Akhaja, Jagdish

From: Douglas Maxwell [redacted]
Sent: 04 November 2014 16:33
To: Planning; Markwell, Jonathan
Cc: 'HUTCHINSON, Marc'; 'David Castle'; 'Gordon Maclean'
Subject: Application 2014/4332/P - OBJECTION
Attachments: hs1174 113 ATKINS Interim QRA Report Response - 7 11 13.doc; hs1161a Interim QRA on current dams 28.8.13 HHS FINAL REVISION A Response to Atkins Additional Comments 7.11.13.doc

Importance: High

To: London Borough of Camden

For the attention of Jonathan Markwell

Ponds Project Planning Application No 2014/4332/P

Additional Documents relating to the Applicant's Quantitative Risk Assessment (QRA)

We refer to our objection to this planning application dated 6 August 2014 and supplementary objection dated 12 September 2014. We understand that you have now appointed AECOM, Reservoir Panel Engineers, to review the application and report to you. We have recently been told that AECOM has queried aspects of the applicant's QRA, and that an updated QRA is now being prepared by the applicant.

The Society also had significant queries and concerns on this QRA and submitted these to the City of London on 23 September 2013. We received in reply a 'Quantitative Risk Assessment Interim Report – additional comments for Stakeholders', Rev 2, 7th November 2013 (attached as **hs1174** above), but this failed to answer any of our queries. We therefore replied on 15 November 2013 both with further queries and with a schedule of our previous unanswered queries (attached as **hs1161a** above). To our regret, both the City of London and Atkins then declined to answer any of our questions and concerns.

We would therefore be grateful if you would refer both this message and our two attachments to AECOM for their consideration.

Regards

Douglas Maxwell
The Heath & Hampstead Society

E [redacted]

HHPP: Quantitative Risk Assessment on Current Dams
Draft Interim Report Rev 5.0 dated 29.8.13

Reply by the Heath & Hampstead Society to Atkins 'Additional Comments for Stakeholders'

JW / hs1161a / Revision A/ 15.11.2013

WITHOUT PREJUDICE

The Society thanks Atkins for their paper 'Quantitative Risk Assessment Interim Report – additional comments for Stakeholders', Rev 2, 7th November 2013. This was forwarded to Stakeholders on 8 November with the explanation *In response to queries raised by the Heath & Hampstead Society in relation to the interim QRA, Atkins have prepared the attached response named 113 Interim QRA Report Response – 7 11 13*

However, we much regret that this general paper fails to answer any of the queries that we submitted on 23 September 2013. It also provides information that we believe is misleading and factually wrong. As this QRA on the current dams is the first detailed explanation to Stakeholders of the possible risks of the dams that might justify the HH Ponds Project, we regard it essential that these items are clarified, and that a corrected and realistic QRA be produced urgently.

Reading down the Atkins report, (paragraphs and pages are not numbered), we extract and comment on various statements below. We then itemise our original questions that have not been answered

We now request that a detailed answer to each of our queries submitted in September, and to the additional points raised in our response below, be provided to us no later than 22 November.

HHS response to Atkins 'Additional Comments'

Overtopping

1. The probabilities of failure for overtopping presented in Table 4.3 are individual probabilities of failure for each pond due to embankment overtopping experienced at the particular pond for the full range of flood events, and without any breaching of the other ponds. For example, Bird Sanctuary will start to overtop in a 1 in 50 year flood event, whereas Highgate No. 1 will only start to overtop in a 1 in 10,000 year event (as shown in Table 4.2). This vast difference leads to the difference in probabilities of failure for these two ponds from overtopping. We accept that overtopping is by far the most likely failure mode, and that overtopping frequency may be broadly as shown in Table 4.2, (but subject to our original unanswered queries). **However, we assert that Table 4.3 – Overtopping Probabilities of Failure is wildly incorrect and presents a completely unrealistic assessment of the probabilities of dam failure.** This is because the physical properties of individual dams have not been taken into account, but Atkins has applied a single extremely conservative overtopping failure relationship model to every one of the dams – see point 3 below. This leads to conclusions that are the exact reverse of reality

   For example, ignoring the Stock Pond, Atkins in Table 4.3 suggests that the most probable dams to fail are the Bird Sanctuary dam on the Highgate Chain, and the Mixed Bathing dam on the Hampstead Chain. **However, the 'Peer Review' by the respected dam engineers AECOM 2010 on page 10 states the exact opposite, based on practical observation:** *There are also two dams (Bird Sanctuary and Mixed Bathing) that appear to pose low risk* [of breaching] *by virtue of their abnormally high width in relation to their low height.* Table 4.3 is therefore discredited. This Table and all the conclusions that stem from it should therefore be repeated using realistic data.

2. The actual durations of overtopping that would be considered to have the potential to cause embankment erosion are much less than that presented in Table 4.2. We will update the durations in Table 4.2 to reflect the duration of overtopping that could cause the embankment significant erosion. Not only have the probabilities of dam failure been based on an unrealistic physical model, but it appears that the assumed durations and velocities of overtopping have been significantly overstated. We urge that an updated Table 4.2 be issued urgently, and then dam failure probabilities be recalculated.

3. In order to estimate the probability of failure of the embankments from overtopping we have developed a single relationship of overtopping depth, duration and velocity verses the potential for erosion leading to embankment failure. This is a simplification however the information required to allow a detailed assessment of the potential for each pond embankment to fail as a result of overtopping is not available. This is not correct. Information on each dam is readily available and should be used to give realistic results. Full physical information on each dam was presented by Haycock in his 2011 and earlier reports. Atkins Supervising Engineer inspects and reports on each dam on a 6 monthly basis, and is well aware of and reports on vegetation, grass cover and other factors.

4. .....a probability of 1 is only assigned if these conditions are present, which is only the case for overtopping of Stock Pond during a PMF event. For all other situations we have assigned a probability of failure based on the developed relationship and these are all less than one, **indicating that failure is not certain.** We note that, even using the unrealistic relationship, failure is not certain on any dams apart from the Stock Pond. We also note that Atkins has however assumed every dam on both chains will fail at the same time, and that this unrealistic assumption is the basis for the published Average Societal Loss of Life (ASLL) of 1414 persons.

ASLL (Average Societal Loss of Life)

5. The Average Societal Loss of Life (ASLL) has been calculated for the PMF event without breach of the ponds and with breach of all the ponds as 1095 and 1414, respectively, for both pond chains combined. The 'incremental' ASLL of the ponds breaching could then be considered 319. The City has no responsibility for and little control over the 1095 predicted deaths due to run-off, dam overtopping and surcharge of inadequate sewers downstream. It has a statutory responsibility to try to prevent the 319 'residual' deaths only, which might arise from the dams breaching, and this alone is the main purpose of this project.

6. On consideration of the above and the high ASLL obtained from the breach modelling, the large number of people within the downstream flood extent, the large number of basements in Camden, and the potential for destruction or flooding of road, underground and rail infrastructure, it is clear that the Hampstead Heath Ponds will be considered High Risk. We agree that the Environment Agency will categorise the Heath dams as 'High Risk'. This means only that they will be covered by the full requirements of the Reservoir Act 1975 in respect of supervision and inspection etc. This Act has nothing to do with design, which is left to the Supervising and Inspection Engineers, who may make recommendations *in the interests of safety.* This term is not defined in the Act.

Warning Time

7. A recent request to the Met Office to give the City warning of severe storms and particularly those of a 'convection' type confirmed that the Met Office could not guarantee such a storm could be 'predicted' or any 'warning' given to the City. We assert that the Met Office can give warnings of more frequent severe storms up to 4-5 days ahead, and that these will be progressively refined as the storm approaches. However, we agree that the Met Office may not be able to predict the most severe and remote 'stationary convection' type storms of the type experienced in 1975. These storms are typically of an annual probability of 1:10,000 years to the PMF (Probable Maximum Flood), which is calculated by Atkins for this project as an annual probability of 1:400,000 years. Warning of these will adequately be given in another way, as well described by the City in their report on the 'Preferred Options' to the Consultative Committee meeting on 12 November 2013, para 27, which states: -

In January 2012 the Stakeholder Group received a presentation from Thames Water who advised that the flood alleviation scheme installed under the Heath in the 1990's was only designed to accommodate a 1:70 year storm, this is significantly less than the design standards required to 'virtually eliminate' the risk of dam failure. If the PMF event were to occur in this

part of London ***then the sewer system would already be operating at capacity with sewers surcharging water.***

This is exactly what happened in the 1975 storm, described by Haycock in his detailed 2011 report of this event as *the most severe storm event ever recorded in London....The water flowing off Hampstead Heath has been described as 'waterfalls'... The sewers were surcharged with roads becoming 'rivers'...Residents experienced their houses flooded by 5 ft of water for over two hours as the storm passed and many experienced flooding and damage only five minutes after the heavy rainfall started which emphasises the sudden nature of the flooding.* None of this flooding had anything to do with the Heath dams, and neither of the bottom dams on each chain even overtopped. The Heath dams are now being designed for a PMF rainfall depth almost 40% higher than in 1975, which is assumed to fall uniformly over the entire Heath. The downstream community, the Emergency Services, Camden, and the City staff will thus be well warned of a severe storm as residents will be flooded by discharge from inadequate sewers almost from its onset. Table A.2 in the QRA indicates that the lowest dams on each chain may not start to breach until more than 6 hours from the onset of the PMF storm. **There will thus be more than adequate warning of such a storm hours before there is any risk of dam breach. We therefore request that the QRA be recalculated on the basis of 'Warning'.** Haycock / CARES QRA in 2009 showed that warning could reduce ASLL to 10% of that calculated for no warning. This implies that the ASLL on the current dams could reduce to approx 110 deaths due to run-off and overtopping, - for which the City has no statutory responsibility and little control. It is quite possible that no deaths might arise due to dam breach – which is the focus of the proposed project – as appropriate warnings will have been given and acted upon hours before the event, should it happen.

8. Atkins lists, as below, 11 steps they suggest would have to be taken before a warning could be given. These appear to have been produced mainly to give the impression that warning is not practical, rather than give a coherent plan of action. We regard this list as utterly disingenuous and completely irrelevant because, as indicated above, severe downstream sewer flooding would have occurred hours beforehand and evacuation would by then be well underway to **an evacuation plan that should already have been prepared by LB Camden, under its responsibilities of the Civil Contingencies Act 2004.**

   In order to correctly identify that there is an imminent risk of failure of one or more of the ponds, which would then trigger the emergency services to undertake evacuation, the following steps would probably be required:

   1. Site staff on site and aware of situation (maybe middle of the night) or meteorological monitoring system gives warning.
   2. Site staff watch to see how situation develops.
   3. Site staff decide situation is getting 'serious'.
   4. Supervising Engineer (SE) informed of high water levels alarms in ponds.
   5. SE contacts All Reservoir Panel Engineer (ARPE) and describes situation and risk.
   6. ARPE and SE travel to site.
   7. ARPE / SE visually assess situation and obtain information from operators as to the extent of the flood event and likelihood of escalation of the situation.
   8. ARPE determines whether risk can be reduced by any physical means, e.g., clearance of blockage, redirecting inflows or excavating an emergency spillway.
   9. ARPE uses all the information available to assess the risk of failure of the dams and likely timeframe.
   10. ARPE discusses the situation with the Police and determines next steps in relation to potential evacuation of downstream residents; how to evacuate, who to evacuate, etc.
   11. Situation escalates and decision made to begin evacuation.

   The above process has many steps and will take time to progress through these even if the threat is assessed to be very high from the start of the process.

   We also comment that under RA 1975 a Supervising Engineer must be appointed to supervise the operation and maintenance of the reservoir and produce an annual statement. On the Heath, Dr Hughes from Atkins is the SE, and he inspects, tests and reports on all the dams on a 6 monthly basis. Operational advice during a PMF flood incident is amongst the duties of a SE and there is no necessity to delay his advice by involving an All Reservoir Panel Engineer, as

indicated in steps 5 to 10 above. Dr Hughes is, however, an ARPE in his own right, and this has not been mentioned. We therefore query why these 11 steps have been made unecessarily complicated, other than to try to substantiate that a warning could not be given in time.

9. In addition, it is likely that in an imminent failure situation neither the City of London staff, or indeed the Police, will be allowed to enter the area of potential inundation.
   Thus warning times cannot be used to reduce the impact of the situation.

   We disagree with the above statement, as the Emergency Services will have already been working for some hours in the flooded area, as they were in the 1975 event when 2,000 calls were made to them. The additional water released by a possible dam breach which begins 1 hour after the start of overtopping of each pond embankment and it then takes 1.5 hours for the full embankment breach to development.will probably not make the situation materialy more serious than that already being dealt with.

Preliminary Comments submitted by the Society that remain unanswered

The Society submitted, on 23 September 2013, some initial queries on the QRA report. However, as this Report was more a summary overview, with little of the calculations/data/maps etc being presented; further information is required for a proper assessment. We therefore reserved the right to submit further queries after the presentation made on 27 September, and after requested further information has been presented.

However, we regret that the recently submitted 'Additional Comments' by Atkins fail to answer any of our queries that we submitted on 23 September. We therefore request that answers to each query be provided to us no later than Friday 22 November.

These queries are:-

1. Table 4.2 p.5: It is not possible to assess without hydrographs. What is the relationship of peak velocity and maximum depth with duration? Please provide PMF hydrographs for all ponds
2. Table 4.2 p.5: Please explain why Highgate durations on 1:1,000 are longer than 1:10,000
3. Table 4.2 p.5: Please explain why some 1:10,000 durations on both chains are longer than the equivalent PMF durations
4. Para 4.5 and Table 4.1: Are these results based on an assessment for each dam individually?
5. Para 4.11: What duration causes *that failure would definitely occur if 0.6m* overtopped? We note that none of the dams reach this level
6. Para 4.12: We note that you have assumed a single extremely conservative probability of one overtopping failure relationship model to be applied to every one of the dams, rather than develop a specific model for each individual dam. Please demonstrate that this assumption is valid. For example, please inform us which two current dams you consider to be the least robust, and which two are the most robust, and then demonstrate that your model would reasonably represent the failure of these dams. Would this be indicated by 4 more curves on Figure 4.1?
7. Para 4.13 and Figure 4.1, p. 7: Duration of overtopping is a key aspect in failure [see Para 4.11]. Please therefore explain how duration is taken into account in Para 4.13 and Figure 4.1
8. Para 4.14: Please provide Table 3.2
9. Table 4.3, p.8: We are puzzled by this table, [for Overtopping Probabilities of Failure, which appears to be on an individual pond overtopping basis, not a cascade failure basis] and would welcome detailed explanations. For example, it appears that the Bird dam is far more likely to fail, by c. 3 orders of magnitude, than Highgate No 1 dam. Similarly, the Mixed Pond dam appears far more likely to fail than the Vale of Health pond dam, etc. Please substantiate.

10. Para 4.21 and Table 4.4: Are these results based on an assessment for each dam individually?
11. Paras 4.23, 4.24 and Table 4.5: These indicate that overtopping failure *is by far the greatest threat to the ponds by several orders of magnitude*. Please therefore substantiate why, as stated in Para 4.12, your adoption of one probability of overtopping failure relationship model to be applied to every dam is appropriate, rather than developing individual models for each dam.
12. Paras 4.26, 4.27: These state that failure of one dam will cause failure of all downstream dams, and a total cascade failure of all Highgate dams is assumed. Please substantiate that this would occur.
13. Paras 4.29, 4.30: A total cascade failure of all Hampstead dams is assumed. Please substantiate that this would occur.
14. Overtopping depths are shown in Table 4.2, p. 5, for both chains without dam breach. If there is a progressive cascade failure of all dams, what additional depth of overtopping would occur on each dam and what is the probability of this occurring.
15. Para 5.3: We note that ASLL is based on 'no warning'. We are puzzled at the mention of 41.4 minutes as the maximum warning time based on a suggestion by Haycock to empty the ponds before a storm. This suggestion has not been adopted on the current design and hence appears irrelevant, yet this being used to substantiate that there is insufficient time to give warnings downstream. Please clarify this, taking into account the times available as indicated in Para A13 and Table A.2
16. Please calculate ASLL based on the recommended minimum of 2 hours warning
17. Figure 5.1 p.12: This shows a line showing the reduction in LLOL with 60 mins warning. Please show the line for 2 hours warning
18. Paras 5.4 and 5.5: We note that both CARES in 2009 and Haycock in 2011 produced detailed inundation maps for PMF cascade failure which were similar to the EA inundation maps. The Design PMF for the current project is significantly reduced. Please produce your inundation maps for the current project for PMF Overtopping and PMF Breach, which presumably exist in order to produce Table 5.1.
19. Para 5.4: Please substantiate that Kings Cross and St Pancras stations etc are *within the risk area.* We note that Figure A.1, p.22, shows a Schematic Boundary Area included in the hydraulic model that includes these stations and is extended to the River Thames, but para A8 implies that this is only assumed for the benefit of the 1D-2D modelling, and so does not necessarily show the predicted inundation area.
20. Tables 5.2 and 5.3, p.13/14: Please clarify the basis for these tables. Do they assume cascade failure of all dams on both Highgate and Hampstead chains simultaneously, and do they present the totals for both chains combined? If so, please present the totals for each chain separately.
21. If Table 5.3 shows the combined ASLL on both chains due to all dams breaching under a PMF as 1,414, please explain why Tables 5.4/5.5 show ASLL for all dams breaching under 1:100 year storm as 1,244 and 1,271 [Highgate and Hampstead respectively] leading to a combined ASLL of 2,515, and where there is little overlap of the catchments.
22. Para 5.13 and Table 5.4, p. 14: Please substantiate that a 'sunny day slope stability failure' of the Stock pond [ie. no rain, releasing Stock pond contents only] would lead to a cascade collapse of the entire Highgate chain. What is the stored volume in the Stock pond under no rain conditions, and what depth/duration/velocity would it produce at the Ladies Pond dam?
23. Para 5.13 and Table 5.5, p. 14/15: Please substantiate that a 'sunny day slope stability failure' of the Stock pond [ie. no rain, releasing Vale of Health pond contents only] would lead to a cascade collapse of the entire Hampstead chain. What is the stored volume in the Vale of Health pond under no rain conditions, and what depth/duration/velocity would it produce at the Mixed Pond dam??

24. Para 6.4: This para quotes figures apparently calculated in Sections 4 and 5. Please identify these, as we cannot locate them.
25. What is the least remote return probability [ie. the smallest storm] at which the current dams on either chain would cause fatalities from i) any embankment or embankments overtopping and ii) any dam or dams' collapse?
26. Is Atkins in a position to provide, if requested, the full software codes of the computer programme or programmes they use for any of their design calculations together with assumption inputs and technical algorithms, as we understand these are owned by third parties?

Hampstead Heath Ponds Project

QUANTITATIVE RISK ASSESSMENT INTERIM REPORT – ADDITIONAL COMMENTS FOR STAKEHOLDERS

Rev 2, 7th November 2013

Overtopping

The probabilities of failure for overtopping presented in Table 4.3 are individual probabilities of failure for each pond due to embankment overtopping experienced at the particular pond for the full range of flood events, and without any breaching of the other ponds. For example, Bird Sanctuary will start to overtop in a 1 in 50 year flood event, whereas Highgate No. 1 will only start to overtop in a 1 in 10,000 year event (as shown in Table 4.2). This vast difference leads to the difference in probabilities of failure for these two ponds from overtopping. In reality a storm is likely to affect the whole chain but the overflows will dictate, for a particular event, whether overtopping will occur.

As overtopping failure is by far the most likely failure mode it contributes, almost solely, to the overall probability of failure from all failure modes. This is highlighted by the fact that the probability of failure of Bird Sanctuary by overtopping in Table 4.3 is the same as the probability of failure from all failure modes presented in Table 4.5.

The durations identified in Table 4.2 relate to the duration of overtopping of the actual pond embankments. The durations indicated are calculated by the hydraulic model and include the full length of time that the embankments are overtopped, even if this is only by an extremely small amount, from the commencement to the end. This can happen when the pond is full following the overtopping event and if a small lower section of embankment exists the model will assume water is still trickling over this section for some time. This is the case for some of the ponds for some of the modelled flood events where the embankment overtopping hydrographs have a long duration due to very minor amounts of overtopping which would not be considered high enough to cause erosion of the embankments. As such the actual durations of overtopping that would be considered to have the potential to cause embankment erosion are much less than that presented in Table 4.2. We will update the durations in Table 4.2 to reflect the duration of overtopping that could cause the embankment significant erosion.

In order to estimate the probability of failure of the embankments from overtopping we have developed a single relationship of overtopping depth, duration and velocity verses the potential for erosion leading to embankment failure. This is a simplification however the information required to allow a detailed assessment of the potential for each pond embankment to fail as a result of overtopping is not available. Even if more information was available the probability of erosion and failure can depend on so many variables, such as grass cover condition in various seasons, location of trees on the embankment, the undulating embankment slopes, etc, that it would be difficult to apply a definitive relationship. However, the general industry accepted guidance indicates that if an embankment in a reasonable condition with reasonable grass cover were to experience overtopping of around 0.5m depth with velocities near 5m/s and for a duration of 2 hours or more, failure is almost certain to occur. This is the basis of the relationship developed for our assessment and a probability of 1 is only assigned if these conditions are present, which

is only the case for overtopping of Stock Pond during a PMF event. For all other situations we have assigned a probability of failure based on the developed relationship and these are all less than one, indicating that failure is not certain.

Breach

For the breach modelling we have assumed that the breaching begins 1 hour after the start of overtopping of each pond embankment and it then takes 1.5 hours for the full embankment breach to development. This is based on best practice, experience and judgement. This then filters down the cascade of ponds and the modelled breach timings are therefore a function of the overtopping start time for each dam, as calculated by the model.

ASLL

The Average Societal Loss of Life (ASLL) has been calculated for the PMF event without breach of the ponds and with breach of all the ponds as 1095 and 1414, respectively, for both pond chains combined. The 'incremental' ASLL of the ponds breaching could then be considered 319. This value is extremely high, particularly when considering the requirement of the recently implemented part of the Floods and Water Management Act, 2010, which considers high risk reservoirs to be those which endanger the life of at least one person. This is further described in the Reservoir Risk Designation Guidance (Environment Agency, August 2013) recently published by the Environment Agency which states:

"The Environment Agency have decided that human life could be endangered if the following thresholds are exceeded:

a) *the likely loss of life is calculated to be greater than or equal to one*
b) *in the case of individual properties, the rate of water flow is greater than or equal to $3m^3/s/m$. A value of $3m^3/s/m$ is considered to represent the threshold at which structural damage to properties is expected to begin*
c) *the likely loss of life is calculated to be between 0.8 and 1 and there is a significant population at risk of flooding downstream. A 'significant population at risk of flooding downstream' will normally be considered by the Environment Agency to be wherever there are more than 200 people or 20 businesses within the downstream flood extent. However, there may be circumstances when the Environment Agency chooses to apply the precautionary principle where there are less than 200 people or 20 businesses. Examples of residential, business or recreational areas include, but are not limited to: houses, flats, hospitals, prisons, offices, warehouses, permanent caravan parks, caravan and camping sites, places of work, sporting venues, places of worship and parks.*

The Environment Agency will also consider damage to infrastructure from an uncontrolled release of water where it could lead to direct loss of life. For example, the destruction of a chemical works leading to the release of hazardous substances, or the destruction or flooding of road and rail infrastructure. Indirect loss of life as a result of infrastructure damage (such as a death from hypothermia through inundation of an electricity sub-station which causes power loss) is excluded and not considered."

On consideration of the above and the high ASLL obtained from the breach modelling, the large number of people within the downstream flood extent, the large number of

basements in Camden, and the potential for destruction or flooding of road, underground and rail infrastructure, it is clear that the Hampstead Heath Ponds will be considered High Risk.

The incremental ASLL has not been calculated for each of the cascade breach scenarios provided in the report. However, as the ASLL figures for each of the scenarios are similar to the value obtained for breach of all ponds on both chains the incremental ASLL would also be similar and well above the threshold of the loss of life of at least one person.

Warning Time

When a storm occurs an engineer cannot predict whether the event will lead to failure of one or more of the ponds. There are many variables including floating debris, blockage of spillway, fracture of pipes, human mistakes as well as the uncertainty associated with the hydrological events and the hydraulic performance of the system.

A recent request to the Met Office to give the City warning of severe storms and particularly those of a 'convection' type confirmed that the Met Office could not guarantee such a storm could be 'predicted' or any 'warning' given to the City.

In order to correctly identify that there is an imminent risk of failure of one or more of the ponds, which would then trigger the emergency services to undertake evacuation, the following steps would probably be required:

1. Site staff on site and aware of situation (maybe middle of the night) or meteorological monitoring system gives warning.
2. Site staff watch to see how situation develops.
3. Site staff decide situation is getting 'serious'.
4. Supervising Engineer (SE) informed of high water levels alarms in ponds.
5. SE contacts All Reservoir Panel Engineer (ARPE) and describes situation and risk.
6. ARPE and SE travel to site.
7. ARPE / SE visually assess situation and obtain information from operators as to the extent of the flood event and likelihood of escalation of the situation.
8. ARPE determines whether risk can be reduced by any physical means, e.g., clearance of blockage, redirecting inflows or excavating an emergency spillway.
9. ARPE uses all the information available to assess the risk of failure of the dams and likely timeframe.
10. ARPE discusses the situation with the Police and determines next steps in relation to potential evacuation of downstream residents; how to evacuate, who to evacuate, etc.
11. Situation escalates and decision made to begin evacuation.

The above process has many steps and will take time to progress through these even if the threat is assessed to be very high from the start of the process. The ARPE needs to be certain that imminent failure is likely and there is a real risk that lives could be put at danger in order to make the decision which will involve a huge amount of resources. This decision will be made all the more difficult given the close proximity of the ponds to Central London and the sheer size and scale of the evacuation requirements including evacuation of the underground and mainline stations. Early, unnecessary evacuation has to be balanced against the public losing confidence in the safety management of the site.

By the time the above steps have taken place, and the decision has been made to evacuate, it is likely that the warning time, from the time of the evacuation decision to failure of the ponds, would be minimal, and almost certainly less than the time required to make a significant difference to the number of people at risk downstream of the Hampstead Heath Ponds.

The new Guide to Risk Assessment for Reservoir Safety Management (RARS) published in March 2013 by the Environment Agency / DEFRA, states the following in relation to warning times:

"In estimating the base case highest individual risk and average societal life loss it should be assumed that there is generally no warning. The exception is where the population at risk is well downstream of the dam with an intervening community where it may be reasonable to assume that the alarm would be raised once the flood wave had passed the first community and that the population downstream would be warned (allowing a reasonable time for the authorities to receive the alarm and issue warnings). Where allowance is made for some warning this should be stated in the impact assessment for the dam. It is considered unlikely that in the UK context any effective warning would be given".

It is to be noted that the above paragraph is also included in Supplement No. 1 to Interim Guide to Quantitative Risk Assessment for UK Reservoirs (DEFRA, May 2006) however in this document the last paragraph is different and reads *"It is considered unlikely that any effective warning would be given unless there was at least two hours travel time for the flood wave after the alarm had been raised".* This is where the statement provided in the CARES report *"warning is considered to only be effective if there is at least 2 hours between the dam failure and the flood wave reaching the affected area"* was based on. Our assessment of no warning time is based on the recommendation of the more recent guidance provided in the RARS document and the fact that there is a very short travel time for a flood wave into Camden.

In addition, it is likely that in an imminent failure situation neither the City of London staff, or indeed the Police, will be allowed to enter the area of potential inundation.

Thus warning times cannot be used to reduce the impact of the situation.