, CFU stands for colony forming units, and so from a microbiological perspective, one would take a sample, one would-- If it's a water sample, one of the strategies would be to filter that water, resuspend the bacteria and place them onto an agar plate, and on that agar plate, bacteria will grow and you would then count the number of colonies which is the growth of the bacteria on that plate, and the reasoning is that one colony would equal one bacteria but you may have aggregates of bacteria, but you're basically getting a general assessment of the quality of that water based on the outcome which is colony forming units to assess the microbiological quality.

Q Thank you. So, at 6.1.5, we have got consideration of Legionella with a threshold, if I could put it like that, of 100 CFU per litre as being out of specification. At 6.1.6 you note that NHS GGC have some-- their own procedures and their own guidance. You see that?

A Yes.

Q And you then start to break

that down a little bit in the next couple of paragraphs. 6.1.7 is looking at the GGC guidance here, noting that – this must be in respect of Legionella because that's what's in the previous paragraph – the total variable counts at those temperatures that are less than 100 CFU per millilitre are considered acceptable. Now, CFU we know about, but if you look at 6.1.5, the reference there was to concentration per litre.

A Yes.

Q The reference at 6.1.7 is to concentration per millilitre, and then if you look briefly again at 6.1.8, the reference is to a concentration per 100 millilitre. Is there any particular significance as to what volume measurement denominator is used in these, or does each one have to be taken individually?

A So, in terms of Legionella sampling, what you have is the requirement for a large volume of water and the standards for taking those samples are you would take a litre of water from your sample and you would filter or centrifuge the whole litre, resuscitate it, treat it and then recover the counts back onto an agar plate, and recalculate it back up to a litre with such examples of Pseudomonas.

Q I'm beginning to lose the top----

A Sorry, with Pseudomonas, what you're looking at is a smaller sample

being taken of 100 mls, and you equate back to per ml or per litre in order to give you a count to assess the microbial safety and quality of that water sample.

Q Okay, thank you. Sorry, okay.

THE CHAIR: Yes.

A Thank you.

THE CHAIR: Just on audibility, if you're close to that microphone, that helps.

A Is that better?

THE CHAIR: Yes.

A Thank you.

MR MACIVER: Now, that series of paragraphs I've taken you to there is referring to different types of guidance. Some is health and safety guidance; some is GGC's internal guidance. I assume that the health and safety guidance is a kind of objective standard that everyone would have to meet?

A You could call it national guidance. So, that's national dependent on-- regardless of whether it's England, Scotland, Northern Ireland or Wales.

Q But that wouldn't necessarily-- That wouldn't, in fact, be the case for internal or GGC only guidance, would it?

A I think you've answered your own question. Their own guidance would be for GGC and/or internal to Scotland if it's SHTM.

Q Yes, and as these paragraphs-- as you read these paragraphs, if the

suggestion was that that guidance was principally for the purpose of provoking question-- provoking testing or prompting supervision, surveillance, etc., rather than other national guidance which might be about setting objective standards for safety, would you be in a position to comment upon a suggestion like that?

A Can you rephrase your question?

Q It may be NHS GGC's position that the thresholds which they have set have the particular purpose of encouraging follow-up testing internally?

A Yes.

Q Would that seem reasonable to you, looking at what you've recorded at 6.1.7 and 6.1.8?

A Yes.

Q And would it also follow that nothing in particular would-- Would it also follow that-- Let me start again. Would you able to draw a conclusion as to risk from the thresholds that been set and the internal guidance?

A Yes.

Q Could you explain, please?

A Because they're putting in their own SOPs, if you want, based on their own findings. So we have guidance for Legionella. We have guidance for Pseudomonas. We do not have set guidance for Cupriavidus and, therefore, they've put their own SOPs/work

programs in place in order to set limits for the alert-- the point at which alerts should be administered for the presence of those microorganisms.

Q Might it be that persons setting alert limits might set them for different reasons?

A We do set them for-- Yes, because you may have different alert limits for highly vulnerable immunocompromised patients compared to those in general wards who are not at such risk from those microorganisms.

Q And so if one particular limit were met or threshold were reached, would that of its own necessarily enable you to draw a negative inference?

A In terms of safety, in terms of----

Q Yes.

A Where you may have highly vulnerable patients within a particular ward – say an augmented ward/transplant ward – someone may set particular limits for that ward for the water microbiology, but the patients within that ward may actually travel on a journey through the hospital for different reasons, and therefore one would have to ask the question, “How do you then protect that patient from the water in the rest hospital where you have a different limit?”

Q Okay. So, in fact, perhaps, are you saying that, to tie it back to what

we've discussed at the very start, that one has to take into account all the circumstances in order to assess exactly what a particular piece of information might mean?

Q Yes, and if you're describing limits for a particular high risk patients then you need to ensure those limits are maintained whatever that high risk patient is within the hospital.

Q But some limits might be set for other reasons----

A Yes.

Q -- and you'd have to assess them case-by-case. Returning to-- I've taken you on one page further perhaps than I should have done. 284 has a reference at 6.1.3, which you may have already covered this morning, but it relates to written-- to an aspect of the written scheme-- specific aspect of the written scheme that I have some interest in which is the obligation to appoint certain roles. You see that, and there's designated person----

A Yes.

Q -- authorising engineer, Legionella risk assessor, and we're aware also of other positions, authorised person for water being one of those. How significant are those appointments for the safe running of a water system?

A We discussed earlier on about there are many aspects to the safety of

the water system. Some of them are risk assessments, some of them are remedial measures and that some of them are staff, and in order to complement those other measures, we have to ensure that you have competent staff, that these staff are appointed, that they're named, that they're trained and that you can demonstrate that training, that they understand the risks and the remedial measures to be taken to control the risks within the water system.

Q If those posts are unfilled for any period, what does that mean or indicate?

A It means it may be more difficult to ensure that there's a competent control strategy in place if they don't understand what they're doing. If there's no one there in the first place, then how can you do that role? And if the person who's there hasn't been trained, then one would have to question, “Do they understand the principles of health and safety guidance?” Do they understand the principles of SHTM and controlling microorganisms to protect highly vulnerable patients?

Q So those are perhaps downstream consequences of not having a person in those roles. What does it tell you about what's happening upstream? What can you tell about-- overall----

A If that person hasn't been

appointed?

Q Yes.

A Then someone up the chain hasn't been doing their job because these are legal obligations through the health and safety guidance to put people in these roles in order to ensure there's a safe water system.

Q Thanks. I think we're on page 284 at the moment, and to skip back-- forward to 285 for a different purpose this time, here, section 6.2 starts with considering, "L8 Legionella water system risk assessment 29 April 2015." Now, we already saw that. It flashed up on screen for a moment this morning. This was the DMA Canyon report. Do you recall that?

A Okay. Yes.

Q And that's bundle 6, page 122, please. Now, it's a very lengthy document and it's certainly not my intention to try and pick through it with you.

A Okay.

Q But I'm interested in a couple of references that are made in it. One of them perhaps relates to a matter we were discussing just before lunch, and you recall we had a discussion that spoke about water quality about filtration and about a bypass?

A Yes.

Q If you look at page 206 of this document, you'll see in the largest

paragraph on that page there was bypass pipe work. The cursor went-- is right where you need to be. So, it's recorded here:

> "There was bypass pipework set up to run from the Hardgate Road mains to domestic (Bulk) water supply system connecting in after the Booster Pumps. This was noted during DMA's initial site walk round and reported to Estates. DMA again noted this in April and again reported it to estates. DMA were advised in mid-April this had been removed by Mercury/Brookfield. This line could potentially have introduced debris to the distribution system which would otherwise have been removed by the filtration units and could be a contributory factor to any out of specification microbiological results."

Does that tie in with what you were telling us before lunch?

A That's my interpretation, yes.

Q So in terms-- part of what you were telling us was about the quality of filtration system. Does it follow from the existence of this bypass that whatever the filtration system might have been designed to do, it couldn't have done it?

A Correct.

Q You do consider the bypass a little bit in your report, if we move back to that at 286 and at 6.3-- Sorry, the expert report rather than the DMA report. That will be 21, Volume 1, I think. Yes, thank you. 6.3.1 and 6.3.2 are recording-- and may indeed be a direct lift, in part, from the DMA report. Two pages further on at 288, you've helpfully provided a diagram of what the bypass had done. So the thick red line, two red arrows on the lefthand side, is, I think, the bypass pipe effectively. So it starts at mains water supply and enters the system at some point above booster pump number 2. I'm interested in what it bypassed.

A So it bypassed the raw water storage, the filtered water storage tanks, and then looks like the booster pumps. We have had some debate about this in the past.

Q What are the consequences of that?

A The consequences are that the ultrafiltration unit would not have filtered out what it was supposed to, and therefore that contaminated water, from my perspective, would've entered the system.

Q Right, the word "contaminated" appears again. Perhaps we avoid that word for the moment.

A Okay.

Q Just tell me what sort of things

are getting in that wouldn't have been getting in had----

A So, sediment, debris, bacteria.

Q Thank you, and if you recall what I read you a moment ago from the DMA report, DMA are talking about the line having potentially introduced debris to the distribution system, which would otherwise have been removed. DMA didn't mention microorganisms. Do you recall that, or would you like to see the passage again?

A You can bring it up again, if you wish.

Q Right, it's Bundle----

A If you'd like to.

Q Back at Bundle 6, page 206. If we see the last three lines, DMA are talking the significance to them of the main-- from the large paragraph, beginning, "There was bypass pipework." On the fifth line, "This line could potentially have introduced debris to the distribution system."

A Okay.

Q So DMA's concern appears to be that there might be debris, sediment, whatever, getting into the system. They're not particularly concerned about microorganisms. Is that fair?

A They've written what they wanted to write in terms of their opinion, but it could not have introduced debris, sediment and anything else without there being bacteria present.

Q Perhaps I don't need to pursue that any further. Returning to your own report at page 289, during this section you're referring to various findings to various information that you've taken from the DMA report, and then you're drawing a set of conclusions, and those are the bolded paragraphs. Is that right?

A Correct.

Q Now, I'm not going to take you through all of those. We have them. They're written down, but I'll take to the ones that appear to me to be-- that you might be able to tell us a little bit more about.

A Okay, yes.

Q In the middle of that page, 6.3.7 and 6.3.8 are where DMA are identifying a lack of temperature control, and the particular concern is that:

> "On the day of the risk assessment, the majority of the cold water temperatures recorded were more than 5 degrees higher than those recorded at the water tanks, with peak temperatures of 30 degrees Celsius."

You draw what by this point may be the expected conclusion-- is that excessively high temperatures are providing conditions for proliferation.

A Yes.

Q I'm interested in heat gain itself as a phenomenon. Can you explain the significance that, please?

A So, in terms of the cold water pipe, you will have guidance where all pipes should be insulated. Where you have an uninsulated pipe or a pipe is even insulated but running alongside a hot pipe or in a warm room, that water will start increasing in temperature from 20 degrees upwards. When the outlet is operated, water will flow through the pipes, reducing back to 20 degrees centigrade. Water switched off will become stagnant, stasis, and where there is no insulation, where there is a presence of a hot water pipe, you'll get a greater degree of heat gain in cold water pipe, and the outcome of that is you have greater opportunity for the growth of microorganisms within that section of pipe work.

Q What is the failure that allows that to happen?

A Sometimes it's design: the pipes are too close, the cold pipe is too close to the hot water pipe. Sometimes it's a lack of insulation, and that is a situation where the system should be audited, it should be assessed, and perhaps if it's not audited and not assessed and there's no insulation, then it will not be corrected.

Q Moving onto the bottom of the

page, we're back to debris in a slightly different context. There's a mention of debris in filtered water tank storage, storage tank 2B.

A Sorry, the 6.3.11?

Q 6.3.11/6.3.12 should be the bottom of the page in front of you. You say that, in your view, it was:

> "The presence of debris in the washers provided additional nutrients for growth of pathogens."

What's the significance of this being observed in the filtered water tank?

A So, your filtered water tank is the cold water that's going to be distributed around the hospital. So if you have debris and biofilm and microorganisms in that tank for whatever reason, then every time the water leaves the tank, it's going to distribute some of the debris, some of the sediment and some of the bacteria that have grown in that water in the tank, either in the water phase or as a biofilm. Then that water will then be distributed to every cold outlet in the hospital.

Q And this tank again is something that happens after the filtration units?

A Correct.

Q So, again, if the bypass rendered the filtration units irrelevant, then would the presence of the metal

washers, debris noted here-- Would that basically do the same thing?

A It would provide additional nutrients, additional surface area and, for example, things like Legionella likes iron anyway, so you may even be developing a situation where you could have Legionella growth in the water tanks because you have metallised washers within that tank.

Q If you flip onto the next page at the top of that you should be following the line thought in paras 13 and 14 as to where the water goes next:

> "Contaminated water in the filtered water tank 2B was then pumped to the hot and cold domestic water system, in which there's a lack of temperature control. [You draw the conclusion there that] Contaminating bacteria and sloughed biofilm from 2B continued to contaminate and multiply in the hot and cold water system through to the outlets."

Would you like to elaborate upon that at all?

A I'm not sure there's much more to elaborate on. You have a situation where you have a large, large water tank and it's designed to have a particular turnover, and you have sediment, you have debris, you have biofilm, you have

materials in that tank that shouldn't be there, such as the washers. Those tanks should be inspected as part of the PPM, as part of your written scheme, as part of your water safety programme, and then you've got a situation where you're presenting opportunities for growth then being distributed to the rest of the water system, including the hot.

Q So, is this another example of a coincidence of factors that are leading to bad outcome?

A You could say that, yes.

Q By which I mean nutrients, plus temperature, plus water, with the potential for growth.

A Yes.

Q The next two paragraphs are returning to the idea of heat gain but, again, in a different context because they're recording that, "dump valves were not operational." Firstly, what are dump valves?

A So, basically, as part of the control system within the cold water system, they had valves that would operate automatically based on temperature monitoring within the cold water system. When the cold water system had reached 23 degrees centigrade, the dump valve would automatically open to discharge that water. From a discussion we've had earlier on, you would then replace that

with replenished water. You remove the bacteria from the water phase. You brought in water which is colder and it may have a slightly higher concentration of chlorine.

Q The specific issue that you're noting here as a problem is at the start of paragraph 16, which-- your view that, "The dump valves were not operational and not connected to the BMS," the building management system. Is that correct?

A That was taken from a DMA report, yes, so it's a guess. It's a view and an opinion based on the evidence which I was presented with.

Q Now, the suggestion that it's the lack of connection to the building management system that makes the dump valves not operational, would you accept that dump valves can operate in different ways?

A They may do, yes.

Q It could be manually done?

A Could be.

Q They could be set automatically that wasn't linked into a central control? Would that be possible?

A Could be, but the fundamental point was that DMA identified that they weren't operational, regardless of how they were engineered to operate.

Q Okay, so, from that perspective then, does it matter what type

of dump valves we might be dealing with?

A I would've thought not. The important point is that they were not discharging the water, and therefore we were providing opportunities for increased cold water temperatures and opportunities for microbial growth, which then recede back into the water system.

Q At the foot of the page, we move on from the cold water system to the hot system when it goes on to 6.4. The broad circumstance that you start out with here at 6.4.1 is DMA identifying a lack of temperature control, and you note that calorifiers were operating at lower than intended temperatures and that return temperatures were 40 to 45 degrees. Could you explain to me what return temperatures are and what's the significance of that value, 40 to 45?

A Okay, so, starting out, your calorifiers should be heated to 60.

Q If you can perhaps even start before there. I've got a vague picture of the hot water system being something of a circle.

A Yes, so, you've got your water tank. You've got a pipe coming out of that, from which the hot water will flow to hospital system. It will then go around the hospital system and come back to the calorifier. As that hot water pipe is going around the hospital, it will have primary and secondary loops which are branched

off the main line into other parts of the hospital. The calorifier, which is a large heating cylinder, will heat the water to 60, and the water will pass on the flow around the hospital, and it should return to the calorifier at 55, so it's only allowing for a loss of five degrees across the entire network.

Q And when it gets to the calorifier, it goes back up to 60? Is that----

A Yes, because your calorifier is a heating vessel, and so when it goes back into the calorifier it will heat the water back to 60 through the majority of the cylinder but probably not at the very bottom because it's below the heating element.

Q In principle then, the hot water system would operate by having water circulating round and round, occasionally being drained off.

A Yes.

Q But it would circulate round and round, never getting below 55.

A In practice, that's the ideal. What your scenario here is-- what DMA identified was up within particular loops the water was going below 55, below 50, and getting down to – you can see the temperatures there – 40 to 45 degrees centigrade.

Q Why is 55 the target?

A Fifty-five is the target because

you have some remaining control of the bacteria in the water system at that temperature, so you'll reduce the opportunity for growth such that you do not get multiplication, or if you get multiplication it will be-- all control is in a contact time, and so the higher the temperature the better, the quicker the kill, but 55 gives you an opportunity to keep control of, particularly in this case, Legionella and other gram-negative bacteria within the water system.

Q And what does it mean if 40 to 45 is being seen?

A So, you remember the growth graph we talked about earlier on in terms of temperature range? So, that area of 40 to 55-- 40 to 50, sorry, you're looking at an ideal opportunity for growth.

Q Moving onto the next page. There's a different problem that's being identified in the top two paragraphs, which was a calorifier being offline for months and being reinstated without evidence of flushing, pasteurisation and so forth. What follows from that?

A What follows from that is you have a large cylinder of water which would have been sitting stagnant, sitting at a reasonable temperature for microbial growth, and also within the bottom of the calorifier, you will have a certain amount of debris and rust collected underneath the heating element, and then if you--

That debris and rust will create nutrients for the growth of microorganisms, so you've got nutrients for them to grow You get certain temperatures which will then provide the opportunity for growth, and if you do not fully provide a planned preventative maintenance programme for that calorifier before you return it into service, then potentially you are supplying the rest of the hot water system with a range of microorganisms and debris into the system that you have not controlled.

Q Thank you, and 6.4.5 and 6.4.6 are different again. Here you're identifying-- We're back to dead legs, and you're identifying excessive length. Could you explain to me what information you had and what's the problem with that?

A So, ideally, as a hot water system goes around the building, you have the spur coming off between the flow and return to your outlet. Those spurs should be as short as possible. Where you've got a longer spur, the longer the pipe, the more the water, the greater propensity for the growth of microorganisms within that extended length of pipework.

Q The reason for that being?

A The reason for that being is when that tap/outlet/shower is not being used, then you will have stagnation, you'll

have an increase in temperature for the cold and you'll have a decrease in temperature for the hot, and you will have the opportunity for microbial growth within those lengths of pipework and waterborne pathogens.

Q At 6.5 there's a section dealing with ancillary equipment. I don't think we need to go to that, and then over the page, we see at the very top EPDM flexible hoses are addressed again. I think you probably told us enough about those. 6.6 is different in nature, though, because it's dealing with water microbiology, and here there's a recording of various out of specification results for Legionella, and you are drawing a perhaps unsurprising conclusion at 6.6.2 that such high Legionella counts raise concerns for high-risk patients. You see that?

A I do.

Q Over the page-- In fact, that's the last of them. That's the end of the consideration in your report of the information that you've got from the 2015 DMA Canyon report.

A And just before we go off that page, of course, those counts or those alert levels for Legionella-- those are based on the national guidance. So, those are guidance which have been in place for decades, since probably the 80s and 90s, because they recognise risk

from Legionella in water systems and hospitals. So these are not recent figures or new guidance. These have been in place for many, many years.

Q Thank you. The extra time there enables me to notice that 6.5.4 also mentions EPDM but in a different context, and here you're talking about non flow through expansion vessels.

A Yes.

Q Were these expansion vessels that were part of the hot water system at this point?

A If we're still in the hot, yes. In fact----

Q Let's go back one page and we'll just check that. It's 291. That's ancillary equipment. I don't think it records whether that's hot or cold.

A Pardon? Sorry?

Q This is in 6.5, which is just marked "ancillary equipment". I don't think we're recording here whether it's hot or cold.

But, to go back to the reference on the next page at 6.5.4, you mention here that the use of non flow through expansion vessels with EPDM bladders provide nutrients and surface of the growth of pathogens. Nutrients and surfaces is, I think, covered by you in your answers this morning about EPDM. What's the significant reference of non flow through expansion vessels? “Non flow through” is the emphasis that I would make.

A So, basically, it's an upside down jar, to put it in simplistic terms, and it's connected to the water systems, and inside of the jar you have a rubber balloon, for want of a better word, and what that water balloon does is, for example, when the booster pumps are working or the temperature is going high at 60 degrees centigrade, you'll get expansion because of the hot water. You'll get expansion because of the booster pumps. You'll get expansion because the water's flowing, and what the bladder/the balloon does is be able to take up the capacity of the water and basically equate through to a smoother flow on the water through the system.

You described it as a jar. Is it a jar with an opening at each end?

So think of it as an upside down jar, but it's not got a screw cap lid on it; it's just a metal container, and the water comes in from the bottom, and the water goes into basically the balloon bladder, and then it takes up the capacity and expands and contracts, and because it's made of EPDM you have the same scenario of the flexible hoses we were talking about earlier on, and the Intertek results – I don't know if you were going to touch on these earlier – provide the evidence that these were heavily, heavily

contaminated, particularly with the range of pathogens which have been found in the water system.

Q Okay. I think that's probably enough to let us know that there was contamination, but just in terms of the image of these, do you know the gasometers that are beside the M8 as you approach Glasgow city centre?

A Yes.

Q Were they effectively expansion vessels on a much larger scale?

A I think so, yes. I'm not sure whether they are, because when they're full and when they're empty, they're at different levels, whereas in this context-- Maybe it's too simple, but it's like the balloon expands within the solid sphere of a metallic container.

Q The ones I'm thinking of are within cages. So if the cage is the jar and the cylinders are the bits that go up and down, would that be roughly what you're talking about?

A If that works for you, then yes.

Q Perhaps we won't place any reliance upon my skills there.

A Just like the rubber balloons.

Q But his Lordship did ask the question about did they have an opening at each end or not?

A So, these are non flow through, so the opening is only at the

bottom, so it's going in and out the same, whereas the flow through it goes through the bladder and out the other end.

Q Which is better?

A Flow through would be much better.

Q And why is that?

A Because all the time you're replacing the water inside the bladder, because if you think of the non flow as just like a balloon, the water is going in and out, so you will have the growth of the microorganisms most of the time probably in a stasis environment, and so you would basically compression and decompression, whereas your flow through-- Think of it like any of the taps. Once you're flowing water through it, you're replenishing it with either hot water or, if it's a cold expansion vessel, cold water at 20 degrees again.

Q If there's a flow through vessel, does that mean that there's a current taking everything from one end and out through the other end?

A It will move, yes.

Q Whereas in a non flow through version, the distinction you're drawing is that there'll be one opening, and sometimes water will be going in the opening and sometimes it will be coming out, but whether it's going in or whether it's moving depends on how close it is to the opening.

A Yes.

Q And does it follow from that that there might be bits around the outside that never leave the vessel?

A That will be the scenario, yes, and that'll be why the Intertek results demonstrated such heavy fouling and contamination within the non flow through expansion vessels. But if you want a real good explanation of them, I think you should go and ask one of the water engineers.

Q No, thank you for humouring me these last few-- That's the last section which you're considering material from the 2015 DMA report, and we saw the date of it. That was the end of April 2015, and that's around the time of patient entry into the hospital. If you think back to your key questions that you were addressing, the first of them was, "From the point at which there were patients, was the water system in an unsafe condition in the sense of presenting an additional risk of unavoidable infection to patients?" Does the material that you've covered so far allow you to answer that question?

A Yes.

Q What's your answer?

A One would consider that it was in an unsafe condition, that it had not been managed or was not being managed appropriately.

Q In the course of the witness evidence that we've had so far over the last several weeks, there have been a number of points that may or may not be new, that have come out in more detail. I think you may be aware of many of those anyway, but could we skip back to 203 of the report?

There's the briefest of references here in paragraph 3.3.2 to some problems that you were aware of prior to handover, and you're referring to matters of design, build, dead legs, stagnation after filling between build and commissioning, taps, commissioning, handover work. The reference in the middle about stagnation after filling, we've heard some evidence that what happened-- You may or may not already be aware of this, but to fill you in, what happened is that the system was filled once, drained down, filled again and effectively left until it was put into operation, and that would have been a period of perhaps nine months. Can you give your views on that?

A We know and we have it in guidance after many years of experience that pre-filling water systems leads to contamination of the water system, leads to stagnation because these systems are traditionally filled but they're not flushed. There's no management particularly going on. We have the guidance,

planned preventative maintenance for valves/for many other components. This is traditionally not carried out during that period while the system is just filled. Therefore, if it's just a stagnated system, then you have an ideal opportunity for areas of the system to provide areas where microbial growth will occur.

Q And is that what you have observed, or is that the understanding you've gained through reading the material in the DMA Canyon report, for example?

A I think the DMA Canyon report, and I think from others as well. It was filled beforehand.

Q Thank you. Now, moving back to the page we were on, which I've misplaced the number-- It should be around 232, I think. Perhaps we're further on than that. Give me a moment. Could we go to 292 rather than 232? Yes, that was the end of the consideration of the 2015 report. If we move over the page, we'll see that we move on to a Legionella audit from May 2017 by the authorising engineer. I think your view at the bottom is-- It's your view that the 2017 audit reiterated the findings of the 2015 DMA report. Is that correct? Do you see that?

A Yes, I see that, yes.

Q There's only one specific item that I'd like to draw your attention to,

which is in the in the bullet point list in the middle of the page. At the fourth bullet, there's a recording that, "There was no Authorised Person for water in post at the QEUH." Do you see that?

A I do see that, yes.

Q Now, if this is being recorded in a report in May 2017, what are your thoughts about that?

A With the hospital having been handed over two years previously, with authorised engineer-- authorised person reports should be carried out annually as per the regulations, and therefore one could consider that the lack of an authorised person could be once again a missing link where issues could have been identified and dealt with.

Q In terms of if you think back to the four parameters that we started off with, would this be a management failing?

A Very much a management issue, yes. Because it's part of regulation, then there should have been processes in place for that to happen. This was a very, very, very big hospital, a very complicated water system, and therefore the more expertise you can use to assess that system and assess what remediations are required, then the more likelihood would be that those mediations be put in place.

Q If we move over the page, 6.8

is a compliance officer's report roughly in the same period, August 2017, and 6.9 is another Legionella assessment also by DMA Canyon in September 2017. There are specific matters addressed in the report, but I don't intend to go to them. It may be enough if we look at 6.9.1 where you're identifying that the risks identified in the executive summary of this report are similar to those highlighted in the April 2015 report. Do you recall that and coming to that conclusion?

A Yes.

Q What's the significance of that?

A Here we are, two years after the previous audit. It was a Legionella risk assessment. It identified a number of high risk issues within the water system and the management of that water system. Two years later you have this-- the same company, the same team going in with the same expertise and they're identifying the same problems, which they identified two years previously. It would indicate that those issues, which they had identified in 2015, had not been addressed.

Q So, if I were to ask you the same question again, instead of 2015, now about 2017, which is, “Was the water system in a safe condition?”, what would your answer be?

A My answer would have to be that the system was not in a safe

condition.

Q I'll take you out of order a little bit at this point because you may be aware that there was a water system incident in 2018 whereby a series of infections arose that were believed to be linked to the water system. Are you aware of those?

A Yes.

Q Could I ask you at this point to turn to Bundle 10, which is a series of minutes from the water technical group? There are three documents within that that I'm interested in, really, about the initiation of this incident. First of those is the first page that you've got here, page 5, minutes of a meeting-- of the water review meeting, 6 April 2018. Various attendees, and do we see the lower half is considering Horne taps again?

A Okay.

Q I'm not going to go back to Horne taps. If we look two pages further on, we see that the discussion changes to a subgroup convening, and then there's discussion on IMT update. Do we see here that there are now positive results being noted in the first paragraph for Stenotrophomonas? Do you see that?

A Yes, these are blood cultures.

Q And then a different pathogen in the second paragraph, Pseudomonas. Do you see that?

A I do.

Q And then the third paragraph is specific to RHC, I think, and it's saying that:

> "...3 lots of positive results from RHC with several results from risers and outlets [within the hospital within] QEUH, some of which have been reported higher up the stack since the last reported previous Thursday. It was noted that there is a huge variety of species including a single sample with a coliform which can be gut flora."

And a particular bedroom has been put out of use until this was clarified. So, you agree with me we're getting the picture here that there is a very widespread problem beginning to be uncovered?

A It appears to be so, yes.

Q Two pages further on and we've got a 13 April meeting. Only briefly here under, "Matters Arising" in the middle of the page, we see that results-- This one week later, results are still coming back, and it appears that, from the paragraph below that, the outcomes are being mapped out. If we move onto page 14, the next water review meeting, one week later, 20 April, and here, "Matters Arising", you see in the middle of the page there are, "...drawings of the site" in the first paragraph. But then:

> "It was noted the spreadsheet results had shown there were now contamination in the tanks. Two tests required on the tanks as they are split – one sample dip test and the other taken from the valve at the bottom of the tank. It was reported that these had already reported as clear of any contamination with the exception one report was then followed through the following week with clear report even though there had been no disinfectant used or passed through the system. "

So, we see this as another location entirely.

A So, you're building up a picture of what we would call systemic contamination.

Q If we look at the bottom paragraph on the page, we can see that the conclusion is being drawn within the meeting itself.

A Okay.

Q

> "Every floor is showing some contamination with various species, so we can assume there is a widespread contamination in the buildings."

Do you consider that to be a correct conclusion to have drawn from the passages that we've seen so far?

A I do.

Q And does that also fit with your conclusions that you've drawn from 2015 and 2017, the information you've seen about those years?

A It does.

Q So, to ask you the same question, again. At this point in 2018, what's your view on the safety of the water system?

A If you're identifying that range of microorganisms, including E. coli, in that range of different component parts of the water system, different floors and different equipment, then one would say that a system is systemically contaminated, and it wasn't safe for high risk patients. In fact, the presence of E. coli would suggest it's not safe for anyone at that point.

Q Thank you. To turn back to your main report, at page 298, there's the next section, we're looking at-- In fact, I'll just pass over these, I think. You're looking at the 2018 authorising engineer audit. The next page has the 2018 Legionella risk assessment. 300, you look at water microbiology. Then at 303 move back to a subject that we have touched upon but from a different perspective this time. You're looking at incoming mains water supply at 6.15, "Incoming Mains Water supply to cold water storage tanks." Now, the factual

basis that you're recording here is:

> "A mains water inlet valve and water meter were analysed for microbial contamination... Deposits were found in the internal surface of the pipe and in the casing in the meter fan and were white in colour and solid to the touch. Microbiological analysis demonstrated that there was greater than 10 to the power 10 CFU per gram of material. "

Now, the reason why I go there is that the number is literally orders of magnitude different from where we were at before.

A Correct.

Q However, the denominator, the per unit, is different. We were talking about liquids before, per litre, per millilitre, per hundred millilitres. Here we're talking about solids and the measurement changes to per gram. Is there a comparison that can be drawn between the limits that we were looking at before? What should we draw in-- Better question, sorry, and answer this one: the better question is what should we understand from a result of 10 to the power 10 CFU per gram?

A So, the per gram is because the material that they recovered from the filter was a solid mass by the looks of

things, and because it's a solid mass, they were able to weigh out a certain amount of it, and then they were able to extract from that material onto an agar plate, if that's the system they used, by probably putting some of the material into a solution-- a set solution.

And then they were-- what we say is plated out a small proportion of that onto an agar plate to get the colony forming units, the little cells, on the plate, and by counting them and relating back to the volume, relating back to the weight of material, they were able to get count of 10 to the 10 per gram, and in a system such as a water system where you have material, which is supplying water to the water system, which is 10 to the 10 per gram, it sounds like an awful lot of bacteria.

Q Well, it does. I mean, in the abstract, 10 to the power 10 is a colossal number, but given that it's in a solid, and given that it's per gram, and given the location from which it was taken, the mains inlet, are you able to say what risk is posed by this?

A So, assuming this is a mains inlet valve prior to the ultrafiltration unit, and assuming at that point the ultrafiltration unit is actually in place and operating, then it would pose no risk to the water system.

THE CHAIR: Sorry, could you just

repeat that?

A It would pose no risk to the water system, because the way the system was designed is the mains water supply from Scottish Water goes into the hospital and goes through an ultrafiltration unit to remove sediment, debris, and bacteria, and so if this mains water inlet valve is before the ultrafiltration unit, then any of the sediment, any of the bacteria would be blocked from passing into the water system. That's assuming it is before the ultrafiltration unit, which is my understanding. If it's not, if it's after it, then you have a different scenario.

MR MACIVER: Okay, and this describes that mains water inlet valve, and you tell me that the implication of that is presumably that it's right the initiation of getting into hospital premises at all?

A That's my assumption. We would have to look at-- It may be useful to look at a map or a plan as to where it exactly was so that we can categorically say that.

Q In any event, this passage here, should we understand the significance of it as being less about the inlet valve and what's on it itself and more about the role of filtration?

A Yes. So, to me, the importance of that point is previously they bypassed the ultrafiltration unit. The

amount of material in this mains water inlet would perhaps given indication of the potential for material that may have been introduced.

Q To complete the picture, this valve was examined in 6.15.1 on 11 July 2018, so it's over three years after the hospital was opened. It's presumably been in place for even longer than that?

A Yes.

Q Deposits will have built up over that time?

A Yes.

Q The deposits will have had things in them that have eventually built up or-- Sorry, not the deposit, the water will have had things in it that have eventually built up into those deposits, but am I correct that it's not possible to draw, for example, a conclusion about water quality without more information?

A Correct.

Q Thank you. The next page has a section on expansion vessels, 6.17. You may have answered those already, so give me a moment. 6.17.1 records certain problems. The metal holding plates are found-- what are the metal holding plates because they are found-- they are stated to be extensively corroded.

A So the metal holding plates would have been the infrastructure which the bladder was attached to.

Q Is that the jar in your analogy?

A Yes, so it would have been-- the bladder has to be attached to something, and so those holding plates would be part of the infrastructure of the jar.

Q And as you say in the last sentence there, the holding plate and the bladder were found to exhibit a strong reaction for biofilm?

A Yes.

Q Meaning biofilm was present?

A Correct. By the chemical test which they've used, which is the hydrogen peroxide, to determine the presence of catalase which the gram-negative bacteria have in the structure, and you then have the presence of bubbles indicating a positive test, and so it's a-- It's quite a rough test, but it's enough to say, "Yes, there's a biofilm there," and the higher the score for the number of bubbles gives you some semi-quantitative impression. If you get five rather than zero-- If you get a five, then you've got a much higher concentration of bacteria present.

Q You do elaborate a little bit in the next sentence, 6.17.2.

A Okay.

Q Not in that specific way, but you give more detail:

"Scientific analysis indicated

that 75 per cent of the samples analysed from the expansion vessels were positive for Cupriavidus."

A So it's not just corrosion deposits, and the corrosion deposits themselves would create additional surfaces for the growth of microorganisms, but it's also the growth of some of the microorganisms which can be shown to be a risk for patients.

Q If you look at your conclusion in the next paragraph, your view is that the expansion vessels are-- no, your view is that these expansion vessels which were identified as being non-compliant in 2015 were later identified as being contaminated with Cupriavidus. So, these are the same expansion vessels that DMA were looking at and----

A Yes.

Q -- suggesting that things be done with four years previously?

A Yes.

Q And if we read on, in fact, we see you're setting out a chain of events here:

"From 2015, the contaminated water from the expansion vessels would have continually seeded the hot water system, tap outlets, showers, water coolers with these waterborne pathogens . With the hot water being less than 55 degrees and there being heat gain in the cold water, growth of microorganisms would have taken place, increasing the risk of health care associated infections. "

Do you need to comment on that at all?

A I'm waiting for a question.

Q Is this an example of the holistic analysis that you have been-- that you've told me about earlier that, in order to determine risk, one looks at all the circumstances?

A Yes, and importantly it really is, I think, something we have to say, that the DMA reports in 2015 recognised many of the problems which were, again, identified in 2017, and they hadn't been addressed in that intervening period and, therefore, they were still a continuing risk.

Q And what's your assessment of that risk?

A In terms of?

Q Safety.

A That the system could have been safer, that the system could have been managed, and that's part of the issues we're looking at, and that's where your water safety group, your written scheme and your plans for remediation come in. Having used your water safety plan to recognise and identify the risks because that enables you, through your

written scheme, to put remediation processes in place, and each time of-- It's like a deck of cards, and if it falls down, you only need one-- sometimes you only need one of those failures to bring your deck of cards down. Probably a very poor analogy, but----

Q We'll move on, in any event. On the next page, we've got 6.19 about shower hoses, you've-- showers and shower hoses, and we've spoken about both of these things beforehand, but you're discussing here a range of positive results taken from these items. Your conclusion at 6.19.2 is that, in your view:

> "The detection of Cupriavidus, other waterborne pathogens and fungi in the shower heads and hoses from multiple different patients in 2A and 4B indicated that those microorganisms had established as a biofilm on the components examined."

How do you come to that conclusion, that it's biofilm that's involved?

A Because of the analysis and the evidence we were presented with.

Q Can you elaborate on that? What's the analysis that allows you to know that it's biofilm rather than, say, free floating pathogens, or is that----

A Without bringing up the report,

I'm pretty sure it was when they removed material from the surface, particularly from the shower head, I think they were scraping bits of material off, if I've got that right, and therefore that's biofilm they're scraping off, and you have to-- and, again, it's-- Even if they're just taking the water sample and the sample's positive, some of those bacteria could be coming from the biofilm, sloughing off into the water.

What's important is shower heads and shower hoses are well recognised as a risk for high risk patients, and this goes back to the HSE Legionella guidance which had been in place for decades and recognising that, particularly for Legionella and for some of the other microorganisms, it's that release of the microorganisms in small water droplets, large water droplets, and in aerosols because of the special route and the mechanism by which we contract Legionella, which is breathing in the bacteria.

It may also be worth adding there was a Dr Jo Walker who works in Scotland who, this year, published that 80-- something like 80 to 86 per cent of showers within her hospital areas were not used on a daily basis. So where they're not used, that increases the risk. We know the flexible hose has EPDM within it. That's a risk. We know

stagnation is a risk. We know the plastics within the shower heads are a risk, and so you're going to get the growth within there as a biofilm in the surface, whether you've analysed it or not.

Q Okay. The next section, 620, is going back to taps. Can we go over the page? I think we've probably covered most of what's on that page already. 307 on the next page. There's one reference that I'd like you to explain, which is at-- Well, perhaps I'm being thrown by the formatting glitch. The last sentence of 626 onto----

A Okay.

Q -- goes into 627:

> "Microbiology results presented by Intertek demonstrated that these outlet taps were recontaminated by waterborne pathogens within a few months with an increased risk of infections."

And in the first, sort of, (inaudible) shouldn't have those in the first sentence where you are speaking about your experience of the last two metres of any water system being high risk. Can you explain to me, firstly, about the reference to the last two metres of any water system being high risk? What do you mean by that?

A So, this is a way of expressing-- Remember earlier on today we were talking about spurs from the hot and from the cold system? So, you have your hot flow and return pipe, and from that comes a spur, and down that spur it leads to a tap outlet or shower outlet or some other form of outlet, and you also have your cold pipe going to those outlets.

The way of describing this is the last two metres from the flow and return and the last two metres from the cold pipe are the-- basically the highest risk areas because once the water flow stops flowing, you have a stagnating pipe, and so we describe that as the last two metres because we recognise that, microbiologically, it is a high risk area for microbial growth.

Q But it needn't necessarily be two metres, literally?

A Correct, it's an expression which we've maybe misappropriately defined by putting a number onto it.

Q It is a point, essentially, about dead legs, or effective dead legs?

A It is, yes.

Q And a common length of a dead leg that one might find around a tap is the last two metres?

A As I said, it's maybe now a misappropriation because we have-- we have the specialists and experts have written into guidance that you bring the return of the hot water system – the flow and return – as close to the pipe for the

tap as possible, so it shouldn't be two metres. It should be two inches or as small an area as possible, and we may touch on it later in terms of post-refurbishment and identification of dead legs.

Q Well, I was going to touch upon the refurbishment in another way, which was my reference to the last sentence there about recontamination within a few months, and that was identified by Intertek----

A Yes.

Q -- and you'd referred to Intertek yourself about half an hour ago. I'm less interested in what Intertek had found-- Well, I'm interested in the finding of recontamination within a few months after refurbishment. What does that tell you about the water system if that's what's happening?

A So, if you're refurbishing a unit and you're replacing the pipework and the taps and the outlets with new components, and you start operating the system and you then retest within two months and you have positive microbiology again, then it would tell you that upstream of those components you are seeding the last two metres and the outlets with bacteria from the water system or there's a particular component somewhere that's seeding with bacteria.

Q Could you move onto page

311? 6.22 here is speaking about analysis of pre and post-flush samples, and you explain what that means in 6.22.1:

> "Analysis indicated that 33 per cent of pre-flush (or sample taken when the tap has been opened) samples, and 44 per cent of post-flush sample taken after the tap has been flushed samples were positive."

So that's one proportion, one third roughly, pre-flush samples positive, but a greater number post-flush. You draw the conclusion at the bottom that this indicates systemic microbial contamination.

A Yes.

Q Can you explain that to us, please?

A Okay, so, amongst everything else you talked about – everything that needs to be put in place to protect the system – one of the pragmatic and practical things to do is to monitor whether your control strategies are working, and the only way you can monitor whether a control strategy for reducing microbial growth is working is whether you measure a number of bacteria in the water system.

The way you do that is by taking what we call the pre-flush, which is the

first batch of water coming out of tap. So you have your bottle underneath and you turn the tap on straight away and you take a sample. What will that-- if you're following me, that will tell you about the contamination within that very short area of the tap-- of the water which you have taken and will tell you about the microbial contamination in that last few-- half a metre/a metre of the water that you've sampled.

And the second way of doing it is if you flush the water out the tap for a minute or two minutes, depending on your standard operating procedure, then you put your water bottle underneath. What you've done is taken water from further back in the system to assess the water quality upstream. Where you have similar amounts of positivity, it means your outlets are contaminated, but importantly your pipes and your water upstream in the main water system are also contaminated. That explains why, after a few months, you had tap outlets contaminated, because if the rest of your system is contaminated and you decide to refurbish and replace components at the outlets but you're still using the same contaminated water from the main system, you will then flow that water through to your outlet and contaminate those outlets again.

Q What about the specific

numbers here that you had 33 per cent of pre-flush and then a higher number post-flush? Is that a significantly higher number that-- Is there any further conclusion that you would draw from that?

A I would leave that to a statistician. I think it's sufficient to suggest that the system is contaminated systemically.

Q By "systemically," you're basically meaning front to back?

A Correct.

Q The bottom of the page is drains and traps, u-bends, and we've addressed the reference to u-bends there, but----

A Thank you.

Q -- no indication----

A Yes, bottle traps.

Q Yes, bottle traps.

A Thank you.

Q But in your conclusion over the page-- Sorry, give me a moment to make sure I've got this right, 6.23.5. Your view here is that:

> "The drained traps contained a wide range of materials, including plastics, hair and slimy debris, gross fouling, providing nutrients and surfaces for the colonisation and growth of biofilms containing a wide range of pathogens that increase

> the risk of HAI, not just from microbial contaminated water sources but also from the drains. The contaminated drains would have resulted in the basin being contaminated either as i), bacteria from the drain were washed out the drain when the drain was occluded, or ii), when splashing occurred during the use of the sink. Splashing [as you say] would have led to retrograde contamination within a particular radius."

Can I ask, when you're talking there, you're speaking in conditional sense: "would have" resulted in contamination. Does that indicate that you're speculating there? Did you see these events occur?

A Events?

Q Events being contamination from the drains, from the traps back out.

A Let's reinterpret that. Did I see bacteria coming out or material-- black material come out of the sink units? No, I did not. I'm basing this on the interpretation of the evidence presented to me by the Inquiry that the drains were contaminated. I think some of the other areas describe black slime coming out of the drain. What I recognised personally was splashing associated with the use of a number of hand washing stations. Also – I don't know if it's an appropriate time to talk about it – where you have that

splashing either on the walls or dripping down the walls or splashing back onto the staff, but it's easier to see on the walls, you know it's going beyond the sink unit.

You also had situations that I observed where you had broken sealant behind the wash hand basins. We've talked a lot about biofilm, and we've talked a lot about water. What you would get there is a moist area behind the wash hand basin where the sealant's been broken, and you would get bacteria and mold growing in those areas, which is not a particularly good environment for high-risk patients.

Q That would be the result of splashing, as you describe it.

A Yes.

Q But does it follow that that's splashing from the drains?

A That's splashing from the sink unit as the water tap has been operated. We have evidence on a number of occasions indicating that the drains-- We talked about the bottle trap earlier, and again, back to Intertek, one of their classic reports is the evidence of a centimetre thick material and black grime within the bottle trap. Bacteria are mobile, and bacteria will transport themselves across a hydrated, moist environment from the drain to contaminate the surface of the sink, and when you get splashing, you will transmit

those bacteria into the ward environment.

Q But that depends upon material making its way from the drains outwards?

A Where you have sufficient material in the bottle trap, partly as is indicated here with the gross fouling – and one of the other ones talks about plastic materials – you will get occlusion of the drain area. Where you get occlusion of the drain area, you may get-- I'll use the word back-siphoning, but I don't think it's quite the right word. You'll get water residue within the sink area, so it's not flowing away properly, and therefore when you then turn the tap on, you've got water not flowing away properly. You'll get a greater amount of splashing, but, due to the poor occlusion and the poor draining away, you will get-- you will get almost a back-siphonage of whatever's within that bottle trap.

Q Is it too simplistic for me to say that that occlusion process that you're talking about is effectively an extension of the drain outwards?

A It's a extension of a drain outlet that has become blocked because materials and substances have been put into the drain.

Q Let me ask you a more abstract question perhaps then. In regards to what ought to be done about drains, we've heard evidence about there

being a variety of views, and one of the witnesses, Peter Hoffman, had described his view that one shouldn't attempt to clean drains because the mechanism for doing so itself was a spreader of contaminants, as recorded at page 41, my Lord, of his transcript, for reference. (To the witness) What are your views, insofar as you have any views, about how to treat drains?

A Ask two microbiologists a question, you might get two different answers. What we're describing here is a scenario where there is an increased risk to high-risk patients, one of which really we've talked about all day is about the water system. If you control the water system and you're still finding infections and you then start finding these organisms within the drain, is it acceptable to leave it like that, or should you, as professional, pragmatic, practical experts, use it again within this field of providing protection for patients-- Should you not put processes in place to remediate the drain and reduce the opportunity for microbial growth and particularly waterborne pathogens and other patient pathogens, which may have been deposited within that sink drain through inappropriate washing of medical devices?

A So, your answer now is based upon a specific event, which is that

infections, presence of pathogens and so on is being detected. My question, I think had been more abstract----

A Okay.

Q -- which is, in general, ought one to be touching drains? Do you have an answer to that question?

A I think if you're going to talk in general terms, then you can talk in general terms of the hospital, and there will be areas within that hospital where you would consider that general patients are not at risk from either the waterborne pathogens or indeed maybe from what's in the drain, but where you have high risk patients, you may wish to take view that there could be periodic, practical, planned maintenance to reduce, decontaminate-- I'll use the word "contamination" if I'm allowed to, please, of the drain.

But what we have to take into consideration is the training of staff and evidence from the healthcare infection reports that staff were depositing materials into the drains. They were cleaning tracheostomies within the drains that were taken out of patients, therefore contaminated by patient material. So what they're doing is providing additional nutrients that should not otherwise have been there. So you could take a view that you may or may not want to decontaminate the drains, but you may also want to take a view about educating

staff and training staff about the risks and putting in a longer term plan to remediate the drains.

Q Thank you. So, moving towards the end now at page 315, you reach your conclusion at 6.28 of the historical assessment of the key unsafe aspects. At paragraphs 1 and 2, you're recording some context, some reviews and findings/observations made. At 6.28.3, you state your conclusion, last two lines:

> "I've reviewed the data and evidence from when patients started to occupy QEUH and RHC. My view is that the water and waste system from the cold water storage tanks through to the taps, showers, drains and anciliary equipment was microbially contaminated with a range of waterborne pathogens from the date at which patients occupied QEUH and the RHC, and those pathogens posed a risk to the patients in the hospitals."

Now, that's a conclusion that's expressed in terms of contamination and risk. In terms of safety, which was the key question, you've answered my questions to a large extent, but as this is a conclusion of a historical section of your report, can you give a global historical view as to the safety of the water

system?

A Up to that point, then my conclusion would be that the water wasn't safe for high-risk patients. We've demonstrated a number of reasons why that was the case through lack of water safety group, lack of water safety plan, lack of the written scheme, and lack of the implementation of the remediation plans, as well demonstrated through the DMA risk assessments and the authorised persons, authorised engineers reports.

Q And just to be clear, when you're saying "up to that point," the paragraphs that we've been looking at go up to 2018/2019 but not beyond, so should I understand your answer as being up to 2019?

A Yes, because I'm assuming we're going to be touching on what happened after that and the changes that were put in place, refurbishments and continual dosing.

Q Yes. Well, you move on to that, the next page, 317. I wonder if we might, given that you've introduced it-- if you might give me your understanding of what improvements kicked in after that point.

A There was obviously recognition and many hypotheses about the water system being at fault, and therefore a number of different scenarios

and practical remediation strategies were implemented. In some cases, it was short-term dosing with biocides, and then eventually it was a continual dosing with chlorine dioxide. There was also, prior to that, the implementation of filters, point-of-use filters, on sink units within the high-risk areas, as well as the recognition from the previous DMA reports and the authorised engineers reports that there were certain areas lacking in terms of the water safety plan and the right written scheme. Many of these areas started to be addressed as we were going forward in this time period.

Q It's 7.1 that we have up here, setting out background reports of infection, results of testing and so on. There's one point within this section that I want to draw your attention to, which is 7.1.5, where you're reporting a hypothesis from Health Protection Scotland. The specific reason why I bring this up to you is if you look at the footnote. It's attributed to a report, Storrar and Rankin. I think you're aware that that is a report that you received in draft and never in fact proceeded beyond draft.

A I didn't actually know that at the time but, yes, I've learned that now.

Q It's referred to a number of times in your report----

A It is.

Q -- largely for factual reasons, but this reference here is different because, here, you're reporting a hypothesis that appears within that draft. Would you accept that a draft speculative matter, a draft hypothesis, is not something on which one ought to be placing reliance?

A That's an interesting point.

Q Well, I can perhaps make it less interesting by asking you not in the abstract, but to what extent, if any, do the conclusions in your report rely upon the hypothesis that is in that paragraph 7.1.5?

A It doesn't.

Q Thank you.

A Do you need me to explain?

Q If you can.

A You can't see what's on the next page, but the next page basically says that----

Q We'll go to the next page.

A Their conclusion is that it was B and C. Is that the next page? Okay, there may be a bit missing somewhere. I don't know why. So I think their conclusion was B and C, and-- Sorry, it's in that paragraph. I'm not reading it properly. And I wouldn't agree with that.

Q Okay.

A Because ingress contamination, as we learned-- As I demonstrated from the evidential

documents which I was given, the ingress was part of the problem with bringing the bacteria/the sediment/debris into the water system.

Q Okay. So we can safely set 7.1.5 to one side.

A Yes, thank you.

Q Thank you. Now, we did look briefly at the next page. 7.2 was about remediation strategies, and you've listed a host of them in two bullet lists. It's 7.2.4, "Physical and chemical treatments". I think we've largely covered those but, in actual fact, it may be useful if I just read them out and you can comment if you wish to. "Additional primary ultrafiltration was installed." That's an improvement?

A Correct. You really should ask an engineer, but I guess if two ultrafiltration units is good, then is three better? There must be a reason why they decided that was the case.

Q The second bullet is "Disposable shower heads and hoses." Is that good?

A Yes, very good.

Q Because?

A Because you're replacing like for like with a brand new clean unit and taking the old contaminated one away on a regular planned preventative maintenance programme.

Q So, when you mentioned, with

shower heads, the presence of biofilm, for example, regular replacement either stops or interrupts biofilm from forming. Is that right?

A Yes, and by this time they would have had point of use filter shower heads present, but you also have the potential for contamination of the outside body of the shower head, and if that's then replaced on a regular basis then it removes any potential for microbial growth on the surface of the shower head.

Q Thank you. Next bullet was "Thermal disinfection". What's meant by that?

A What's meant by that? That's starting the process of ensuring that the 60 degrees are coming from the calorifier and 55 has been returned to the calorifier. So you're maintaining these strict temperature regimes as set out in HSE guidance.

Q The next bullet is the other kind of disinfection, "Dosing treatment of parts of the water system." We've heard about that from other witnesses, but that's the chlorine dioxide program. Is that correct?

A I think they used other chemicals first as well for periodic decontamination of outlets but, yes, it's using the chemicals which they felt would reduce the microbial contamination.

Q Do you have a view on that? Is that a good thing?

A I think you have to take it in the context that we discussed that many of the outlets-- and, going back to that last metres because it may give you a picture in your mind, if that's contaminated and if they decide to disinfect it with a chemical, we also demonstrated that where you have pre- and post-contamination-- If the whole system is contaminated and you only replace the outlet, then as soon as you start flowing the water again you will get recontamination of those outlets, so that thermal disinfection, which is temporary and of an outlet, is only part of the solution for a small period of the time.

Q Okay. The next bullet should be straightforward, I think. "Increased flushing", that's a good thing?

A Yes, because you're flushing out the bacteria from the water phase.

Q The next two we've dealt with. We've got full-scale continual dosing you mentioned a moment ago. We've got cleaning and replacement of drains, and we discussed that. Then the next two bullets are removal of particular items: wash hand basins and water coolers.

A Yes.

Q Perhaps the explanation is obvious from the first narrative: to remove direct transmission risk. Presumably a good thing.

A And the shared water coolers is something I think I returned to periodically through the report and that I observed from the evidence I was presented with, and some equipment, for example the water coolers, was subcontracted, and therefore it was always someone else's responsibility, but NHS GGC had a responsibility to ensure that equipment like water coolers was maintained and there was a PPM regime in place to reduce the risk, and some of the IMT minutes demonstrate that they had to remove water coolers because they were identified as being a risk and were not being maintained.

Q Okay, thank you, and the last bullet there is "Increased water sampling" before we move on to infection prevention and control strategies, and those strategies include reducing exposure of patients to water, management of lines, provision of bottled water, increased use of single-use equipment, addition of other gram-negative microorganisms to the alert list, and the addition of water to the risk register. From your point of view, are all those measures sensible and good developments?

A Yes, they are all sensible and good, and what it demonstrates – and what I hope these two paragraphs demonstrate – is that there's no one

single strategy. No single one approach will work, that you have to take this multiple approach to ensure that you can reduce the risk for patients.

Q So, taking those all together, does that add up to a good response?

A Yes.

Q Your conclusion is slightly different emphasis here. It's your view that the extent of remedial strategies, 7.2.6, employed at the hospital provides evidence that water and wastewater systems were recognised as transmission routes for gram-negative environmental microorganisms.

A So therefore they've implemented all these control strategies.

Q Yes.

A So that's got to be good.

Q Thank you. The next two pages discuss in very brief terms or record that there were test results of various kinds. Page 319. The next sections are recording a series of test results that were brought back, running for the most part again up to 2019/2020. That goes to 7.10 on page 320. To what extent are those results running up towards 2020 or thereabouts useful to you for assessing the state of the system today?

A Sorry, which paragraph are we on?

Q All of those paragraphs. I was

attempting to sum them up----

A Page 320?

Q Yes, page 320 down to paragraph 7.10 are effectively a series of short sections whereby you're recording that particular results were obtained at particular times, those particular times being 2018, 2019, 2020.

A Sure. Okay.

Q Are those any help to us in assessing the second key question, which is what's the state of the water system today?

A Yes. I was writing from the perspective of the author, and the microbiologist is demonstrating that a much smaller amount of samples that are taken are positive for the range of gram-negative microorganisms, fungal species and Mycobacteria that we're interested in. However, from my perspective, I'm more interested in, “Where were these samples actually taken from? Were they from high-risk units?” because we can't tell from this data. It may tell us that there's a much smaller number of samples of positive, but from the perspective of the high-risk patient, what was the risk to them and where were those positives in terms of mapping them out on the floor of the hospital?

Q Okay. Thank you. I appreciate that, and maybe the section at 7.11 will give us some illumination on

that, because here you're talking about a particular ward within the children's hospital, 2A and 2B. You've drawn various conclusions over the page. Paragraph 5, here, you're saying that even the detection of low counts doesn't mean there should be complacency in terms of risk to patients because effectively there's still scope for proliferation even from those low counts. Is that correct?

A Yes.

Q The next bolded paragraph, you are giving a view when you say:

> “The lack of efficacy of chlorine dioxide dosing system reflected the extensive microbial contamination and biofilm formation that formed the hot and cold water system due to lack of servicing and PPM. Such high counts of those microorganisms indicate a potential risk to patients.”

That's presumably a bad thing.

A It demonstrates that biocides, per se, regardless of what the chemical nature of it is, is not a panacea in the control of microorganisms and biofilms and water systems. You may have heard from other experts already that products like chlorine dioxide can take many months and years, indeed, to enable the control of biofilm to be

achieved, and one of the things from my own perspective is that the implementation of strategies like this sometimes provide the staff with confidence and the knowledge that they're thinking that the water is safe because the biocide has been applied, because the point of use filter has been applied, but it's not always the case. In terms of the chlorine dioxide, we had some situations here where we were demonstrating presence of the microorganisms, and where you've got point of use filters applied, thinking everything's safe, but you've then got that drain exposure coming back into the water system.

Q You allude to that, in fact. It's two pages further on, 323 at 7.11.20, where you're actually stating perhaps much the same thing. It's your view that:

> "Risk assessments and written scheme highlighted the risk of microbiological contamination of TAP components. However, even after refurbishment and extensive biocide treatment, the inherent risks of microbiological contamination in the water system had not been sufficiently controlled. "

So, that's 2022 in wards 2A and 2B. Would you like to elaborate upon that at all?

A In the context that-- from all the bundles and all the packages that are being put in place, the hospital is a safer place in terms of the water microbiology. But what these results demonstrate is that, as I think you used the words, biocides are not a panacea, filters are not a panacea, and it's not just the water system. It's not just the drain, but it's the whole package which we were talking about earlier on about the water control strategies and the infection control strategies, including the training of staff and their understanding of the risks from the hand wash basin, the risks from the drain and the risk of them recontaminating that area through their daily practices, and therefore that training is so important.

Q So is this an example of, perhaps, things moving in the right direction but not yet to your satisfaction?

A Definitely moving in the right direction, yes, but demonstrating that-- It's not me that needs to be satisfied. It just identifies that there are areas which are not as straightforward in their control as may necessarily have been envisioned. "More challenging" I think is what I'm trying to say, in some of the areas than would have been thought.

THE CHAIR: Sorry, can you just repeat that last sentence?

A Where you're introducing a

biocide, it won't always reduce the presence of the microorganisms and reduce the biofilm to a safer level, as you would consider, because it's all about getting the biocide to where it needs to be, which is where the bacteria are, and if you've got a chemical coming through the water system, that's being lowered in concentration through the water system because it's being challenged by the presence of a similar organic carbon, and you might have started out with 0.5 ppm, but by the time you get to the tap it might only be 0.1 ppm, and therefore there's an insufficient concentration to reduce the bacterial biofilm. And we go back to the outlets and the biofilms and the planned preventative maintenance that's required, and you also have a situation of the drain, these low concentrations of biocide are unlikely to penetrate a centimeter thick sludge that's in your bottle trap.

Q Would it be a fair summary to say that we're dealing here with 2022 results from that particular ward and you're not satisfied yet that the biocides or other measures have yet sufficiently improved matters?

A It's improving it and reducing the risk, but there's always a certain amount of risk left if your biocide is not getting to where the bacteria are.

Q If we move over the page, 324, it's the same wards, para 7.12. The

same wards, but they're now 2023 test results, and it's the first paragraph you record the closure for refurbishment and reopening in March 2022, but you note that through the periods late 2022 to the start of 2023 there was water samples demonstrating sporadic presence of Pseudomonas gram-negatives and AMS:

> "A number of these positives are in water samples that had point of use water filters attached which would indicate that positive results were due to retrograde contamination which may be a result of [hand contact or washing of medical equipment or discarding down the drain]."

Now, we haven't touched upon point of use filters at all in your evidence. Is there anything you want to say about those particular pieces of kit?

A Only again in that the point of use filters are used for a very specific reason, which is to control the microbial quality of the water coming from the filter. So, there should be no microorganisms coming out of the filter because it's an absolute filter. What it doesn't do is control the water quality in the water system, so you can still have a contaminated water system but the water coming out of that filter will be appropriate for a high risk patient.

Q What would you say about whether point of use filters could or should constitute long-term solution to water system problems?

A Water systems are inherently complex. One may consider that where you have a continual dosing regime that you may be able to remove the filters because you've deemed that the water quality is now in a safer situation and you've reduced the risk to patients. But you have to consider that the biocide, as I was discussing earlier, may be quenched or reduced as it goes through the system, and there are examples of where biocide systems have stopped working for whatever reason or it's challenged within the system and so, you can't rely on just one system, either the filter or the biocide.

Q The last two paragraphs on the page are, firstly, referring to March 2023 reports, which recorded some contamination, and then at paragraph 4:

> "However, a small percentage of GNBs including Pseudomonas and atypical mycobacteria, were out of specification. So according – the authors suggested these results point to a well performing system where conditions favourable for microbial growth then there will be proliferation of these bacteria and a risk of exposure of patients to unfiltered water. "

You then draw the conclusion in the next paragraph that you still have concerns about the water system, and you refer to photographic evidence. The question I have about that-- Well, a number of questions. The first one is that when we think back to what you were saying about the 2022 results and when we look at this sentence, do we see that your concerns, which you still have, but they're of a different order to the ones you expressed in 2022?

A So, what we haven't touched on is the Mycobacteria infections that occurred in the presence of the point of use filters. As I tried to describe earlier, these filters are absolute filters. So, there's going to be no bacteria in the outlet coming out of the filter, but somehow, the patients are infected with Mycobacteria. So, those patients must have been exposed to unfiltered water within the hospital. Therefore, there is some risk. Regardless of how you look at it, there is a risk, and you cannot absolutely remove that risk, because the chlorine dioxide has implications in its use in terms of Mycobacteria may be tolerant or, in some cases, some people may describe it as being slightly resistant to the presence of these concentrations of chlorine dioxide, and if filters are in

place and patients are still becoming infected with mycobacteria, then we need to know where and how that is occurring.

Q Okay.

A Does that answer----

Q Yes.

A -- provide my concerns?

Q I'm content with that. There's perhaps a point that might be related to some of what we've discussed just now, but it arises in a different document. In your Direction 5 response, which was Bundle 27, volume 17-- No, it wasn't, sorry. The Direction 5 response itself was 21, volume 6. You may recall – and I may not need to go to it – that there was some consideration in there about a 2022 paper by Dr Inkster relating to gram-negative results from other hospitals.

A Okay.

Q Do you recall that?

A Yes.

Q If I perhaps bring up that paper directly, it's the easiest way of addressing this.

A Thank you.

Q That is Bundle 27, volume 17. I think it may be a document on its own. So, can I see the contents page of-- It will be page 19, I think.

A Yes.

Q This is a recording of Cupriavidus and other waterborne organisms in healthcare water systems

the UK, and it's a 2022 citation from the Journal of Hospital Infection. Now, the reason I bring this up is that you've mentioned-- we're directly after mentioning your concerns around what were recorded as a small percentage of gram-negative bacteria positive results. This paper, as I understand it, does a similar exercise across a number of hospitals in recording incidences of such positive results. Is that correct?

A That's my understanding, yes.

Q The fourth page, then, is the one that I'm interested in, which will be page 22, and there's a small table in the top right-hand corner, which-- do you see that is recording absolute numbers of outlets testing positive or gram-negative bacteria in hospitals at A to J? Do you see that?

A Yes.

Q Now, you may have to take my word for it, but there are 99 out-- In the column N per cent of samples testing positive for gram-negative bacteria, we have 9 out of 15 for the first hospital, 11 out of 15 for the second, and so on. You may have to take my word for it, but 99 out of the 157 samples that are recorded there were positive for gram-negative bacteria, and in most of those hospitals that is half or more of the results being recorded there.

The question is, given that you've

expressed concerns about positive results being returned at the Queen Elizabeth, would you also-- and I accept you don't know necessarily any more about those particular hospitals that are mentioned in this survey, but would you also have concerns about those hospitals on the basis of the raw numbers in this little table?

A As you mentioned yourself, I know nothing about these hospitals. We know nothing about the control strategies. We know nothing about the water systems. We know nothing about water safety groups, the water safety plans, or the written schemes. But we do know that they have a certain number of positives for these gram-negative bacteria.

Q Is that----

A But we also know, as cited within this paper, that Glasgow had a higher percentage of positives than the other hospitals.

Q We may wish to be careful about that because if you look at hospital F that's recording 19 out of 20 positives, so may not be percentage.

A There's a statement within the paper about the numbers for Glasgow, which I think is in my report.

Q Well, looking at those numbers, would you describe those as representing contamination?

A It looks like it, yes.

Q And would you say the same about Queen Elizabeth? And it's----

A From the evidence we've been provided with, yes, historically, and this was 2022. So, the work must have been carried out-- I don't know when it was published in 2022, but it would have been-- It takes some time to get papers published, so this was some time before that.

Q When you're answering those last couple of questions, are you applying the same standard to what you know about those hospitals and to the Queen Elizabeth?

A Yes, but we know nothing about water safety plans, the written schemes, the planned preventative maintenance programmes, and their medial actions undertaken at those hospitals. We know nothing about the infection rates and how they may have controlled the risk to patients. I think it basically just tells us that this is a common-- that Cupriavidus is common in water.

Q And therefore the important point, moving on from that, is that something be done to address that?

A One would like to take that inference from your water safety group, your written scheme, your water safety plan, that these strategies would have

been put in place for the control of the organisms and reducing that risk, particularly for the high-risk patients.

Q Can we move back to your main report, please, at this point? 325, we've got 7.13 on, "Risk Assessments," and I think you've observed as a concern here that the risk assessments were not being updated often enough. Is that correct?

A That was my view, yes, from the evidence provided.

Q Going on from that, you move in 327 to considering authorising engineer audits, and at that page there's a discussion of the 2020 audit, next page 2021 audit, 2022 audits at the page, and the page after that has a discussion of the 2023 audit. Now, you raise various concerns throughout those sections, but I wonder rather than looking at them individually, if I might cut through that by approaching it in a different way.

On the next page following, you record concerns arising from the 2023 audit at your paragraph at the top of the page and there relates to lack of recorded data on temperature, non-flow through expansion vessels still present. There's only annual servicing of the thermostatic valves and taps, lack of records about risk reduction and again the lack of risk assessments for other water systems. Since you finalised the report, there's

been a 2024----

A Okay.

Q -- authorising engineer report. I don't know whether you're aware of that. It will. It may help cut some of the----

A Did you-- You may have sent it. I can't (inaudible).

Q If I take you to it? It's bundle 27, volume 6. Page 252 is where the report starts and-- Oh, it appears not to be, I'm afraid. Can we try the next page, please? Can you take me back to the contents page? Sorry, I think I've got the wrong page reference. Could we move on to the next page, please, and one more? I appear to have noted the wrong page reference, I'm afraid. Excuse me a moment. Could you go back one page, please, on the index?

I wonder if I've noted down the wrong bundle number. I may have to come back to this after the break. Can I just check we're on 27, volume 6, please? We are. I apologise for this. This is an error on my part. I'll try to approach this by describing to you what the authorising engineer has concluded in 2024, and we may revisit it physically if we need to, but you may or may not recall that the 2023 report and the audit had reduced down to around nine points of concern.

A Yes.

Q You recall that. 2024 has reduced it slightly further. There are now

seven recommendations being given. Six of those are marked yellow and are largely about checking records and so on. I think that also would largely conform to your memory perhaps of the 2023 audit.

A Yes.

Q Is that correct? There's one red point which is common to both, so it's maintained from 2023 into 2024, and it relates to expansion vessels, and whether or not you recall this-- Do interrupt me if you don't recall this, because I'll go to it physically, but the recommendation there is that:

> "Flushing of non-flow through expansion vessels be initiated and recorded as soon as possible."

Do you recall that from the 2023 audit?

A Not specifically, but that-- Is there a-- Is that the only issue you want to raise from it?

Q The reason why I mention that specifically is that if you think back an hour or so to what you were telling us about expansion vessels in 2019, which were on the hot water system and you were concerned about debris, corrosion, non-flow-through nature of the vessels, potential proliferation and so on, and I think your conclusion was that that was evidence of a system that was not under proper control. Would that be correct?

A In those reports, yes.

Q If, in 2024, the recommendation was reduced to commenced flushing of the non-flow-through expansion vessels, which by now are in the cold system only, how does that compare to the concerns you're identifying in 2019?

A It's a similar issue for the expansion vessels, but what you have-- We talked a lot today about bundles and packages and multi-layers of control, and I think you mentioned yourself they've gone from X to Y in number of items identified in these authorised engineer reports, and so they've made a lot of forward gains in reducing the risk across the system, and you will always get-- When a risk assessment is undertaken, regardless of who undertakes it, you will always identify issues within the water system, and hopefully, year on year, they are reducing their risks, and why they haven't addressed that one beforehand, I don't know. Maybe you could ask someone that actual question, but they have made advancements in reducing the risks.

Q Well, perhaps setting the 2024 audit, which you haven't seen, to one side then, the pattern you're describing there, is that the pattern that you've seen from 2020, 2021, '22, into '23?

A Yes.

Q And is that demonstrating clear

progress?

A Absolutely, yes, but you have to take into consideration that from a microbiological perspective there will be opportunities, and we have to ensure that those opportunities are reduced time and time again for the growth of the microorganisms.

Q With that in mind, then, if we think back to the two key questions that we started off with-- and I've asked you key question 1 about the past over and over and you've given me answers there, but key question 2 was about the present condition of the system. Is it in a safe condition in terms of no longer presenting avoidable risk of infection? On the basis of what you have seen and learned about the system, can you answer that question as it relates to the present condition of the system?

A In the term of is it safer, then, yes, it's definitely safer. We have to take into consideration my own visits and identification of the amount of what I would call clutter round about the hand wash basins, equipment placed in front of hand wash basins, which means people would not be able to use them, so they become stagnant. Broken sealant round about hand wash basins--

So, there's always something that someone or another person will see, and from my perspective, it's-- you can

address the water system, you can address the drains as much as you can, but it also needs staff education and training – that's the staff within the ward – to understand why they're flushing because it was still through the healthcare infection reports-- healthcare inspection reports. There was still identification of a lack of flushing or a lack of understanding between staff, or should I say communication between staff as to whose responsibility it was for flushing, and then there was the tracheostomies being washed down the sink and—

So, you need to educate the staff as well, so they're not recontaminating these areas, because, again, it's all very well having your chlorine dioxide, it's all very well having your point of use filter, but if that filter is then being contaminated from a practice being carried out within the ward, then you have the potential risk for contamination of a patient.

Q Now, you've told me the system's safer than it was. The specific question is, “Is the water system safe?”

A Safer.

THE CHAIR: Sorry, what was that?

A Safer rather than safe.

THE CHAIR: From your perspective, is it ever possible to achieve a safe system?

A Mr Maciver, we've had previous discussions in the past, and I

think one of the documents I was sent was an-- apologies for not remembering the name of the new document that was produced in----

THE CHAIR: Sorry, I missed----

A So, there was a new document produced in-- There's a new document produced-- added-- developed in England this year, and it's a progressive document. It follows on from the death of patients in the Papworth Hospital through infections due to Mycobacteria, and the coroner indicated that there should be new guidance specifically for these microorganisms, and that guidance has been written to provide as safe as possible a safe environment for the patient.

So, it's taking everything we know from Legionella, everything we know from Pseudomonas, everything we know from Cupriavidus and providing the patient with a safe environment by reducing exposure to water, and this is about new units being built and new refurbished units. So, it does not apply to existing hospitals unless you're refurbishing or providing a new unit to high-- highly vulnerable patients.

THE CHAIR: Right, you seem to-- I have to say, I haven't picked up all the detail in relation to the coroner's finding, but my question was, from your perspective, is it ever possible to achieve

a safe water system? Now, you introduced the expression "safe as possible". Step one, that indicates that absolute safety is perhaps not possible. Is that right?

A Correct.

THE CHAIR: Right.

A Because, as you've, I'm sure, learned so much during this Inquiry, there are other routes apart from water.

THE CHAIR: Mm-hmm, but even just concentrating on water as a potential source of infection----

A So-- Yes, so, the only way----

THE CHAIR: You use the expression "safe as possible".

A So, the way to do that is to remove the exposure of water from the patient, and that's the scenarios which we've written into this new guidance, going forward, as the Department of Health document for refurbished or new units.

THE CHAIR: Mr Maciver, do you want perhaps to return to your question of current safety?

Q Yes, firstly, to give my understanding of the document you're referring to, that is, as I understand it, new guidance from very recently. August or September of this year?

A Correct.

Q Prepared by Public Health England that will set a----

A Department of Health, not Public Health England, excuse me.

Q That's right. The Department of Health, that will set a gold standard.

A Well, you can use whichever phrase you wish, but it's to improve safety for patients and reduce the risks of waterborne infections as far as possible.

Q So, it's the "as far as possible", "as safe as possible" language that His Lordship and myself have picked up on.

A Yes.

Q The question, and I would ask it one more time, is the system safe now?

A In the Queen Elizabeth?

Q Yes.

A It's safer, because it's not absolute.

THE CHAIR: Sorry, it is safer because there is no absolute? Just repeat that, sorry----

A It's not absolute.

THE CHAIR: I just want to pick you up correctly.

A There is no-- Because of the way the QEH is set up, you're still dealing with a live water system, you're still dealing with staff, you're still dealing with a system that's got – how many is it? – four or five outlets within each-- in each-- every single room. So, ensuring the flushing is all carried out, ensuring the PPM's all carried out, ensuring the chlorine dioxide gets to all those outlets,

ensuring the filters are changed as often as it should do for the point of use filters, for the shower hoses and the shower heads, and then all the other package of work needs to be put in place - your water safety group, your water safety plan, and the water safety group is important because it's not just nominated people coming up at meetings, and were you going to mention--

I was sent some other minutes, more water safety board meetings from the last year, and one of my main takeaway points from what-- those was that it was something between 30 and 70 per cent of the people listed in those meetings were non-attendants. So, my point is that's part and parcel of this programme of ensuring the system is safe for patients.

So, if you have a water safety board, whether it's a board or any other group, where you may have 70 per cent of the people not turning up, who is to say who the important person is on that list, and they may miss a crucial meeting.

Q What I'm taking from that is that-- I don't think I'm going to get you to budge on the question of, "Is it safe?", but am I correct in summarising your perspective as being that where you're dealing with a complex system, a water system with many variables-- Am I to understand it that you are, by

temperament or by profession or otherwise, unwilling to go so far as to pronounce a definitive view on safety?

A No, I'm saying it's safer. I cannot say-- No one can say that system is entirely safe. So, when you MOT your car, it passes MOT, something could break the next day. Does that help in any way whatsoever?

Q I think I probably shan't take that any further.

A Okay.

Q My Lord, I wouldn't have any further questions for this witness.

THE CHAIR: Right. What I need to do now is to discover whether there's any other questions in the room, as it were, Dr Walker, so we'll rise. I would hope for not more than 10 minutes so that Mr Maciver can check, as I say, whether there are any more questions.

(Short break)

THE CHAIR: I'm told four questions.

UNKNOWN SPEAKER: Sorry, (inaudible) discussing it backstage. I lost-

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MR MACIVER: It may even make it to four. The first one's not really a question, but I think I should put it to you because I was fumbling about a bit with my document reference beforehand trying to take you to Bundle 27, Volume

6. It should've been Volume 1. I'll take you there. We've got page 252 on the screen, which is the 2024, as you'll see from the box on the left-hand side, Dennis Kelly, authorising engineer audit. Could you move on, I think, to 255? These are the recommendations, the summary of actions that I was referring you to. Take a moment to cast your eye down, and you'll see if the first six yellow ones are relating to records and so on. Seventh is the expansion vessels one that I read out to you. Do you see that?

A Yes.

Q Do you have anything to add beyond what you've said already?

A Not particularly, but obviously it's been flagged as a high-risk by the authorising engineer, which is-- There are only seven action points, as you pointed out earlier, which are reduction in the previous year. Was that a red item-- I guess I can only ask, “Was that a red item in previous risk assessments as well?” So it's just, “Should it have been done before? It's been highlighted now again and, yes, it should be done within a as-soon-as-possible period.”

Q Okay, thank you. Second question is perhaps the obvious one that escaped my mind just before we closed there. I asked you a number of times about the second key question: is the system safe now? Quite clearly, you

won't go beyond “safer” on that, but you did illuminate us as to the Department of Health new guidance----

A Yes.

Q -- from this year. The language that I took from you there was that the standard was less about absolute safety than it was about as safe as possible. So the obvious question that I perhaps might have asked you before was-- Key question 2 is about is the system safe. Alternative question might have been is the system at the Queen Elizabeth as safe as possible now? What's your answer to that question?

A It's getting there but, as the risk assessment just demonstrated, issues are still being identified that need to be addressed. So you will not remove every risk and you will never remove every risk, and you will continue to have to-- your audits in place according to the regulations which are in place, whether they're the HSE, part 2, part 3, or the ACOP or the SHTMs and ensure that they're being followed, ensure that the bundles are in place, ensure that you have a functioning operative water safety group that's not just a set of nominees but people who understand water safety, people who are trained in water safety, people who understand how to put a written risk assessment and a water safety plan in place.

And then you have all the remediation strategies and testing, which is your last stop to determine whether all your control packages before that are actually working, because there could be failures at any point. I'll relate back like a broken record to that MOT description of a car. When he did his audit, Mr Kelly, he did it on a particular day. He looked at the system as it was on that particular day. We don't know what it was like the next day. So there needs to be assurance that there is a regular assessment, not only by him but by the internal teams doing their own part and their own risk assessments of their water systems, rather than waiting for a year for either DMA or Mr Kelly to come along.

Q Okay. So not as safe as possible, but it's getting there.

A It is indeed, yes.

Q Next question is alluding to point of use filters. One specific that I don't think I put to you was about high-risk groups and point of use filters. In your view, should high-risk groups like cystic fibrosis patients and so on be exposed to water in the Queen Elizabeth Hospital that doesn't have point of use filters?

A So, this is where you need to have discussions with the clinical groups-- clinical teams in understanding the risk which those patients are at, and cystic

fibrosis patients have a propensity for being infected with Pseudomonas aeruginosa. We know from the guidance which the Department of Health published in England that patients in augmented care should be protected. Cystic fibrosis is a group of patients who would be described as being in augmented care. Therefore, that would ensure, if it was in England, that the water would be tested every six months for the presence of Pseudomonas aeruginosa.

So that, as well as doing your risk assessment, complementing that with your results, and if you're getting a positive for Pseudomonas or other microorganisms which the clinical team may judge are a risk for those patients, then one would make the decision to put point of use filters on those taps.

Q The question as I put it to you, is it simply not possible for you to answer it, then, as a yes or no? Should those patients currently in the hospital be given point of use filters?

Q If the water is deemed as being a risk to those patients, then you would fit filters.

Q Are you able to take that view yourself as to whether the water is a risk requiring filters?

A If you want to remove the risk of the water to the patients, then you

would fit filters and/or you would take a different control strategy as determined by your own working practices. You remember guidance is only guidance and provides you with a number of strategies with which you can reduce the risk, and filters are only one part of that risk. So you could take the position of removing the source of the water from where the patient is.

Q Right. I shan't pursue that any further.

A In the context of-- In Holland, one of the strategies that started was identifying little used outlets, and if it's little used, it has an increased risk in terms of microbial growth and opportunities for growth, hence greater risk to the high-risk patient, and if it's little used, then one strategy would be to remove the hand wash basin, and therefore if you remove the hand wash basin there is no water exposure to the patient where the patient is. So it's not always about just a point of use filter. It's about coming up with a remedial control strategy that ensures your patients are not infected. I know that's a long-winded answer but it's not just about whether you fit point of use filters.

Q Okay. The final question I have is a hypothesis I'll put to you about whether it's possible for a strain of Stenotrophomonas, which is in biofilm in

the water system-- Would it be possible for that strain to appear in various patients over a period of months and years and for those cases to be linked, not withstanding that those patients may not have used the same tap? Very-- Oh, Lord Brodie.

THE CHAIR: Right. I think maybe, just as step 1, I need to get all the components in that hypothesis.

MR MACIVER: Allow me then to re-pose that----

THE CHAIR: So, I assume-- Right, just--

MR MACIVER: May I rephrase it as a number of questions, in that case?

THE CHAIR: Yes, okay.

MR MACIVER: First hypothesis is biofilm in the water system which has Stenotrophomonas in it, okay? Second is patients over a period of months and years. Third is that that strain of Stenotrophomonas appears in those various patients. Fourth is for those cases to be linked.

THE CHAIR: Sorry, fourth is----

MR MACIVER: For the cases to be linked.

THE CHAIR: Cases to be linked.

MR MACIVER: And the fifth is the patients have not used the same tap.

THE CHAIR: What do you mean by the cases to be linked?

A Yes, sorry, I was going to

come back to that. It's a very hypothetical situation, Mr Maciver.

THE CHAIR: Well, first of all, what is Mr Maciver's answer to the question? What do you mean by the cases to be linked?

MR MACIVER: Well, four and one are perhaps the same strain. Point 1 was the same strain of Stenotrophomonas. Point 1 was we have a strain of Stenotrophomonas somewhere in the water system in biofilm. Second is, “Is it possible for that strain to appear in various patients over months and years?” Third is those patients don't drink from the same tap or don't use the same tap. In that scenario, is it possible to say that those cases are linked?

A It's such a hypothetical situation. It's extremely difficult to answer. If you look at it in the context of whether-- Does it matter whether it's Stenotrophomonas or whether it's Cupriavidus? And are we talking today? Are we talking about 2015? Are we talking about 2018? Which hospital are we talking about? What control strategies have been put in? It's all hypothetical, and it's all possible, and you will find examples in the scientific literature where Stenotrophomonas has been identified in the hospital and the same strains/isolates have been linked to patients. But to ask that question in the

context of where we are today, it's an extremely difficult question to answer without all the background, without the control strategies and who's investigating it. Are they taking samples from the tap, the location where the patient is at the same time the patient was there, and are they taking the right sample and using the right techniques to determine whether it's linked?

I know I'm straying away from the question, but it's a very difficult question to answer in the context of a yes or no, and I think that's why I started saying there will be evidence in the literature demonstrating cases of Stenotrophomonas in hospital units which have been linked. Is there more to the question you want to give me or----

THE CHAIR: Mr Maciver, if this question is thought to be important by the person who asked you to ask it, I think I'd be open to giving the person who asked you to ask it the opportunity to formulate the question in their preferred way. Now, my guess is that it may be Ms Watt, and therefore if she sees this as an important question, point one, and if she's willing to pose it, I would invite her to join us and ask the question.

MS WATTS: Good afternoon. What I'll do is I'll try and approach it from a slightly different direction. So, if it were to be suggested that two cases of

Stenotrophomonas could not both have come from the water and not from a common source in biofilm if the patients didn't use the same tap, would you agree with that or disagree?

A Gosh.

THE CHAIR: It might depend where the biofilm was.

A It may not actually be a situation of agreeing or disagreeing, but if we go back to a hypothetical scenario of a hospital water system where the microbiology is not controlled, where you have extensive biofilm throughout that hospital, you will have various strains throughout the hot and the cold water system associated with different components. You will have, as we found in Northern Ireland-- We have multiple isolates recovered from, let's call it, the outlet fitting which don't match to the patient necessarily at the time the sample was taken, but you may have one isolate that is identified as being similar to the patient. It doesn't mean that that same isolate isn't present in other parts of the hospital.

MS WATTS: Okay. Can I ask a follow-up question, my Lord? Thank you. I think what I'm taking from that, then, is that if there is a strain of Stenotrophomonas that's present in biofilm somewhere in the hospital, then that might be capable of causing

infections from more than one outlet. Is that correct?

A Yes, and if you look at the evidence which we have based on Cupriavidus and the other organisms from many, many different parts of the hospitals, then it would be potential for a patient to be exposed at different points within the hospital. The Mycobacteria may be a good example of that where, even though filters were in place, the patients were exposed to unfiltered water, regardless of how that occurred.

Q Okay.

A I can't remember the exact locations of where those individual patients were within the hospital.

Q Okay. That's very helpful from my perspective, my Lord, and I think that answers my question. I'm grateful for the opportunity. Thank you.

THE CHAIR: Thank you. Right. Have we got to the end of your four questions?

MR MACIVER: That's that, my Lord.

THE CHAIR: Right. Dr Walker, thank you for your attendance today, thank you for your attendance beyond our normal time of sitting and thank you for your report. You're now free to go, but with the thanks of the Inquiry. Thank you.

THE WITNESS: Thank you, Lord Brodie. Thank you, Mr Maciver and your colleagues. Thank you.

THE CHAIR: And thank you to the legal representatives who are still with us. Now, we sit again, I think, tomorrow at 10 o'clock. I think it's Mr Connal. Am I right?

MR MACIVER: It's Mr Connal with Mr Poplett.

THE CHAIR: Right, and the topic is back to ventilation.

MR MACIVER: It is.

THE CHAIR: Right. Well, we shall see each other tomorrow.

(Session ends)