



HAYCOCK ENVIRONMENTAL CONSULTANTS LIMITED

Independent Hydrologist and Waterscape Consultants

Highgate School - MSC - Phase 2a and 2b - HGY/2023/0338 - Review of BIA, FRA, SUDs and implications of the proposed development for the adjoining owners in Broadlands Road

Client

Broadlands Road (Client Group)

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Date

15th June 2023

Version

2.05

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Non-technical Executive Summary

In the following report we have reviewed a range of documents on the hydrology and hydrogeology of the proposed MSC redevelopment (phase 2a and 2b) including the proposed Oval Sports Basin which is to operate as a flood attenuation basin, namely store flood water to protect the MSC.

The summary comments below highlight key concerns with the current hydrology information submitted by the applicant for the proposed MSC redevelopment. The applicant's submitted documentation regarding the hydrology of the site are currently disjointed, contradictory and missing critical information on the water engineering safety of the proposed works. In relation to the client group that commissioned this review (residents on the south side of Broadlands Road, numbers 27-17), there is insufficient information to determine the risk to their properties.

At the end of this report we have listed key reports and/or assessments that should be undertaken to determine the viability of these proposals and therefore enable an initial assessment of the hydrological risk to our clients properties on the south side of Broadlands Road.

- (1) The Oval Sports Basin is proposed to store a large volume of floodwater above the natural ground level and in effect it will act as a reservoir with an associated dam (western side of the basin). The modelled flood water level is stated as being 109.00mAOD, over 2m higher than the ground level of Number 27 Broadlands Road. The stored water volume is not stated but it likely to exceed 3 000 000 litres. The design and strength of the dam has not been documented. The operation of the dam, namely the design and capacity of the overflow structures, has not been documented. The overtopping of the dam in floods greater than the design events has not been modelled, which by implication means that the safety of the dam from water erosion has not been assessed. Should the dam fail, then the implications for the users of the MSC and residents generally, but specifically on Broadlands Road, will be profound.
- (2) The Oval Sports Basin will be part excavated into the Claygate geology but there are no ground investigations for this structure and the associated excavation works. The known groundwater lenses in the Claygate geology in this area have not been reviewed. The impact of the excavation on the groundwater lenses has not been reviewed in terms of the groundwater that may drain into the Oval Sports Basin nor the impact on the wider area should the hydro-geology of these lenses be changed. Wider impacts may include serious impacts on tree health within the applicant's property (including the wooded area) as well as the gardens of Broadlands Road.
- (3) The MSC redevelopment and its associated Basement Impact Assessment (BIA) currently contradicts the applicant's Flood Risk Assessment, Surface Water Flood Modelling Report and the Drainage and SUDs report. The BIA does not include geotechnical reports as generated by Soil Consultants Limited and it appears that the BIA has misclassified / misquoted the geology of the area and therefore the BIA is factually incorrect regarding the core geological classification for the site. The BIA is based on a very limited set of borehole records. The report has not reviewed local borehole records as published by the British Geological Survey. Neither has it reviewed borehole data submitted to the Council regarding other planning applications local to the proposed MSC and the Oval Sports Basin. The BIA has only considered the MSC redevelopment and not reviewed the Oval Sports Basin which will potentially disrupt

groundwater movement in the wider area of the proposed development. Because of the contradictions between the BIA and other applicant hydrology reports and, critically, the lack of a conceptual ground model for the MSC and the Oval Sports Basin, we would suggest that the BIA is not fit for purpose. The BIA needs to be supported by more extensive data to assess the groundwater impact on the proposed development together with the impact on the wider area, notably Broadlands Road.

- (4) The potential changes to the hydrology of the site have not been assessed by the applicant's Ecology and Arboriculture report. The complete lack of information on the geology associated with the excavation and formation of the Oval Sports Basin means that the risk to the known groundwater lenses within the Claygate geology has not been addressed and therefore the flood and drought stress on the vegetation and wildlife (e.g., trees) has not been reviewed.
- (5) The hydrology reports (e.g., Basement Impact Assessment, Flood Risk Assessment, Surface Water Flood Modelling Report and the Drainage and SUDs report) are currently disjointed, contradictory and do not report key issues (e.g., implications of the Porta-kabin classrooms) regarding the impact or safety of the proposed works. The lack of critical information means that the risk to Broadlands Road, our client group, cannot be assessed.

Technical Overview

In May 2023 a group of residents / property owners from Broadlands Road (residents on the south side of Broadlands Road, numbers 27-17) appointed Dr N E Haycock to review the proposed expansion and re-development of the Sports Centre associated with Highgate School. The development is referred to within the applicant's documentation as the "MSC". The proposed redevelopment includes the expansion of the building with associated basement developments to the south (phase 2A) and to the north (phase 2B). To support and facilitate the redevelopment of the MSC, an excavated oval sports basin (sometimes referred to as the amphitheatre) is proposed to the east of the MSC. This excavated oval basin is to act as a flood attention basin to prevent the current and proposed redevelopment of the MSC from flooding from surface water. MSC Phase 2B adjoins 27 Broadlands Road and the oval sports ground adjoins number 27-21 Broadlands Road.

The technical comments have been generated by Dr NE Haycock, who was the technical representative for the City of London and involved in the formulation of the original BIA methodology. Dr NE Haycock has a detailed understanding of the hydrology of Hampstead and Highgate areas as a result of the detailed hydrological and shallow groundwater modelling for the lakes on the Heath (2004-2010). This work was done in compliance of the Reservoir Act (1975) and the Flood and Water Management Act (2010) and supported the resulting safety works to the dams on the Heath. It should be noted that in addition to the detailed reviews of other basement developments we have undertaken in this area (HGY/2012/1421, HGY/2012/1422, HGY/2012/0556 and HGY/2021/0048), we have conducted a detailed review of the hydrology of Highgate Woods for the City of London and are therefore very familiar with the issues locally to the proposed development.

Documentation submitted for planning applications HGY/2012/1421, HGY/2012/1422, HGY/2012/0556 and HGY/2021/0048 illustrate the sensitivity of the groundwater lenses within the geology of the Claygate Member locally to Broadlands Road. These groundwater lenses (aquifers) have been shown to interact with the historic cellars within the properties on the south side of Broadlands Road which frequently flood and need to be managed in order to reduce the risk of local ground movement. In previously submitted planning application documents (cited above) and subsequent documents prepared for potential planning enquiries, judicial reviews and High Court challenges, we have noted that the Claygate Member consists of near horizontal narrow layers of sandy silt material which is saturated with water. These aquifers give rise to seasonal springs that sustain small ponds (see Appendix 2) and generally feed water into the ground surface resulting in prolonged saturation of this ground in the winter months. These groundwater lenses interact with historic cellars in Broadlands Road resulting in seasonal flooding of the cellars which requires them to be pumped. We refer to these horizontal aquifer layers of sandy silt as "groundwater lenses" within this document, since this was the preferred *lay* term used in the above submissions.

Proposed basement extensions in Broadlands Road have been shown to complicate the groundwater movement and prejudice the hydrogeology of neighbouring properties. The same Claygate groundwater lenses have been shown to be an important consideration for mature tree heath and any disruption of this groundwater could result in profound drought or flood stress being inflicted on these mature trees. The Council took due notice of the submitted documentation and made decisions at the time to safeguard the stability of the hydrology and hydrogeology of these Claygate groundwater lenses.

The MSC Basement Impact Assessment generated by PJCE (June 2022, Rev A) states in section 2.7.1 under the heading of "Subterranean (Groundwater) Flow" that .. "The screening process has not identified any issues of

concern to be investigated further as part of this BIA". Namely, they have concluded that the the geology of the development is "London Clay" and that no groundwater is present. The PJCE statement is factually incorrect. Reports issued by the applicant and produced by EdenvaleYoung (Flood Risk Assessment 23/1/2023, Rev F) state that the geology is the Claygate Member. Further, reports issued by the applicant and produced by Price & Myers (BIA, Science Block, April 2019, Rev 2) duplicate the British Geology Survey map for the area and shows the MSC site to be on the Claygate Member. PJCE (June 2022, Rev A) report includes borehole logs and records that groundwater was encountered at -2.9m (BH1) and -3.6m (BH2) within the planning boundary of the MSC. The existence of groundwater within the Claygate Member suggests that the development will interact with this groundwater lenses and the implications of this interaction needs to be assessed through the BIA process and cannot be dismissed.

The MSC Basement Impact Assessment generated by PJCE (June 2022, Rev A) states in section 2.7.3 under the heading "Surface Flow & Flooding" that .. "The screening process has not identified any issues of concern to be investigated further as part of this BIA." This statement is diametrically opposite to the report issued by the applicant and produced by EdenvaleYoung (Surface Water Modelling Report, 4th July 2022 Rev C) that shows how extensive surface water flooding currently occurs on the site and potentially how surface water flooding needs to be managed. The BIA needs to assess the surface water flood risk based on the EdenvaleYoung report since surface water flooding has been clearly identified which has resulted in major interventions being proposed by the applicants to manage this risk (e.g., Oval Sports Basin). Ingress of this surface flood water into the proposed MSC basement through existing or proposed access routes has not been assessed.

The EdenvaleYoung Surface Water Modelling Report (4th July 2022 Rev C) reviews the overall surface water flood risk to the MSC complex (current and proposed). The report proposes a large excavated oval basin be formed to contain floodwater for moderate to extreme storm events. Neither the BIA, FRA, Drainage and SUDs, Ecology nor Arboricultural reports review the implications of this excavation into the Claygate Beds. No ground investigation has taken place for this area, as far as we can determine. No assessment of the implication of draining the Claygate groundwater lenses has been undertaken. How will this impact the wetness of the Oval Sports Basin? How will this groundwater be managed or maintained so as to not impact adjoining neighbours? How will the potential dewatering of the groundwater lenses impact local properties, their houses, foundations and the health of trees on their property? What would be the implication of dewatering these groundwater lenses on the mature woodland to the east of the Oval Basin as well as the historic wooded hedgerow to the west of the proposed basin? In addition, when this Oval Basin is flooded with surface water from the Highgate School catchment, will this water drain into exposed groundwater lenses and increase the flood risk to the adjoining property basements? Should this proposed Oval basin flood, how will the flood debris, silt and contaminants associated with urban runoff (e.g., trace metal and faecal bacteria) be cleaned from the basin area so as to not impact the health of the Oval Basin users (Highgate School pupils), the neighbouring trees and the quality of the water within the Claygate Member groundwater lenses that interact with the properties adjoining the proposed Oval Basin development? The reports on the Oval Sports Basin have not reviewed how the slopes of the basin will react when the exposed geology is saturated. Equally, the shock hydraulic lateral water load on the northwest section of the Oval Basin, which is to act as a dam, has not been reviewed. Nor has it been assessed whether the core of this dam structure has enough strength to support the stored water, which will have a water level higher than the majority of the floor level of the MSC and adjoining

residential properties. The operation and safety of this dam have also not been reviewed when the structure is exposed to exceedance flood events resulting in overtopping of the dam.

In the following section of this report we aim to set out our technical notes and observations on the BIA, FRA, Drainage and SUDs plus the Surface Water Modelling Report for the proposed development of the MSC. The applicant's reports are currently disjointed and do not share common data nor assumptions. The Flood Risk Assessment is focussed on the structural safety of the MSC building from surface flood water but fails to review the safety to its users, especially when this same report shows that even with the creation of the Oval Sports Basin attenuation reservoir, the MSC is still surrounded by ponded and/or flowing floodwater.

In relation to Broadlands Road, our initial observation/concerns are listed below:

- A. Number 27 Broadlands Road is at risk of the shallow groundwater lenses associated with the Claygate Member being disrupted by the proposed MSC piling infrastructure which may enhance the wetness of this property, its foundation and the overall wetness of the garden with resulting implications for the health of the trees in the garden.
- B. Number 27 Broadlands Road surface water flood risk as currently modelled by the applicant and also under the proposed development still remains unclear. Rainfall statistics need to be based on the orographic data for Hampstead Heath ridge-line not regional datasets. As a result of this, the current reports underestimate the runoff risk from the catchment. The surface water flood models do not consider pipe blockage risk and/or the current condition of the piped network and therefore underestimate the surface water flood risk.
- C. The operation and safety of the Oval Sport Basin is not clear and drainage and overflow/overtopping routes of floodwater from this attenuation basin have not been mapped. These flood routes could pass through Number 27 Broadlands Road.
- D. The operation and safety of the Oval Sport Basin Dam is not clear nor the stability of the internal slopes of this basin when the geology is periodically saturated with floodwater. The attenuation basin peak water level is higher than the ground level of Number 27 Broadlands Road and should the basin dam fail, then extensive damage to Number 27 Broadlands Road will most likely occur. No engineering reports have been presented on the safety of the dam then flood water overtops the structure.
- E. The operation and safety of the Oval Sport Basin's internal slopes when the geology is periodically saturated with floodwater is not clear. The proposed "dry" design slopes, when saturated, may not be stable, resulting in slippage of the side slope. This slippage may extend into the gardens of Number 25-21 Broadlands Road and therefore needs to be reviewed by a geo-technical specialist.
- F. The proposed formation of the Oval Sports Basin may interfere with the movement of groundwater associated with the Claygate sand/silt lenses. Should this occur, then the groundwater regime of properties along Broadlands Road could be adversely impacted resulting in changes in the hydration status of these lenses with implications for the ground stability (properties) and the wetness or dryness of the ground (implications for trees). This risk needs to be reviewed by technical specialists.

Summaries of notes on applicants technical reports.

Summary PJCE Basement Impact Assessment generated (June 2022, Rev A)

The PJCE BIA needed to be extensively updated and integrated with the FRA, Surface Water Modelling Report and Drainage and SUDs reports as issued by the applicant. The BIA needs to review the wider impact of the proposed basement in the reported Claygate Member groundwater lenses. This wider review needs to consider planning application decisions associated with Broadlands Road. The BIA needs to consider the impact of the excavation of the Oval Sports Basin on the Claygate Member groundwater lenses. The PJCE BIA report has a different site boundary to other applicant reports and does not include the Oval Sports Basin to the east of the MSC. Ecology and Arboricultural reports need to review the changes to the water regime should the proposed development proceed as a result of the Oval Sports Basin and also the deflection of groundwater associated with the MSC basements (2b and 2a). (Detailed comments in Appendix I).

Summary EdenvaleYoung Surface Water Modelling Report (4th July 2022 Rev C)

The surface water modelling report is not based on local rainfall history and the well documented orographic rainfall history of the Hampstead and Highgate area. The surface water model therefore may be under-reporting the volume of runoff. The surface water modelling report does not represent the known soil types for the geology of the area and therefore overestimates the volume of water infiltrating into the soil and underestimates the runoff risk. The soil types associated with the Claygate Member geology are not used. The surface water modelling report does not report on the condition and blockage risk to the piped drainage networks and a pipe blockage scenario has not been undertaken. Extreme flood events are often associated with pipe failure. The surface water model therefore needs to assess this risk to determine if the proposed attenuation basin is sufficiently deep enough. The operation of the Oval Sports Basin, how water flows towards it, is it stored safely and how it is dewatered are not documented in this report. There are unanswered issues related to the safety of the flood storage basin, the safety of the dam and the banks of the basin when it is exposed to flood water surge loading. Finally the quality of the stored water has not been addressed nor the impact of the basin excavation of the surrounding Claygate groundwater lenses which potentially has major implications for the properties along Broadlands Road as well and the catchment. (Detailed comments in Appendix I).

Summary EdenvaleYoung Flood Risk Assessment (Site Specific, 23/1/2023, Rev F)

EdenvaleYoung FRA does not review flood water levels for the current and proposed building for all the current and proposed entrance points. This report does not integrate the 'Surface Water Modelling Report' and the 'Drainage and SUDs Report', as should be the intention. The modelled flood extent shows the MSC surrounded by water with possible water flowing to the Oval Sports Basin preventing access to the MSC building in a time of flood from the south. The report is more concerned with the safety of the structure and not the safety of the users. The report fails to make a clear distinction between fluvial flooding and pluvial flooding. In relation to the routing of pluvial flooding, it is not clear how the Oval Sports basin will receive flood water nor how this feature will drain. The proposed excavation of the Oval Sports Basin will most likely expose groundwater lenses associated with the Claygate Member and the protection of this groundwater has not been addressed. The FRA has not addressed the flood risk from surcharges of the sewage or storm water

drainage and how the pollution risk associated with this water will be managed and cleaned up when this water is potentially stored in the Oval Sports Basin. (Detailed comments in Appendix I).

Summary PJCE Drainage and SUDs Statement (1st Nov 2022, Rev 4)

PJCE Drainage and SUDs Statement appears to be stand-alone report and not technically connected to the EdenvaleYoung Surface Water Modelling Report (4th July 2022 Rev C). Pipe blockage risk has not been assessed and the operation of the drainage infrastructure when the MSC building is surrounded by surface flood water has not been reviewed. The Drainage and SUDs Statement does not appear to review the attenuation of runoff from the proposed temporary buildings to the south the MSC nor how this drainage pipework will operated independently of the modelled surface water flooding of the temporary building area. The PJCE explicitly states that new paths and hard standing areas are not included in this assessment, but these would normally be included in an assessment and the logic for omitting these runoff features is not clear. (Detailed comments in Appendix I).

Conclusion

The “Drainage and SUDs Statement”, “Surface Water Modelling Report”, “Flood Risk Assessment” and “Basement Impact Assessment” have reviewed and adopted regional generic datasets to underpin their assumptions on the ground conditions and rainfall / runoff regime of the MSC catchment. None of the reports have collated location information and/or information submitted to the Council as part of other planning applications. The rainfall data used is regional in nature and the reports have not reviewed the orographic rainfall history of Hampstead and Highgate and the frequent flash floods associated with the Hampstead Heath ridge-line.

We do not believe that the BIA is factually correct and this report does not align with other flood and hydrology reports issued by the applicant for the proposed MSC development. The BIA does not consider the impact of the proposed disruption of the groundwater lenses as a result of the installation of deep piling through the Claygate member and the possible deflection of the groundwater lens flow to the east and west of the proposed MSC development.

All the applicant’s flood and hydrology reports have not considered the wider site impact of the excavated Oval Sports Basin on the groundwater regime of the Claygate Member groundwater lenses. In addition, the Ecology and Arboricultural reports have not reviewed the wider changes to the hydrogeological regime of these groundwater lenses should the Oval Sports Basin be formed. The operation of the Oval Sports Basin as an above ground reservoir, with the resultant saturation of the basin’s banks, has not been assessed in terms of the stability of these banks when saturated and the strength of the NW bank which will be acting as a dam. Should the feature be overloaded with water, then defined overflow pathways have not been assessed nor whether this overtopping floodwater would be contained wholly within the applicant’s land holding.

Summary of Additional Information Requested

In the following section we have set out a list of additional information we would ideally need to review to assess the impact of the proposed MSC develop on the key properties on Broadlands Road (e.g., Numbers 17-27). The list is not exhaustive but covers key areas of concern.

- i. Oval Sports Basin - Ground Investigation reports and site geology information. The impact of the excavated basin on the Claygate geology has not been documented and therefore the impact on neighbours' properties and tree hydrology cannot be assessed without this information.
- ii. Oval Sports Basin - Groundwater borehole logs and groundwater level monitoring data within the Basin excavation needs to be reviewed. The hydrogeology of the recorded groundwater lenses needs to be determined to map the potential impact area of the excavation and define mitigation measures, if any are viable.
- iii. Oval Sports Basin - Hydraulic models for flood exceedance events (e.g., 1:1000 year plus half PMF etc). The FRA and Surface Flood Models do not show how the Oval Basin will be managed for flood exceedance events, where overtopping flow will be directed, nor map overtopping flow routes locally to the MSC and Number 27 Broadlands Road.
- iv. Oval Sports Basin - Engineering Report for the design of the Basin Dam. In addition to the mapping of the flood exceedance events, the design of the dam, the overtopping weir or ground protection measures to control floodwater erosion have not been documented. Floodwater storage water levels will be more than 2m above local ground level and the design of the core of the dam has not been documented. The engineering stability to shock lateral water loading has not been reviewed.
- v. Oval Sports Basin - Engineering Report for the design of the Basin Side Slopes. The perimeter of the basin is designed to be graded at 1:2 batters but the stability of this material when saturated in flood events, or when the toe of the slope is saturated has not been reviewed. If the basin slopes adjoining Number 27-21 Broadlands Road should fail, then this slope failure may extent into these properties' gardens and impact trees, temporary buildings and building foundations.
- vi. Oval Sports Basin - Engineering Report and Maintenance schedule for the Oval Dam and the associated infrastructure needs to be reported. Given the basin location, volume plus elevation of flood storage water and exceedance overtopping flood risk, should the structure be classified by the council as a Reservoir and be subject the legal regulation under the Flood and Water Management Act 2010?
- vii. Oval Sports Basin - Maintenance of the basin after a flood and the clearance of flood debris (debris, silt, contaminants etc) has not reports or cited. Will the storage of this material onsite present a risk to users of the Oval Sports Basin, the wider community and also the ecology locally to the basin?
- viii. Oval Sports Basin - The applicant's Ecology and Arboriculture reports needs to review the above information and assess the impact of the development on tree health (flood and drought stress) as well as the impact on tree root plates should ground movement occur due to bank slippage. Equally, the construction of the Basin Dam will most likely have an impact on the trees and hedgerow between the MSC and the Oval Basin and needs to be assessed given the historical significance of this hedgerow. Once

the Ecology and Arboriculture reports have been updated, then we will need to review these reports for our clients.

- ix. MSC - There is limited borehole information for the MSC and the Oval Sports Basin. There is no information on the ground conditions between the MSC and Number 27, 25 and 23. The extent of the reported groundwater in the MSC borehole installed in 2016 needs to be explored to determine the extent of the known groundwater lenses and therefore the impact of the MSC basins on the hydrology of this aquifer. The applicant's BIA is based on only two boreholes which does not allow a conceptual model of the site to be formed. We would request that a plan for further ground investigation is submitted to the council, which we hope we could review and agree the plan of an extended ground investigation. This may include access to Broadlands Road gardens, subject to owners' agreement.
- x. MSC - Water Level data from the single observation borehole installed in 2016 for the MSC needs to be included in the BIA and the rainfall response dynamics of the borehole reported. If observation data has not been collected since 2016, we would request that weekly water levels are reported for a minimum of 6 months. Ideally, additional observational boreholes need to be installed (see above) and this data also collected for a minimum of 6 months and ideally over the winter period.
- xi. MSC - The Soil Consultants report on the borehole investigation as well as the geotechnical design of the proposed piling depths needs to be included in the BIA. This report has been quoted in the BIA but the whole report was not included in the BIA report. The ground investigation report ideally needs to be updated with the extended network of boreholes and water level observational data (see above) and the BIA resubmitted with the new data assessed.
- xii. MSC - The Surface Water Flood Model and the Flood Risk Assessment do not document how surface water will be directed safely to the Oval Sports Basin to store flood water. The direction of surface flow, depth and velocity are not reported. If Thames Water Storm Drains are to be discharged into the basins, then the method of intercepting this flow needs to be outlined. If Thames Water Storm Drains are to be connected to the water retention basin, will this asset be controlled by the applicant or Thames Water?
- xiii. MSC - The Surface Water Flood Model and the Flood Risk Assessment need to review flood exceedance events and the overtopping of the Oval Sports Basin. Flood routes for overtopping events has not been reviewed in term of the engineering safety of these flood routes, the impact on the MSC and Number 27 and 25 Broadlands Road. The safety of people in residence in Broadlands Road has not been reviewed nor the evacuation of the MSC in modelled and exceedance flood events.
- xiv. MSC - The Surface Water Flood Model needs to reassess the rainfall data used in the flood modelling against local meteorological records held by the Hampstead Scientific Society and or the City of London. Extreme rainfall events are common locally to Hampstead Heath and the current rainfall data is not reviewed against the known orographic risks.
- xv. MSC - The Surface Water Flood Model report needs to map the total flood water extent and include data where the modelled floodwater depth is between 0-100mm. This shallow water may extend into Broadlands Road properties. If there is a known vertical error in the modelled flood water levels (or ground terrain model) then this needs to be reported.

- xvi. General - The FRA, Surface Water Flood Model, BIA and Drainage and SUDs report all need to be integrated and consider the MSC development and the Oval Sports Basin as a whole. The site boundaries and data reported is not currently integrated and is often contradictory, notably the BIA stating there is no surface water flood risk when the other reports model and report this risk. We urge that additional data is secured on the MSC and Oval Sports Basin ground conditions, additional assessments completed on the safety of the structures etc in order that the risks to wider environment including Broadlands Road can be assessed.
- xvii. General - It should be noted that FRA, Surface Water Flood Model and Drainage and SUDs do not directly address the issue of the Porta-kabin temporary school classrooms proposed within the MSC runoff catchment. We understand that the Porta-kabins will be located onsite for 10 years, but there are no runoff simulations for this infrastructure. The Surface Water Flood Model does show the area when the Porta-kabins are proposed to be flooded with 0-200mm of water, but no section of the FRA deals with safety of these buildings and their evacuation. There is a critical need to address this issue and re-run flood runoff models and review the performance of the Oval Sports Basin as well as the runoff risk to the Porta-kabins users and the users of the MSC.

Appendix I: Technical notes and observations (v1.05)

PJCE Basement Impact Assessment (June 2022, Rev A)

1. The authors of the PJCE-BIA are listed as structural engineers and not hydrologist or hydrogeologists. It is unclear if PJCE have been supported by qualified hydrologists or hydrogeologists as the BIA methodology requires.
2. PJCE BIA report has a different site boundary to other applicant reports and does not include the Oval Sports Basin to the east of the MSC. This excavated basin needs to be included in the BIA because of the potential disruption to the groundwater lenses within the Claygate Member. The disrupted groundwater has wider side implications as well as implications for the MSC in terms of bringing groundwater to the surface locally to the southern section of the proposed building.
3. PJCE BIA figure 2.0 (p5) is too small and text for the land levels is too small to allow a review of the geometry of the basements and depth of piles.
4. PJCE BIA does not include 'Soil Consultants Limited' report and the recommended depth of the piles to support phase 2a and 2b. Drawing in Part 5 have no piling depths marked (see L2384-PJC-P2B-B0-DR-S-00901).
5. Site borehole investigation was done in Jan 2016. Site window samples done in Dec 2018. Borehole logs are only reported and the complete report by Soil Consultants Limited does not appear to be present in the main report nor Part 5 of the submitted documents. The classification of the geology is not reported in the borehole logs. The logs seem to show an upper softer geology (Claygate, Member with orange colour) and a deeper stiff blue clay (London Clay -5m), but PJCE refer only to London Clay. We would request that the 'Soil Consultants Limited' full report is issued and their classification of the geology confirmed. PJCE BIA does not align with the classification of the geology, as issued by British Geological Survey nor other applicant documents that refer to the surface geology locally to the MSC as the Claygate Member. As a result the BIA questionnaire has been completed incorrectly (e.g., Q1a) and section 2.7.1 statement is incorrect.
6. The PJCE has not collated any local site information from other planning applications, namely Broadlands Road. PJCE have not collated reported flood and basement incidents reports in recent planning applications but relied on low resolution regional datasets (see Part 3-4). As a result the statement in section 2.7.3 are incorrect and also do not align with applicants FRA, Drainage and SUDs report or the Surface Water Modelling report.
7. Soil Consultants Limited borehole log for BH1 shows water ingress at -2.9m. This groundwater ingress into the borehole is consistent with data collected over the last 10 years in borehole logs for Broadlands Road.
8. Soil Consultants Limited borehole log for BH2 shows water ingress at -3.6m. This groundwater ingress into the borehole is consistent with data collected over the last 10 years in borehole logs for Broadlands Road.
9. Both BH1 and BH2 report sand or silty sand layers in the geology. This is consistent with data collected over the last 10 years in borehole logs for Broadlands Road.
10. There are only 2 boreholes and 4 window samples supporting the MSC application, which is surprisingly small number given the extent of the development. Only one borehole has been installed with a piezometer but no historic water level information has been presented in the report. PJCE had the

opportunity to monitor groundwater levels and dynamics from 2016 which would have shown the status and dynamics of this groundwater lens.

- I 1. The depth of the basements (phase 2a = -4m, phase 2b = -5.5m) appear to interact with the water ingress layers reported in the site investigation logs, but this has not been mentioned. PJCE only cite superficial ponded water in the upper 1m of the boreholes (which was not reported by Soil Consultants Limited in their borehole logs) and not the deeper water ingress (-2.9 to -3.6m).
- I 2. PJCE seem to have chosen a construction method for the basements prior to the completion of the BIA process. Since the groundwater has not been acknowledged there is no assessment of how the recorded groundwater may react to the installation of the sealed piling curtain and therefore no mitigation proposals have been reviewed to deal with the possible disruption of the movement of groundwater in these possible lenses and how this deflected groundwater may interact with adjoining properties and public road infra-structure.
- I 3. PJCE are of the opinion that there are no water courses within 1600m of the proposed development, based on large scale map interpretation. There is no collated history on the seepage points and water courses for this catchment based on historic mapping information. The wider movement of surface and groundwater has not been reviewed nor the location of historic ponds in the catchment as recorded in the first series OS maps. The PJCE report has not generated an accurate conceptual model of the site and its geology, but kept their assessment limited to the footprint of the current building.
- I 4. The report does not appear to review the impact of the proposed "Oval Ground" to the east of Phase 2a and Phase 2b and the implications of this ground excavation on the groundwater lenses with the Claygate Member.

Summary PJCE Basement Impact Assessment generated (June 2022, Rev A)

The PJCE BIA needed to be extensively updated and integrated with the FRA, Surface Water Modelling Report and Drainage and SUDs reports as issued by the applicant. The BIA needs to review the wider impact of the proposed basement in the reported Claygate Member groundwater lenses. This wider review needs to consider planning application decisions associated with Broadlands Road. The BIA needs to consider the impact of the excavation of the Oval Sports Basin on the Claygate Member groundwater lenses. Ecology and Arboricultural reports need to review the changes to the water regime should the proposed development proceed as a result of the Oval Sports Basin and also the deflection of groundwater associated with the MSC basements (2b and 2a).

EdenvaleYoung Surface Water Modelling Report (4th July 2022 Rev C)

- I 5. Just an initial observation but the EdenvaleYoung Surface Water Modelling Report was issued 4/7/2023 but checked in 2029. Ironic.
- I 6. Surface Water Modelling report does not have a figure showing the extent of the pipes network that was modelled, nor the condition of the existing pipe network. The report assumes all the pipe network is in good order and 100% effective with no current blockage and no blockage risk during moderate to extreme storm events. The Randall Survey LLP data is not included in the submitted report. These comments also apply to section 4.6.3.

17. EdenvaleYoung Section 3.2.1 cites regional rainfall datasets but this has not been cross checked with the rainfall history of the Highgate area and the orographic rainfall effects recorded for Hampstead and Highgate which has resulted in frequent extreme rainfall events. The most recent event was 76mm of rainfall in 90 minutes on 18th October 2022 which was cited by Met Office as 179 year event but is 5 times more rainfall than the 90min 1:1000 year event reported in EdenvaleYoung figure 3.2. The DDF2013 data is not applicable to the micro-catchments associated with Hampstead Heath and all DDF2013 data needs to be reviewed relative to the Hampstead Scientific Society meteorological record and a local hyetograph adopted for all simulations in order to ensure the the models represent known rainfall history. Ideally the surface water flood model needs to be validated against recent and well recorded flood events. These comments also apply to section 4.9.2.
18. Section 4.4.2 reports that the catchment soils are “loam” based on large scale EU soil databases. The published soils maps for Hampstead Heath cite that soils associated with the Bagshot Beds (the geology of the upper section of the catchment) are Fyfield (571g) and therefore loam soils. The soils associated with the Claygate Member are mapped by SSLRC as Denchworth (712b) and have a wetness class IV. The infiltration data for the surface runoff model appears to have adopted soil types that are not applicable for the lower sections of the catchment and therefore under estimate the runoff risk by overestimating the infiltration of rainwater into the soil.
19. In relation to section 5.2.2, the surface water runoff model does not seem to factor in the temporary accommodation being proposed to a large area of astro-turf and how this will impact the runoff regime of this section of the catchment. The runoff model assumes that the Oval Sports Basin will have a loam soil, when the material will be exposed Claygate geology with limited topsoil. The lack of drawings showing the current and proposed land use and runoff assumptions for these land use area means that there is a risk that the runoff risk has been underestimated.
20. As noted above, in section 6.2.2, the condition and completeness of the drainage network is not recorded. The condition and blockage risk of the current drainage network is not reported. The runoff simulations do not report on blockage simulations nor the portion of water being drained from the site through the piped network and relative the volume of overland flow and volume of water being attenuated. The capacity of Broadlands Road culverts as they flow to the NW is not reported. Comments apply to section 7.2.1.
21. In section 7.2, EdenvaleYoung report the current extent of flooding, as modelled, but have omitted any mapped data relating to water depths between 0-100mm. If this shallow flood area is not reported then the total extent of the flood areas is not know. This is critical information when reviewing the flood risk to Number 27 Broadlands Road.
22. Section 7.2.1-7.3.2 reports that the current flood depth for the northern section of the MSC is 1.27m (depth of water), or the water reached a modelled level of 106.89mAOD (figure 7.1, 1:100y + 20%CC). Figure 7.4 reports that as a result of the proposed flood mitigation measures, floodwater levels are reduced by 100mm locally to sample point 1. This implies that water levels would be 106.79mAOD for the 1:100y +20%CC event. Section 7.3.3 states that the proposed flood level of MSC Phase 2b would be

106.40mAOD. This implies that flood water levels are higher than floor levels. This contradicts the statement made in the BIA by PJCE?

23. Section 7.3.2 states that the depth of water in the Amphitheatre flood attenuation basin (Oval Sports Basin) would be 1.00-1.50m (water levels 108.50 to 109.00m) but the report does not state, or map, how this water will drain into the Oval Basin in an extreme runoff event. Are Thames Water storm drains to be connected to the Oval Basin or throttle pipes introduced within the Thames Water storm drains to allow excess water to flood into the basin? How does the Oval Basin drain, what is the dewatering rates, does this dewatering rate comply with the rates quoted in the Drainage and SUDS documentation? The volume of stored water is above the downstream land levels and the basin will operate as an elevated impounded structure with the northwest bank acting as a dam. Does the dam have enough freeboard (top level is mapped at 109.50mAOD). Is the dam to be listed and inspected under the Reservoir Act (1975, 2010). Is this Claygate Member bank (an it's possible sand/silt lenses) being design to cope with the shock loading of water. Will the dam be engineered? How safe are the banks when they are saturated with water since the proposed banks to the north of the basin are shown at a 1:2 gradient (see drawing 733_01 (DP)001) but is this safe when the slope are flooded, will bank slippage occur? How safe will this dam be in the event of an extreme event (> 1:100y+40%CC)? If the flood is extreme, how will the excess water overflow the dam and not damage the dam structure. Finally, the quality of this flood water has not been addressed, nor the implications of the residence time of the water onsite, and finally the safety of the users of the site post flood (soil contamination and bacterial in-wash) and the impact of the stored water on the local geology. The operation, performance and safety of this attenuation basin and the implication of excavation on the wider site has not been addressed.
24. Figure 7.4 suggests that number 27 Broadlands does not flood but water depths from 0-100mm are not mapped. See comments above.
25. The function and capacity of the extra gully mentioned in section 8.1.2 is not explained, nor the capacity of the downstream Thames Water storm drains cited. Note that the SUDs attenuation tanks have not been cited in this report and we assume the flow rate from the SUDs tanks is not allowed in the piped drainage network?
26. Section 8.1.2 cites a bund to the south being at an elevation of 106.00m, but the reported floodwater depth in section 7.2.1 is higher than this bund (see our comment 22).
27. Do we assume that rainfall that accumulated in the part enclosed basement for MSC Phase 2a (the basement courts to the south of the building) are pumped to the storm drains. This has not been cited in either the FRA, SUDs nor model reports.

Summary EdenvaleYoung Surface Water Modelling Report (4th July 2022 Rev C)

The surface water modelling report is not based on local rainfall history and the well documented orographic rainfall history of the Hampstead and Highgate area. The surface water model therefore may be under reporting the volume of runoff. The surface water modelling report does not represent the known soil types for the geology of the area and therefore over-estimates the volume of water infiltrating into the soil and under-estimates the runoff risk. The soil types associated with the Claygate Member geology are not used. The surface water modelling report does not report on the condition and blockage risk to the piped drainage

networks and a pipe blockage scenario has not been undertaken. Extreme flood events are often associated with pipe failure. The surface water model therefore needs to assess this risk to determine if the proposed attenuation basin is sufficiently deep enough. The operation of the Oval Sports Basin, how water flows towards it, is it stored safely and how it is dewatered are not documented in this report. There are unanswered issues related to the safety of the flood storage basin, the safety of the dam and the banks of the basin when it is exposed to flood water surge loading. Finally the quality of the stored water has not been addressed nor the impact of the basin excavation of the surrounding Claygate groundwater lenses which potentially has major implications for the properties along Broadlands Road as well and the catchment.

EdenvaleYoung Flood Risk Assessment (Site Specific, 23/1/2023, Rev F)

28. EdenvaleYoung FRA has not considered the excavation risks associated with the Oval Sports Basin (amphitheatre) in terms of the implication on the Claygate Member groundwater lenses and therefore groundwater flood ingress into this basin.
29. Section 2.1.1 refers to figure 2.2, but the figure contains no information and the reference marker in the images does not relate to the location of MSC.
30. Section 2.1.3, paragraph 1 states "Accordingly it is considered that surface water flood risk is not an issue.". EdenvaleYoung FRA is confusing fluvial flood risk, from ordinary or main rivers, with surface water flood risk, pluvial flooding. EdenvaleYoung Surface Water Modelling Report clearly shows and documents existing surface water flooding. Section 2.1.3 is misleading.
31. Section 2.1.3 needs to make reference to the displacement of flood water storage, especially at the northern end of the MSC phase 2b works. This lost storage volume should normally be documented and a permanent replacement volume documents for the site, not just a extreme flood storage volume associated with the proposed Oval Sports Basin.
32. Section 2.2.5 relates to groundwater flood risk and uses regional datasets and not information reported in planning submissions related to Broadlands Road over the past 10-11 years. Groundwater flood risk needs to be addressed in an integrated BIA which also covers the Oval Sports Basin.
33. Section 4 does not state how the Oval Sports Basin will operated, how water will flood into the basin nor drain from the basin. Section 4 refers to a bund to the south of the MSC building, at elevation 110m, but there appear to be no drawings should this bund.
34. Figure 4.1 is replicated from the Surface Water Modelling Report and does not show water depths from 0-100mm which is critical to the understanding of the flood risk to Number 27 Broadlands Road.
35. Figure 4.2 does not seem to show the temporary class rooms on the astroturf to the south of the proposal Oval Sports Basin but it does show standing water in this area suggesting the majority of these building will not be accessible in moderate to extreme floods.
36. Section 5 does not report on the flood water levels for all the entrance points for the current and proposed building but figure 4.3 suggests that the current and proposed MSC building will be surrounded by floodwater and the potential evacuation of the building will need to be through standing or flowing water at a depth of 0-1000mm deep.

Summary EdenvaleYoung Flood Risk Assessment (Site Specific, 23/1/2023, Rev F)

EdenvaleYoung FRA does not review flood water levels for the current and proposed building for all the current and proposed entrance points. This report does not integrate the 'Surface Water Modelling Report' and the 'Drainage and SUDs Report', as should be the intention. The modelled flood extent shows the MSC surrounded by water with possible water flowing to the Oval Sports Basin preventing access to the MSC building in a time of flood from the south. The report is more concerned with the safety of the structure and not the safety of the users. The reports fails to make a clear distinction between fluvial flooding and pluvial flooding. In relation to the routing of pluvial flooding, it is not clear how the Oval Sports basin will received flood water nor how this feature will drain. The proposed excavation of the Oval Sports Basin will most likely expose groundwater lenses associated with the Claygate Member and the protection of this groundwater has not been addressed. The FRA has not addressed the flood risk from surcharges of the sewage or storm water drainage and how the pollution risk associated with this water will be managed and cleaned up when this water is potentially stored in the Oval Sports Basin.

PJCE Drainage and SuDs Statement (1st Nov 2022, Rev 4)

37. PJCE Drainage and SuDs Statement does not seem to be integrated with the EdenvaleYoung Surface Water Modelling Report (4th July 2022 Rev C). Surface Water Modelling Report should have determined the drainage capacity of the site and the nature of the capacity within the Thames Water Storm Drainage Network. The fact that the northern section of MSC currently floods in moderate storms suggests that the drainage network does not have the capacity to transfer additional water. The quoted discharge rates of 8, 12 or 5 litres per second need to refer to the status of the storm drains, as modelled by EdenvaleYoung, for similar runoff events.
38. PJCE Drainage and SuDs Statement nor the EdenvaleYoung Surface Water Modelling Report (4th July 2022 Rev C) refer to blockage risk of the Thames Water Storm Drainage Network and how the SUDs proposal will respond in these scenarios.
39. PJCE Drainage and SuDs Statement is limited to the new roof runoff area of the MSC and its associated new car park area. The PJCE explicitly states that new paths and hard standing areas are not included in this assessment, but these would normally be included in an assessment and the logic for omitting these runoff features is not clear.
40. PJCE Drainage and SuDs Statement assumes that the Orchard Sports Ground (which we assume relates to the Oval Sports Basin / Amphitheatre) is porous and does not generate any runoff. The Amphitheatre has a considerable area of seating and re-enforce engineering to the slopes of the Amphitheatre, but this runoff risk has not been assessed. PJCE Drainage and SuDs Statement by implication does not seem to recognise that the Oval Sports Basin will periodically be flooded and the runoff from this stored water will impact the capacity of the drainage network.
41. PJCE Drainage and SuDs Statement does not state the location of the roof runoff attenuation tank (221-341 m-cu). We assume that given the limited space to the north, east and west of the MSC and the need to protect the sites boundary trees that the attenuation tank would be located to the south or south east of the building. If the tank is at depth then the risk of groundwater ingress into the tank has not been

assessed. Equally if the tank is to southeast of the MSC then this tank structure risks being in the footprint of the dam for the Oval Sports Basin thereby undermining the safety of this possible structure.

42. PJCE Drainage and SuDs Statement nor the EdenvaleYoung Surface Water Modelling Report (4th July 2022 Rev C) review the local rainfall data and the orographic rainfall history of Hampstead and Highgate. The peak rainfall data used in the SUDs calculation will most likely be underestimating the rainfall and runoff risk resulting is drainage and SUDs features being under capacity.
43. The operation of the drainage and SUDs solutions needs to be assessment against the modelled surface flood water as modelled by EdenvaleYoung. If the car park and path areas are submerged by catchment surface water then the SUDs tank will be rapidly overwhelmed and the increased roof area will exacerbate the current and predicted surface water flooding to the south, east, west and north of the MSC.

Summary PJCE Drainage and SuDs Statement (1st Nov 2022, Rev 4)

PJCE Drainage and SuDs Statement appears to be stand-alone report and not technically connected to the EdenvaleYoung Surface Water Modelling Report (4th July 2022 Rev C). Pipe blockage risk has not been assessed and the operation of the drainage infrastructure when the MSC building is surrounded by surface flood water has not been reviewed. The Drainage and SUDs Statement does not appear to review the attenuation of runoff from the proposed temporary buildings to the south the MSC nor how this drainage pipework will operated independently of the modelled surface water flooding of the temporary building area.

Appendix 2: MSC Drainage Basin (RT), Flow Lines (RT-D8) against the background 1st Series OS Map and Environment Agency LiDAR (DTM 1m).

