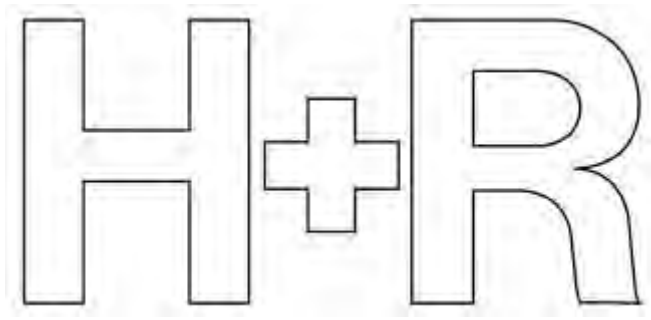




PRELIMINARY INVESTIGATION OF DAMP

HEATON HALL ORANGERY, HEATON PARK, MANCHESTER

JOB NO. 212.97



MANCHESTER CITY COUNCIL

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1 INTRODUCTION

1.1 AUTHORITY AND REFERENCE

Hutton+Rostron Environmental Investigations Limited carried out a damp survey at Heaton Park Orangery on 16th February and 15th March 2022 in accordance with instructions received from Aidan Watson by email dated 7 December 2021 on behalf of Manchester City Council. Reference was made to drawings supplied by Aidan Watson, reference 010090425104 for the identification of structures. For the purpose of orientation in this report, the building was taken as facing south

1.2 AIM

The aim of this investigation was to identify damp problems or relevant building defects and to give recommendations on any remedial works required to correct such problems and prevent damp problems in the future using environmental means as discussed in Appendices A, B, C & D

1.3 LIMITATIONS

This survey was confined to the accessible structures. Specialist investigative techniques are therefore employed as aids to the surveyor. No such technique can be 100 per cent reliable, but their use allows deductions to be made about the most probable condition of materials at the time of examination. Structures were not examined in detail except as described in this report, and no liability can be accepted for defects that may exist in other parts of the building. We have not inspected woodwork or other parts of the structure which are covered, unexposed or inaccessible and we are therefore unable to report that any such part of the property is free from defect or, in the event that such part of the property is not free from defect, that it will not contaminate and/or affect any other part of the property. The contents of this report do not imply the adoption of the role of Principal Designer by H+R for the purposes of the Construction (Design and Management) (CDM) Regulations 2015

1.4 H+R STAFF ON SITE

Chris Whitfield
Christiana Shovlin

1.5 PERSONNEL CONTACTED

Aidan Watson – Manchester City Council
David Clegg – Heaton Park

2 EXECUTIVE SUMMARY

2.1 OBSERVATIONS

2.1.1 Exteriors

At roof level, outlet catchpit and overflow pipes were small in diameter and vulnerable to blockage. Valley gutters, drainage gulleys and outlets were generally clogged with debris. At the south façade and east entrance, several ferrous metal dowels/cramps had corroded and degraded the stone surrounding. Render was debonding from parapets and at the north elevation where in direct contact with the ground. A brick-lined culvert drainage system was present to the perimeter of the south elevation; construction, condition and extent are unknown. A brick-lined ventilating trench served the earth-retaining structures of the northwest extension; it was partially collapsed and filled with debris. There was inadequate surface drainage to the north patio and evidence of surface water pooling

2.1.2 Interiors

High moisture readings were identified in the earth-retaining solid masonry walls, near the poorly drained north patio at ground level, and below defective rainwater outlets. Timber joinery in these areas were also damp and partially decayed. Water penetration was occurring via defects identified in the roof coverings and areas of residual moisture corresponded with vulnerable rainwater outlets that had previously blocked. Windows throughout were closed, and the building was unheated. All walls, floors and ceilings were of solid masonry construction and heating/ventilation was inadequate, resulting in conditions for regular condensation and increased materials moisture contents

2.2 RECOMMENDATIONS

H+R have provided separate recommendations for immediate 'mothballing' refurbishment (see 5.1 and 5.2). Recommendations for immediate mitigation works and further investigation are as follows:

2.2.1 Exteriors

Consideration should be given to increasing roof drainage outlet sizes and overflow capacity. Maintenance of all roofs and roof drainage should be improved by increasing frequency. A detailed survey of all drainage culverts, ventilating trenches and below ground drainage systems should be commissioned to determine their construction, condition and extent; to inform repairs/maintenance regimes

2.2.2 Interiors

Background ventilation should be improved and the existing heating system should be recommissioned and put to regular use. H+R should conduct further investigations to monitor the drying of masonry masses during refurbishment. Masonry should be sufficiently dry prior to commencing finishing works. H+R should be commissioned to conduct a detailed survey of timbers of the northeast and northwest roofs following exposure

3 BACKGROUND

Heaton Hall was originally constructed between 1772-1789 by Architect James Wyatt as a home for Sir Thomas Egerton. The Orangery was later added by James' nephew Lewis Wyatt in 1823 as part of extensions to the east and west wings

The Orangery's original design was of a long, symmetrical, single-storey range with a projecting polygonal central bay, each end colonnaded and the rest pilastered with glazed enclosure between, in keeping with the Palladian style of the rest of the Hall. Windows between the pilasters were originally glazed the full width and height beneath the moulded sandstone cornice to ground floor level

This original design remained largely unaltered until the building was sold by the Egerton family to the Manchester Corporation in 1902. Around this time, the glazed dome and hipped roofs to the centre and either wing were replaced with a concrete flat roof. The glazing to the south elevation was also removed (Fig. 5); sand and cement rendered infill panels and pilasters were added to house much narrower and shorter windows. A variety of service pipes were added to the elevation, as well as a central, apparently timber door to the right half of the projecting polygonal central bay

The next major phase of alteration was in the early 1970's, when the Orangery served as a café (according to park staff). The infilled section between each stone pilaster was again altered to house full-height windows of roughly the same dimension as those which are currently in-situ, though with projecting metal rails. Flowerbeds abut the Orangery (Fig. 6-7)

Heaton Hall, including the Orangery, was closed to the public in 2011. The Orangery was refurbished as part of multiple phases of work to the Hall generally, grant aided by Historic England, reaching completion in 2017. Works included recovering of the flat roof, re-rendering, and replacement of the south elevation windows. According to accounts of park staff, the Orangery was heated periodically after initial closure in 2011, but has been unheated in recent years

4 OBSERVATIONS

4.1 EXTERIORS

Roof references used in the report are as per the plans at Appendix F

4.1.1 Main Roof (RF-002)

- 1 Roof coverings: The roof covering was of torch-on bitumen felt roof covering, presumably over thermal insulation and possibly over an earlier mastic asphalt roof covering. The felt was turned up on the sides of the parapets and lapped with an EPDM-based lead alternative, sealed with mastic were chased into the parapet
- 2 Coverings condition: The roof generally fell to the north, though there was localised ponding in undulations. There was no apparent degradation of roof coverings. There was no evidence of failure between seams of the bitumen felt or any patch repairs. There was no evidence of water penetration to the interiors associated with failure of the flat roof coverings to the main roof
- 3 Roof drainage: The roof was drained via 4 outlets to the north elevation (referenced 1,2,4 and 6). Rainwater drainage was assisted by sunken drainage gulleys intended to divert water towards these outlets. Outlet 1 terminated via a downpipe to the drainage gully of RF-003, outlet 2's downpipe fed to the eaves gutter of RF-003, terminating via downpipe 3, outlet 4's downpipe fed into hopper 4, and outlet 6's downpipe terminated onto RF-004; hoppers, downpipes and overflows were generally of lead. Lead overflow pipes passed through the north parapet wall (roughly 120mm above catchpits), in case of failure of the primary rainwater drainage system
- 4 Drainage condition: Generally, the diameter of catchpits and overflows were extremely small (between 40-60mm) and highly vulnerable to blockage. The roof was surveyed during heavy rain; due to the falls of the roof, no rainwater was discharging via outlet 2. Instead, water of the central portion drained to outlet 4, which was surrounded by debris at the time of survey. All outlets were generally clogged with debris. Outlet 6's lead downpipe was damaged
- 5 Roof access: The existing access onto the roof via the sash window to Heaton Hall may be arduous to some, and could discourage routine maintenance

4.1.2 Northwest Extension Roof (RF-003)

- 1 Roof coverings: The roof covering was of torch-on bitumen felt
- 2 Coverings condition: Rainwater was pooling in the southeast corner. There was no apparent defect and no evidence of water penetration
- 3 Roof drainage: Catchpits drained to the east cast-iron eaves gutter before discharging into downpipe 3
- 4 Drainage condition: During the survey, drainage appeared to function as intended. However, downpipe 3 was probably overloaded and was therefore

susceptible to blockage. Debris and building rubble was noted within the southern drainage gulley/catchpit

4.1.3 Northeast Extension Pitched Roof (RF-004)

- 1 Roof coverings: The roof covering was of standing seam aluminium sheets to a mono-pitched roof terminating in a valley gutter to the north
- 2 Coverings condition: No evidence of significant issue
- 3 Roof drainage: The roof drained into a valley gutter at the north wall which terminated in a stainless-steel hopper and plastic downpipe 7 at the east external face of the boundary wall. This appeared to be discharging directly onto the ground
- 4 Drainage condition: The gutter was blocked with debris and supporting standing water. Hopper 7 was damaged and filled with debris

4.1.4 Northeast Extension Flat Roof (RF-005)

- 1 Roof coverings: The roof covering was of torch-on bitumen felt
- 2 Coverings condition: The re-roofing works had not accounted for an opening for a service pipe penetration in the southeast corner of the flat roof. As a result, there were numerous attempts at waterproofing, using liquid bitumen waterproofing compound and torch-on bitumen patches. There was also splitting in the east felt upstand beneath the verge capping to RF-004. Both of these defects were allowing water penetration
- 3 Roof drainage: Roof was drained by a plastic eaves gutter to the west, served by plastic downpipe 5, discharging directly onto the ground
- 4 Drainage condition: No evidence of significant issue

4.1.5 Parapets

- 1 Construction: Sandstone parapets to the main roof (RF-002) were continuous to the north elevation, to the south elevation above the colonnaded portions, and centrally, separating the colonnade roofs from the central gallery area of the Orangery. The parapets were topped with sandstone coping stones, joined together by metal cramps, bedded and covered in mortar. Coping stones were bedded on a recently installed lead damp-proof course; 2 additional layers of older lead of a thicker gauge were present within the parapet masonry: one at mid-height and one over the cornice. Most internal faces of the parapets were covered in a pigmented lime render
- 2 Condition: There was corrosion and failure of original ferrous cramps, and many had been replaced with stainless steel. The corrosion had caused cracking of the cramp pockets of the coping stones. Mortars to cramps had failed throughout. There was splitting in the lowest layer of lead, possibly allowing for water penetration through the mortar joints of abutting string course units. Where exposed, sandstone was delaminating and soot-impregnated; where recently rendered, render was cracked and de-bonding throughout. Craze cracking was typical of shrinkage due to poorly managed/rapid drying. Water penetration via the parapets should be forestalled by the lead damp-proof courses; where failing, this presents a potential pathway for moisture ingress. Debonding render primarily poses a risk to surface drainage and, depending on the condition of the brick substrate, may allow a route for water penetration

4.1.6 Façades

- 1 South elevation construction: South elevation comprised mainly of sandstone columns to each colonnaded end with sandstone pilasters to all glazed enclosed areas. Stone and infilling was solid-walled. Surrounding each window was sand and cement rendered brick infilling. The stone fabric to the rear of each colonnaded portion was coated in a pigmented lime render
- 2 South elevation condition: Original metal dowels had corroded resulting in cracking in the stone to the south elevation; inspection with a metal detector indicated that such dowels were regularly spaced and present on all stone columns/ pilasters. Indent repairs were seen sparsely throughout, corresponding with locations of degraded ferrous fixings. Indent repairs had generally used a contrasting stone. However, there were approximately 5 cracked stones that required an indent repair. Further corrosion related cracking was present at the entrance of the east colonnade, caused by disused door fixings. Some delamination and erosion of sandstone persisted throughout, with very scattered wash-out of lime mortar between stone units. The upper surface of stone windowsills had generally delaminated and previous mortar repairs had cracked. Wetting was caused by rainwater splashback from the perimeter hardstanding and pooling rainwater on the sills
- 3 North elevation construction: Solid brick wall coated in a lime render. The thin top coat of render was pigmented. Render extended the full height of the walls from the cornice to the hardstanding of the patio, in direct contact with the exterior ground
- 4 North elevation condition: Some mechanical damage and cracking was noted to some stone sills. Render to the rear elevation was severely de-bonded and cracking to the bottom 500-1500mm of the wall. It is likely that wetting of the masonry has caused salt crystallisation and subsequent debonding of the render. This was also exacerbated by the render's direct contact with the patio hardstanding

4.1.7 Windows and Doors

- 1 Window and door construction: All windows to the south elevation had recently been replaced with single glazed, sliding sash, softwood frames extending almost the full height of the internal space. Glazed double door to the projecting bay had also recently been replaced. To the north elevation, windows were softwood framed, double glazed. Timber framed secondary glazing was included to window openings on the north elevation of the main gallery. Windows to either extension were of varying types and shapes - mostly timber framed, some with wired glazing
- 2 Window condition: Windows to the south elevation showed no signs of significant decay. They were observed to rattle in the wind, which will aid in the building's ventilation, but may be undesirable upon occupation. Windows to the north elevation of the main gallery appeared to have been repainted relatively recently. The windows to the extensions likewise appeared to have recently been repainted. The easternmost window of the gallery was decayed by wet rot at its sill and the base of its casing, likely associated with the defect in roof coverings of roof RF-005
- 3 Door condition: The double doors to either colonnade showed no signs of significant decay or defect. Both doors to the projecting centre were free of significant decay, though were extremely difficult to open due to lack of use. The back entrance door via the northeast extension was decayed at the base of its casing due to debris build-up at the foot of the external steps

4.1.8 Surface and perimeter drainage

- 1 Surface drainage construction: All rainwater downpipes terminate at the north elevation. All, save for downpipe 7, terminate into the surface drainage network of the north patio. Downpipe 7 terminated to the ground outside the boundary wall. One surface drain served the entire north patio. The back entrance via the northeast extension, and the area surrounding was not served by any surface drains; though, a floor drain in the interior of the northeast extension drained water penetrating beneath the door
- 2 Surface drainage condition: All downpipe outlets to the north patio were blocked with debris. Additionally, the patio was not graded toward the drain. Based on accounts by staff, splashback and tidemarks on the base of the wall, and debonding of the render, the patio supports a fair amount of standing water in times of heavy rainfall. The entrance to the northeast extension, likewise, suffered from pooling water and debris collection
- 3 Perimeter drainage construction: Drains to the perimeter of the building were joined by a network of brick-lined culverts visible at the south elevation. A separate trench, constructed with the intention of ventilating the earth-retaining structures was present at the north boundary wall and the north wall of the northwest extension. This was constructed in brick and shielded by a brick capping; it is unclear whether this was an original design or retro-fitted in response to internal damp. Beech hedges partially concealed this trench along the north boundary wall
- 4 Perimeter drainage condition: Visual inspection of the brick lined culvert was limited and only possible through the drains to the south elevation. The brickwork of the trench to the north boundary wall was in poor condition and where brick headers to the trench were missing, debris and soil had collected within. Root networks of the hedges immediately adjacent will continue to compromise the brickwork of the trench

4.2 INTERIORS

4.2.1 Roof/Ceiling

- 1 Construction: The flat roof was constructed of steel reinforced concrete beams with a concrete deck. The beams were plastered and painted
- 2 Condition: No visible evidence of erosion to concrete or corrosion of reinforcements was noted. No evidence of water penetration via the roof above was noted

4.2.2 Walls

- 1 Construction: Walls were directly plastered in the main gallery and tiled in the bathrooms. The wall separating the kitchen from the main gallery was a plasterboard lined timber stud partition. Skirtings to the main gallery were plaster where present, save for the timber skirting to the stud partition. Exterior walls were all 'solid' masonry and partially earth-retaining to the east and northeast (See Appendix F)
- 2 Condition: Generally, plaster was intact, save for localised de-bonding to the west and north walls, which generally corresponded with roof drainage outlets. Multiple phases of re-plastering and salt efflorescence to surfaces indicated repeated failures of outlets immediately above

4.2.3 Floors

- 1 Construction: Solid floors were present in all areas. The main gallery was finished with ceramic tiling. The kitchen and adjacent room had vinyl flooring up to skirting level. The northwest extension rooms were finished with a mix of ceramic tiling and vinyl sheeting
- 2 Condition: Ceramic tiling was covered with debris and there was some mechanical damage. There was no apparent structural cracking. However, the floor to the west half of the main gallery was not level, though this may be original to the construction of the building

4.2.4 Condensation risk analysis

- 1 Masonry wall construction: As all exterior walls were of solid masonry construction, their U-levels are relatively high. Therefore, these walls are particularly vulnerable to condensation-related damp. The Orangery is reliant on adequate heating and ventilation to ensure intermittent surface condensation or interstitial condensation does not accumulate over time
- 2 Heating: The main system of heating was a wet radiator network. The gas combi boiler was housed in the northeast extension and had 12 no. column radiators throughout the main gallery. Additionally, there were 2 no. electric fan radiators in the northwest extension and 2 no. electric fan heaters to the projecting centre of the main gallery. The property has no shortage of heating facilities, though these were not in operation during the survey. The lack of heating will not allow the masonry structures to heat up and “drive off” moisture-vapour which has condensed on its surfaces - exacerbating the effects of condensation-related damp noted in this survey
- 3 Ventilation: Mechanically assisted ventilation was present in the kitchen, which terminated to the roof; a boiler flue was on the outside of the portion of the northeast extension which housed the boiler. Also, an extractor fan was fitted to the exterior window of the Baby Change Room. Background ventilation was present in the northwest extension in the form of air bricks. No background ventilation was noted within the main gallery of the Orangery. Windows were operable throughout the property, though none of them were open and no trickle vents were observed; windows to the north elevation were not accessible due to secondary glazing. All windows and doors were shut for security, preventing airflow from the exterior; internal doors were closed, preventing air passing through all parts of the interiors. After conversing with staff and observing window condition, they are understood to be closed continuously. The inadequate ventilation of moisture-vapour increased the risk of detrimental condensation

4.3 MASONRY MOISTURE PROFILING

4.3.1 Masonry moisture profiling

- 1 Methodology: Masonry mortar samples were extracted from the solid masonry walls in 18 no. locations at 1500, 1000, 500 and 150mm above floor level to the northern sections and at roughly 300mm above floor level to the south wall, to a depth of approximately 200mm in the wall. Sampling was concentrated in areas subject to water ingress historically or where ground levels were known to be high at corresponding exteriors. Samples were analysed in the H+R laboratory using gravimetric methods. The principles are described in BRE Digest 245. This technique defines both available moisture and hygroscopic moisture. The results of which are set out in the drawings at Appendix F and the table of material moisture contents at Appendix G

- 2 Masonry moisture contents: In the earth-retaining sections, moisture contents were generally high (i.e., their available moisture content was greater than their hygroscopic moisture content), see Appendix F for locations. Samples generally identified high moisture contents at the base of the north wall and in areas subject to water penetration. All samples taken from the south wall were dry. The low hygroscopic moisture content potential of the majority of the damp masonry samples strongly suggests chronic accumulation of condensate as the primary moisture source, rather than moisture from the ground
- 3 Moisture sources: Condensate accumulation in materials within inadequately heated and poorly ventilated zones to the north side of the building will account for much of the excess moisture detected by this survey. The areas of moisture accumulation (damp) also correlate with high ground levels to the north and east, pooling water at the north patio, and rainwater goods vulnerable to failure
- 4 Access: The kitchen and adjacent room were inaccessible for masonry moisture profiling due to wall finishes. As the lower parts of these walls are earth-retaining, it can be assumed that masonry moisture contents are high. Plastic wall finishes may have been installed here to mask the effects of damp

5 RECOMMENDATIONS

5.1 MOTHBALLING

Prior to refurbishment the following recommendations should be undertaken to mitigate the risk of further damage:

5.1.1 Rainwater drainage monitoring

- 1 Outlet inspection and clearing: All outlet locations and drainage gulley should be inspected and cleared regularly. In times of heavy rainfall, or in the autumn months, maintenance should be more frequent. Special attention should be paid to outlet no. 4
- 2 Northeast extension roof (RF-004 & RF-005): Temporary waterproofing measures should be improved surrounding the service pipe penetration through the roof

5.1.2 Surface drainage, brick culvert and ventilating trench inspection

The surface drainage network, brick culverts and ventilating trenches to the perimeter of the building should be fully inspected and serviced. This will involve some shallow excavation and exposure works

5.1.3 Heating and ventilation

- 1 Ventilation: Consideration should be given to instating a means of continuous background ventilation to the main gallery. This should be possible by fitting vents to the north elevation windows, whilst maintaining the building's security. The secondary glazing to north elevation windows should be opened when temporary ventilation is instated. Where fire prevention measures and security allow, internal doors should be kept open to promote airflow to all parts of the structure
- 2 Heating: Heating should be turned on regularly to allow for desiccation of the masonry and for the dispersal of excess moisture-vapour and condensate. The boiler and radiators should be serviced as required

5.2 REFURBISHMENT

The following recommendations are given with the aim of resolving all defects causing damp or decay to building fabric / adversely damp internal conditions. These should be considered if the intention is to refurbish the Orangery

5.2.1 Roof coverings and drainage

- 1 Roof access: Consideration should be given to improving access for maintenance

- 2 Roof covering: If maintenance is anticipated to be imperfect, consideration should be given to re-roofing the building. Works should prioritise increasing the rainwater catchpit and overflow pipe diameters, and re-grading the gallery roof so that rainwater is equally distributed between outlets 2 and 4. If full re-covering of the roof finishes results from this work, consideration should be given to increasing / renewing thermal insulation and roof covering material with the aim of minimising heat loss to interiors
- 3 Curator system: Should roof maintenance be regular and consistent, consideration should be given to installing the H+R Curator monitoring system to all rainwater outlets https://handr.co.uk/assets/22279_HR-Curator-Leaflet-v6.pdf. This system alerts clients when catchpits are blocked so that urgent action can be taken
- 4 Timber condition: Allow for a detailed timber condition survey of the northeast and northwest roof structures from beneath. H+R can undertake this service, if required

5.2.2 Parapets

- 1 Copings: Mortar surrounding cramps to parapet coping stones should be inspected and renewed where degraded, ensuring sheltering of the cramps and protection of the stone surrounding. Where severely corroded, ferrous cramps should be replaced with stainless steel counterparts, then bedded and covered with mortar. All mortars should be suitably specified lime mixes. This material is intended to be sacrificial and will need renewal every few years; copings should be inspected for regular degradation annually
- 2 Lead renewal: The 2 lower (mid-height and cornice level) courses of lead flashing to all parapets should be inspected in detail for defects and renewed/repared where necessary, ensuring lead is adequately chased into the masonry; all replacement lead should be code 4 or 5 (LSTA Rolled Lead Sheet Manual, 2018)
- 3 Render: As render has cracked and is at risk of de-bonding consideration should be given to removing it from all internal faces of the parapets. Where necessary, damaged brickwork beneath should be made good and repointed in a suitable lime mortar. Re-rendering of the parapets may be necessary afterwards

5.2.3 Facades

- 1 Metal cramps: Where corroded, metal cramps should be removed and replaced with stainless steel. The area of degraded stone should be made good, either with an indent repair in sandstone - chosen to match the original fabric in appearance and durability, or with a sacrificial lime mortar repair, pigmented to match the sandstone columns / pilasters. Allow for further corrosion of cramps and future repairs
- 2 Render: De-bonded render to the north elevation and the north boundary wall should be removed. The masonry of the north façade should be monitored by H+R and deemed sufficiently dry prior to the application of any new render. Render should be a suitably specified lime mix, pigmented to match the existing. A bell cast bead detail should be formed approximately 150mm from the hardstanding of the patio / exterior ground level. Consideration should be given to using a thermally insulating render to the north facing rear elevations

5.2.4 Windows and doors

- 1 South elevation windows: Windows should be adjusted / eased to stop from rattling in the wind. This should not be done until finishing stages, however, as gaps in the windows will aid in ventilating the structure throughout refurbishment
- 2 North elevation windows: Windows require detailed inspection to inform a schedule of repairs. Decayed frames could be repaired with a suitably specified timber or replaced with new. H+R can provide further advice on this, if necessary
- 3 Doors: Doors to either side of the central bay should be adjusted for improved operability

5.2.5 Surface and Perimeter drainage

- 1 North patio: The hardstanding should be re-laid so as to fall from the north elevation and into a drain. Alternatively, a covered land drain should be installed immediately adjacent to the north elevation for its entire length. H+R can provide further advice on this, if necessary
- 2 Brick culverts: The brick culvert system should be inspected in detail for extent, construction, and condition. Any defects should be repaired, ensuring the continued use of this highly effective, historical drainage feature. After repairs are made, this system should be inspected and maintained regularly
- 3 Northwest ventilating trench: The brick trench should be inspected in detail for extent, construction, and condition. Repairs to the brickwork should ensure the trench remains clear to below internal floor level, through-ventilated and capped. The trench should be monitored and cleared of any blockages as part of a regular maintenance schedule. Consideration should be given to removal of the beech hedges immediately abutting, as the root systems will eventually threaten the brick fabric of the trench

5.2.6 Walls and ceilings

- 1 Main gallery: Defective plaster to the north and west walls should be removed where de-bonded or where damaged by efflorescence. The masonry beneath should be allowed to sufficiently dry before finishes are applied; H+R can provide detailed recommendations for drying and can conduct site visits to monitor drying, if required. Alternatively, allowance could be made for a ventilated dry-lining. As the ceiling, walls and floor are all of solid construction, consideration should be given to the internal acoustics, especially if the Orangery is to be used for hospitality. All paint finishes should be moisture-vapour permeable to allow for evaporation of solid masonry walls.
- 2 Northwest extension: A drain cavity system may need to be considered if the ventilated trench is not repaired and maintained. Alternatively, following repair of the ventilating trench masonry walls should be allowed to sufficiently dry before wall finishes are instated; H+R should be consulted to monitor drying
- 3 Northeast extension/kitchen: An integrated drained cavity system should be installed to the northeast extension, as walls in this area are earth-retaining and surface drainage to exteriors is minimal. Although the construction of an external drained cavity structure could be considered the excavation and building works may be disruptive and costly

5.2.7 Floors

- 1 Northeast / northwest extension: An asbestos survey should be undertaken to the Orangery. It is possible that existing vinyl floor finishes are laid on top of older floor coverings which may contain asbestos. This survey should be conducted prior to the commencement of works to refinish floors

5.2.8 Heating and Ventilation

The building should be heated and ventilated continuously to ensure the proper dispersal of moisture-vapour. If the present heating system is intended for future use, it should be inspected and tested for functionality. Mechanical ventilation of the toilets and kitchen areas will be necessary

6 GENERAL RECOMMENDATIONS

All new and refurbishment detailing should be assessed for its effect on environmental and structural health. General principles are set out below. Special care is required when introducing new materials, moisture sources or heating and ventilation systems, for example air conditioning

6.1 ROOF AND SURFACE DRAINAGE

6.1.1 Maintenance

All guttering, hopperheads and outlets should be regularly checked and cleared to keep them free of debris, especially during the autumn months

6.1.2 Protection

Hopperheads, gutter outlets and ground gullies should be protected with metal mesh cages so as to prevent blockage and overflow. These should extend higher than the expected water level to reduce the tendency to block and should be easily removable to allow cleaning and maintenance

6.1.3 Overflows

Hopperheads, parapet gutter outlets and valley gutter outlets should be fitted with overflow pipes to drain water clear of the structure in case of blockage. These should be at a level below that at which water would overflow the roof flashings

6.1.4 Roof drainage calculations

Roof drainage calculations should be made to check the adequacy of gutters, drains and downpipes so that their capacities may be increased if necessary, during refurbishment. H+R can carry out these calculations if required

6.1.5 Monitoring

The installation of an automatic monitoring and alarm system should be considered to give warning of blockage or overflow in the roof drainage system

6.2 VENTILATION

6.2.1 Structural voids

All structural voids within the building should be provided with adequate through ventilation so as to prevent moisture build-up. This must be done with regard to the applicable fire regulations

6.2.2 Bathrooms and kitchens

All bathrooms and kitchens should be fitted with adequate extractor fan systems. These should run for at least fifteen minutes after occupancy to prevent condensation. The installation of floor drains should be considered in these rooms in case of overflow

6.2.3 Windows

Windows should be refurbished so as to allow easy and convenient opening and closing by occupants in order to encourage proper ventilation of the building. This is important both for environmental and structural health. Windows should be fitted with security locks so as to allow secure locking in a partially opened position

6.2.4 Paint finishes

Moisture vapour permeable or 'microporous' paint finishes should be preferred for internal and external surfaces and woodwork. This is especially important on window timbers. To take advantage of the properties of such paints, the complete removal of old alkyd paint systems is recommended. Health and Safety: Special precautions should be taken during surface preparation of pre 1960's paint surfaces as they may contain harmful lead

Appendix A

COMMON DECAY ORGANISMS

1 DRY ROT

Dry rot (*Serpula lacrymans*) belongs to the same group of fungi as most of the common mushrooms and toadstools. Reproduction is by means of spores which are produced in enormous numbers by the fleshy pancake-shaped fruiting body. These fruiting bodies generally only appear when the fungus is stressed or dying off. A well established infestation may produce fruiting bodies more than one metre across and be accompanied by thick layers of rust-coloured spore dust. Each minute spore has an outer coat which affords it some protection against heat and desiccation, and germination has been achieved after a twenty-year latent period. Dry rot spores are ubiquitous and there is no domestic or natural environment entirely free of them. They can be found throughout the environment from high up in the jet stream to the middle of the countryside

Spores will germinate and grow in timber with a moisture content of between 20 and 30 per cent. The fine fungal thread (hypha) digests the cellulose and hemi cellulose fractions of the wood, but is unable to attack the structural linings. These remain as a brittle matrix which cracks into cubes under differential stresses. Cuboidal cracking is also a characteristic of many wet rots and does not automatically indicate the presence of dry rot

Fungal hyphae may clump together into a variety of structures known as mycelia which take various forms depending on the surrounding conditions. They may fill a humid cavity as a cotton wool-like mass, or grow across the surface of the timber, as a grey-white skin. Active dry rot has a fresh white or greyish appearance and smells strongly of mushrooms. Distinctive patches of lilac or canary yellow pigmentation are usually present

Some hyphae group together to form conducting strands. These have a fairly impervious outer layer rich in chitin, the major constituent of insect cuticle. The strands, which may reach a centimetre in thickness, are flexible when moist, becoming progressively more brittle as they dry out. Their main function is the conduction of nutrients, through or across inert non-nutrient materials (brickwork etc) to other timbers. Their relatively impervious outer layer, together with an unusual alkaline tolerance, allows them to survive in the mortar layers within masonry and walls. An infested area may be full of dry rot strands. The dry rot fungus may tolerate relatively lower moisture contents and, through this, and other quirks in its biology, is potentially capable of considerable destruction. Realisation of this potential, however, requires a narrow range of environmental conditions and, in practice, several factors restrict growth

Dry rot hyphae may attack timber with a moisture content of about 18 per cent; however, spores would not germinate under these conditions. This moisture content is still 5 to 10 per cent wetter than timber should be in a healthy domestic building, and indicates water penetration or, perhaps, faulty plumbing. There is no evidence that dry rot can 'wet up' timber to any appreciable extent under conditions expected in a healthy building, although this is often claimed. The fine attacking hyphae, unlike the coarse conducting strands, are susceptible to desiccation and dry wood may disperse moisture faster than it can be transported. This means they cannot move through dry masonry and wood or across ventilated cavities

The total breakdown of wood by fungus produces considerable quantities of water. It has been suggested that dry rot can sustain itself on this 'metabolic' water alone. However, in practice, external drying factors disperse the moisture so that favourable conditions can be maintained only in exceptional circumstances such as behind impermeable finishes or in sealed cavities

In order to thrive, dry rot requires a moisture content in timber in excess of 20 per cent, and a relative humidity above 95 per cent. Below these levels the fungus will cease to cause current decay problems. Temperature is also a strong regulating factor, and growth ceases at about 25°C, a temperature frequently exceeded in roof spaces, for example. Large radiators can be particularly lethal to dry rot and measurements of 30°C with 20 per cent relative humidity are not unusual in their immediate vicinity

Dry rot is attacked by many other decay organisms which cause particular damage when the fungus is under stress will eventually destroy it. However, under dry conditions, dead dry rot does not disappear. Strands may eventually darken and the fungal mats may lose their fresh appearance, becoming tinged with brown, and leathery or papery in texture. The decayed wood becomes powdery as it dries, shrinks and distorts, which can be the first sign of decay having occurred behind paint finishes

2 WET ROT

Wet rot is caused by a number of basidiomycete fungi of which the most important are *Coniophora puteana* (cellar fungus), *Poria fungi*; *Fibroporia vaillantii*, *Poria placenta*, *Amyloporia xantha*, *Geophyllum trabeum*, *Phellinus contiguus*, *Donkiporia expansa*, *Pleurotus ostreatus*, *Asterostroma* and *Paxillus panuoides*. They attack both softwoods and hardwoods causing a darkening of the timber (brown rot) or bleaching (white rot). Wet rot fungi usually occur in persistently damp conditions, needing an optimum moisture content of 50 to 60 per cent. Unlike dry rot, the conducting strands of wet rot fungi do not extend far from their nutrient wood, hence they cannot travel through masonry and brickwork. The fruiting bodies occur rarely in buildings. Wet rot has been known to hollow out giant beams. Wet rot *Coniophora puteana* is responsible for up to 90 per cent of wood decay within buildings but raises less concern than dry rot, possibly because it is more easily controlled by standard building techniques. Some wet rots are also called soft rots as they destroy both cellulose and lignin, leaving the colour of the wood largely unaltered, but producing a soft felty or spongy texture. Soft rot is caused by *Chaetomium globosum* and a number of other fungi also found growing on wet wood in buildings

3 WOOD-BORING INSECTS

The common furniture beetle (*Anobium punctatum*) has a life cycle consisting of four stages - egg, larva (which causes all the damage), pupa and adult. The eggs are laid in end grain or in existing flight holes and hatch in 4 to 5 weeks and the new larvae bore directly into the wood. The larvae feed and grow within the wood creating a network of tunnels closely packed with frass (small ellipsoidal pellets). The larvae are whitish, curved, approximately 6mm in length and have well defined dark-brown jaws. When fully grown the larva excavates a small chamber and pupates producing a beetle after 6-8 weeks which bores through a thin layer of wood producing the characteristic emergence holes 1-2mm in diameter. Emergence usually occurs between May and August. The life cycle depends on the condition of the wood, the temperature and humidity. The life cycle usually takes a minimum of 3 years within buildings. Attack is usually confined to the sapwood of softwoods and hardwoods but may occur in the heartwood in timbers such as beech, birch, spruce or in timbers modified by fungal decay. As sapwood only makes up a small cross section of the majority of structural timbers in older buildings, attack is often of little or no structural importance. In most instances of suspected attack, the infestation has died out long ago due to unfavourable environmental conditions. Careful checking is therefore required to establish that living woodworm are present

In cases of active infestation the environmental conditions are often marginal allowing the life cycle to continue but at a very slow rate. Small changes in the environmental conditions can tip the balance against insects. Woodworm attack is often very localised to small areas of high humidity or especially 'palatable' timber and further spread is highly unlikely

In the British Isles, death watch beetle (*Xestobium rufovillosum*) infestations occur most commonly in oak, probably because this wood used to be extensively employed in construction, but infestation can also occur in elm, walnut, chestnut, elder and beech. The life cycle is similar to that of the common furniture beetle but can take many years to complete from one year under experimental conditions, to ten years or more in a building (Ref 11). The hatched larvae wander over the surface of the timber before burrowing into it. When it is fully grown it pupates and changes into the adult beetle which does not emerge until the spring of the following year producing a 3mm diameter hole

In old buildings severe damage can be caused under favourable environmental conditions. Softwoods are occasionally infested where they are in close proximity to damp infected hardwood. Infestation is confined to fungal decayed or damp affected timbers. Many existing cases probably arose from the reuse of infected timbers from demolished buildings and from the use of unseasoned timbers used in their construction. Attack is not confined to the sapwood and often the heartwood is entirely consumed causing severe structural damage. Damage is most severe where ventilation is poor and where timbers are in contact with damp masonry

Death watch beetles are not active fliers. A localised attack of death watch will not automatically spread to the whole house and infest every timber in the building. Lowering of moisture contents of the timber in conjunction with careful observation to determine the level and extent of activity should provide control of the insects. Some severe cases may merit the use of local insecticide treatments as a first aid measure. However, the chemical must be targeted properly or large quantities of toxic pesticides will be used to little effect

Woodworm and death watch beetle infestation will not flourish if the moisture content of timber is below about 14 to 15 per cent. The risk of infestation of insect attack is slight, in timbers with a moisture content at or below 14 per cent and the insect larvae will desiccate below about 12 per cent moisture content. The infestation will eventually die out if the timber moisture content is maintained below this. Healthy roof timbers should have a core moisture content of between 14 to 15 percent, while suspended floor timbers should be between about 11 and 14 per cent. Installation of a central heating system may reduce these moisture contents to about 9 per cent particularly in exposed timbers

It is absolutely necessary to recognise whether an insect infestation is 'active' or 'dead'. The presence of fresh frass (bore dust) in conjunction with damp timbers may be acceptable evidence of active infestation

Appendix B

SPECIALIST SEARCH TECHNIQUES AND THEIR LIMITATIONS

1 PRELIMINARY INSPECTION AND INVESTIGATION

The basis of any investigation is an understanding of building structures and defects and how these may interact to produce the ecological niches in which various decay organisms can thrive. With experience, an initial visual inspection can give a good idea of the areas that will need further study. A check-list for this preliminary investigation includes building defects, significant timber structures and concealed cavities

The condition of concealed timbers may be deduced from the general condition and moisture content of the adjacent structure. Only demolition or exposure work can enable the condition of timber to be determined with certainty and this destroys what it is intended to preserve. A non-destructive approach is therefore required and to help reduce uncertainty, specialist instrumentation and test equipment can be useful. However, it is important to remember that all tests and instruments are only aids to the surveyor, and must be interpreted with experience and care. A slavish reliance on any technique and failure to take into account its limitations is a recipe for disaster. No technique can be 100 per cent accurate or reliable

The techniques that may be used for preliminary investigation include resistance-based timber moisture meters, capacitance masonry moisture detectors, borescopes and Rothounds

2 DETAILED INVESTIGATION

The findings from the initial investigations are followed up by more detailed study. The aim is to determine as far as possible the distribution and extent of all significant decay and organisms in the building, the distribution of micro environments predisposed to timber decay and the building defects that cause them. The extent of significant timber decay should also be determined as far as possible. Active decay organisms may not yet have caused significant timber decay. Conversely, there may be significant decay even when the decay organisms that caused it have been dead for many years. This may seem obvious but many expensive 'treatments' are carried out on insect or fungus damaged timber that has not been infected for tens or even hundreds of years. Key factors that may be noted are species and viability of decay organisms, moisture content of materials, ambient relative humidity, and ventilation. Timber species and previous chemical treatments may also be significant

It is important that the results of the investigation are co-ordinated with the building structure bearing in mind the characteristics of particular periods and methods of building. They should also be carefully recorded and quantified where possible. This allows analysis of the results by other experts, reduces the 'grey' area in which disputes of opinion can arise and forms a basis on which future investigations can build. Photography can be especially valuable and may be used when necessary

3 ROTHOUNDS

Rothounds are specialist search dogs trained to help find dry rot (*Serpula lacrymans*) in buildings. Rothounds may indicate areas of active dry rot even before they are visible to the naked eye. This will occur if the dry rot is just developing, is inside the substance of the timber, between the timber and another surface or within porous masonry. Such indications may be confirmed by comparing them with measurements of the moisture content of the structure or by the use of a drilled sample. Rothounds will not indicate the remains of dead dry rot infestations

In areas indicated by Rothounds the significant timber structures should be checked for structural decay or high moisture levels. Even if these are not found steps should be taken to reduce moisture levels and increase ventilation. This may be all that is required to stop a developing problem and all that is then required is to check the area in 6 months. For this purpose Hutton + Rostron again favour the Rothounds

3.1 Capabilities

- a May detect living dry rot (*Serpula lacrymans*) by the scent of the metabolites produced by the fungus
- b May detect the scent of dry rot even when hidden behind panelling, under floors, behind plaster or in other concealed cavities
- c May detect the scent of dry rot at a distance of several metres depending on scenting conditions
- d May detect early dry rot growth before it is detectable by the unaided human eye
- e May discriminate between living or dead dry rot and between dry rot and other fungi instantly
- f Actively search for dry rot in buildings at high speed, covering 20 to 50 rooms in an hour g May indicate extent and spread of dry rot infestation
- g Will search small inaccessible areas and roof spaces i Will work in furnished and inhabited buildings
- h Totally non-destructive
- i Will work 2-4 hours per day

3.2 Limitations

- a Trained only to indicate living dry rot, not wet rot or dead dry rot. Will not indicate fruiting bodies on old dead outbreaks of dry rot
- b Indicate the scent of dry rot and the point of maximum scent. This may need interpretation as scent can occasionally be moved by air currents from the point of origin
- c Scent will not travel through impermeable surfaces such as neoprene. However, it may be detected at the edge of an impermeable barrier, e.g. around the edge of a room with a rubber-backed carpet covering an infected floor
- d Indicate dry rot infection, not decay. Therefore heavily decayed but inactive outbreaks may give a weaker indication than a recent highly active outbreak that has not yet caused significant decay

- e Maynot work if there is a corrosive or choking dust or vapour. However, Rothounds should not be put off by smells and may detect even small amounts of dry rot in the presence of other strong scents

3.3 Uses

- a Survey of properties prior to purchase, renovation, change of occupancy etc, to quickly check for hidden problems
- b Preliminary survey of properties with suspected decay problems to determine existence and extent of dry rot infestation
- c Survey of properties with known dry rot problems to determine activity and extent of infestation
- d Survey of properties undergoing remedial works to check for additional hidden areas of infestation
- e Survey of properties after remedial works to check for efficiency of treatment
- f Routine survey of properties with past problems thought to be at risk in order to detect recurrence of infestation at an early stage before significant decay can occur
- g Periodic survey of properties with known problems awaiting renovation, to detect 'hot spots' of dry rot activity

These can then be dealt with by 'reactive maintenance' allowing outbreaks to be controlled by minor exposure works and environmental controls. This avoids expensive building or remedial works. Further decay is prevented and infection controlled with significant savings on eventual renovation

4 FIBRE-OPTIC BORESCOPE EXAMINATION

A technique we have found routinely useful over the last 15 years is the use of fibre optics. We use long reach, fixed side view, rigid borescopes and high-power light sources. Although this is comparatively expensive it is essential for getting a clear view across a cavity such as a floor space. It also minimises the time spent and the number of holes drilled. Fibre optic inspection can reveal extensive decay and the consequences of water penetration. However, most wood-destroying fungi will not live on the face of timber which is exposed to air movement because this produces a drying effect. It is always a possibility that a fungus, especially dry rot, is travelling behind a wall plate, for example, and is not detectable from the cavity. Fibre optic inspection may not, therefore, find a minor attack which is developing, but it should indicate where these might be initiated so that faults can be identified and remedied. The siting of inspection holes depends on the points at risk within the room and will usually be located adjacent to balcony floors, flat roofs, cracks in rendering and other points where faults may have resulted in water penetration. Inspection may also be limited in areas of tiled and glued flooring materials and ornate or special wall coverings. Inspection holes are numbered and capped off for future use

5 THE MEASUREMENT AND SIGNIFICANCE OF MOISTURE CONTENT

The moisture contents in timber, mortar and plaster are measured by a variety of methods. Timber moisture content might be ascertained by the use of a standard resistance-type moisture probe which measures the moisture content at the surface of the wood.

However, this moisture content will be subject to considerable fluctuation, depending on current relative humidity and temperature. A rafter in a roof in summer may, for example, have a moisture content at the surface of 16 per cent which might rise to over 20 per cent in winter. This difference would not necessarily reflect increased water content resulting from a fault in the roof, but might simply be a redeposition of water resulting from a considerable drop in temperature

The condition in the core or subsurface of a timber will remain relatively stable which is why the centre of thick timbers may be preferentially decayed. It is this 'deep' moisture content which must be measured if results are to be meaningful. For this reason, a hammer probe with insulated electrodes or deep moisture probe is used to measure the moisture content within the timber. Healthy roof timbers should maintain a stable core moisture content of between about 12 per cent and 16 per cent, whilst suspended floor timbers (excluding ground floors) should be between about 11 per cent and 14 per cent. Central heating will usually reduce this figure to around 9 per cent

Similarly, surface moisture content readings in plaster and mortar are of limited value except for purposes of comparison. A surface capacitance meter may be used on plastered walls. For further investigation absolute measurements of moisture content may be made on site by means of a carbide-type gas pressure meter

Alternatively, samples are taken back to the laboratory in sealed vials, and the moisture contents are measured by the oven and balance method. For this, mortar samples are obtained by drilling holes in the wall and dust from the first inch of each hole is discarded. Dry mortar and plaster should have moisture contents below about 2 per cent. At levels much above this the moisture content of incorporated timbers will exceed 20 per cent and may easily reach levels at which fungal decay is likely

6 OTHER TECHNIQUES

Other techniques that may be used include microscopy, laboratory culture, hot wire anemometry and electronic RH measurement. We have also developed special instruments for measuring 'available' water in materials and for ultrasonic detection of timber-boring insects. More exotic techniques may sometimes be useful such as pheromone insect traps, infra-red thermography, shortwave radar, automatic weather stations and total building monitoring using specialist data loggers

Appendix C

REMEDIAL BUILDING WORKS AND ENVIRONMENTAL CONTROL

The most critical factors for the environmental control of decay organisms are available moisture and temperature. The former is dependent on such factors as moisture content, relative humidity, micro-ventilation, and salt content. In simplistic terms it is necessary to correct building defects leading to high moisture contents in timber and to increase ventilation around timber at risk

In practice there are two problems; first it is necessary to identify the significant building defects and then the best techniques must be chosen to control the environment at each point. This may be achieved by analysing the building in terms of moisture sources, moisture reservoirs and moisture sinks

It is not possible to prevent moisture entering a building entirely and often attempts to block the movement of moisture through a building structure using impermeable materials are ineffective. They may also be counter-productive as they can prevent moisture being dissipated, resulting in high moisture levels and decay in adjacent materials. The more effective and robust approach is that used in traditional buildings. Here, porous materials are preferred, and every moisture source is balanced by a moisture sink. Thus ground water may penetrate masonry but is evaporated off before it reaches timber structures. Similarly, water vapour is introduced by occupation, but is ventilated out via windows, chimneys and other passive and active forms of ventilation. Failure to balance a moisture source with an appropriate sink may result in moisture moving into vulnerable materials and eventually causing decay and other problems

Moisture reservoirs occur when a moisture 'source' has not been balanced by a 'sink' and water has accumulated in a porous material. Typical examples of this are to be found when thick masonry walls have been soaked by persistent leaks or when chimney breasts have been filled with rain water from uncapped chimneys. Such reservoirs may take years to dry out, even when the source has been dealt with. As a result, they can act as a source of moisture for recurrent timber decay over a long period. A special case of this phenomenon occurs when large quantities of water have been used in fighting a fire

In practice then, each area of decay is associated with a building defect, resulting in an increased moisture source, a blocked or inappropriate moisture sink or a moisture reservoir. The appropriate building measures should then be specified to correct that defect

A common example might be the bridging of a damp proof course by raised ground levels. This will act as a moisture source and may result in decay of timbers in an adjacent floor space. Reducing the ground level will cut off this source and will also provide a sink of moisture by allowing evaporation from the exposed wall. The sub-floor moisture level might also be controlled by increasing the other available moisture sinks. Cleaning pre-existing airbricks or inserting additional sub-floor ventilation would be a common measure. In general, it is important to increase evaporative surfaces and avoid obstructing them during refurbishment

Another common example would be a blocked and overflowing parapet gutter acting as a moisture source. This could wet up gutter soles, joist ends and wall plates as well as any other structure in an expanding cone extending from the leak down through the building. Preventing this moisture source may require a number of measures such as increasing the capacity of down pipes, re-lining the gutters and fitting thermostatically controlled trace heating tape to increase free flow of snow melt water

Any failure in a roof finish, gutter or coping will generally result in significant water penetration into the masonry wall beneath, which will then act as a moisture reservoir. Any timber in contact with this reservoir will be at risk of decay as it will tend to 'wick' moisture from the masonry. Steps must therefore be taken to isolate in-contact timber from the masonry using such measures as DPC membranes or joist hangers producing an air gap. It will also be necessary to ensure the timbers are adequately ventilated so that any moisture that is absorbed can be breathed off. Closed cavities or water-impermeable layers over timbers at risk must therefore be carefully searched out and rectified using knowledge of historic methods of construction. Bricked-in lintels and sealed up emulsion-painted sash windows are typical examples of structures at risk in this way

Having cut off the moisture source to a moisture reservoir and protected the 'at-risk' timbers it is next necessary to provide safe 'sinks' for the moisture. This will ensure that the reservoir is dried out in the long term. In some cases, the reservoir can be removed entirely, for example damp pugging can be dug out and replaced. In most cases it is a matter of promoting ventilation around a wicking surface on the reservoir and ensuring that the moisture-laden air can be vented to the outside. Dry lining systems can be useful for this purpose as can the good old-fashioned chimney. Raising the temperature will promote the process of wicking and evaporation. General house heating can help but care must be taken to ensure that water vapour is not being 'pulsed' into other parts of the building by a sequence of evaporation and condensation down a temperature gradient. Heating can be especially useful if it is possible to heat the reservoir material itself. We have devised special systems for heating large section timbers and masonry for this purpose but again the old-fashioned fire-place and chimney is very useful

In some cases, dehumidifiers can be used in the short to medium term, but care must be taken. They often require special 'tenting' and monitoring so that moisture is removed from the appropriate material and not from the world at large. They also require high air temperatures and high RH's to extract moisture efficiently

In all cases most of the remedial building works that may be required are quite within the capacity of the general contractor. Most are traditional repairs though some may take advantage of new materials or techniques such as dry lining, joist hangers and tanking. New and potentially useful products are coming into the building market all the time, for example, time controlled automatic fans, hollow ventilating plastic skirting boards, plastic masonry drains, roof space ventilating systems and moisture permeable paints. All such products and techniques can be used to help in making the environmental control of timber decay even more efficient and economical. All that is required is careful analysis of each situation and a little scientific understanding

Appendix D

MAINTENANCE AND MONITORING

The investigation and building works described in the previous appendices should put a building back into a state of structural and environmental health. The environmental control approach will also mean that a building is less likely to develop problems in the future. This is because the effect of minor building failures should be 'buffered' by the robustness of the systems established. Fortunately, most traditional systems are robust in this way. This is why older buildings may tolerate a considerable amount of neglect and abuse before developing severe problems. However, the long-term health of the building will always depend on adequate maintenance. This is no less true of buildings treated with timber preservatives

A detailed investigation carried out as part of an environmental control policy provides an excellent basis on which to plan the most cost-effective maintenance program. Indeed, the building works required for environmental control are often best integrated into such a program. Short-term 'emergency' measures can be taken to simply halt further decay and measures to replace damaged structures or prevent future problems can be delayed to fit into a longer term plan of works. This flexibility in scheduling work as a result of the environmental approach allows further saving of costs and inconvenience

A maintenance program must also include provision for the routine inspection of all significant parts of the building at appropriate intervals. This should aim to detect and correct problems developing before they cause significant damage. Again the information gained in the investigation can be used to decide on the most cost effective inspection interval

In many cases remote monitoring systems can be very useful in increasing the efficiency and reducing the cost of maintenance programs. They can be especially useful for checking the moisture content of inaccessible timbers in roof spaces, behind decorative finishes and in walls. H+R have developed the Curator building monitoring systems for this proposal

Sensors can be placed at all critical points after the investigation or after the remedial building works. Areas can then be closed up and finishes re-applied, for example sensors may be placed in lintels, joist ends, valley gutter soles or in damp walls to monitor drying. It is important to use enough sensors and to place them with an understanding of the moisture distribution processes because conditions can vary even in a small area. It is these local variations in conditions that produce the environmental niches which decay organisms exploit

If more than 30 sensors are deployed, taking the readings can become onerous and this may result in human error or negligence. In these situations automatic monitoring systems become desirable. H+R have developed a number of specialised 'Curator' data logging systems to do this. With larger systems, the wiring of sensors can also become a problem. For systems requiring 100 or more sensors we can use a 'Curator A' unit working via a single 4-core main cable connecting up any number of nodes, each supporting 4 sensors. This system can be programmed with logging intervals and alarm limits for each sensor and can be read via the telephone system via its own modem. Data from the system can then be analysed using CAD and programs for statistical interpretation on a remote computer

Appendix E



Fig 1:

South elevation; showing general view of the exterior in a sketch dated 1795. The orangery was not added to the west (arrowed) until roughly 1823

(Source: Manchester City Council Local Image Collection)



Fig 2:

South elevation; showing a sketch from 1830. Circled is the orangery

(Source: Manchester City Council Local Image Collection)



Heaton Park - Orangery
Photographs
16 February and 15 March 2022

Hutton + Rostron Environmental Investigations Ltd, Netley House, Gomshall, Surrey, GU5 9QA
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Fig 3:

South elevation; showing general view of the Orangery in 1902. The parapets above the colonnades at either end are visible. The roof to the central portion of the structure was in three main glazed portions. Either wing is covered by a small hipped roof, whilst the central gallery was covered by a cylindrical dome

(Source: Manchester City Council Local Image Collection)

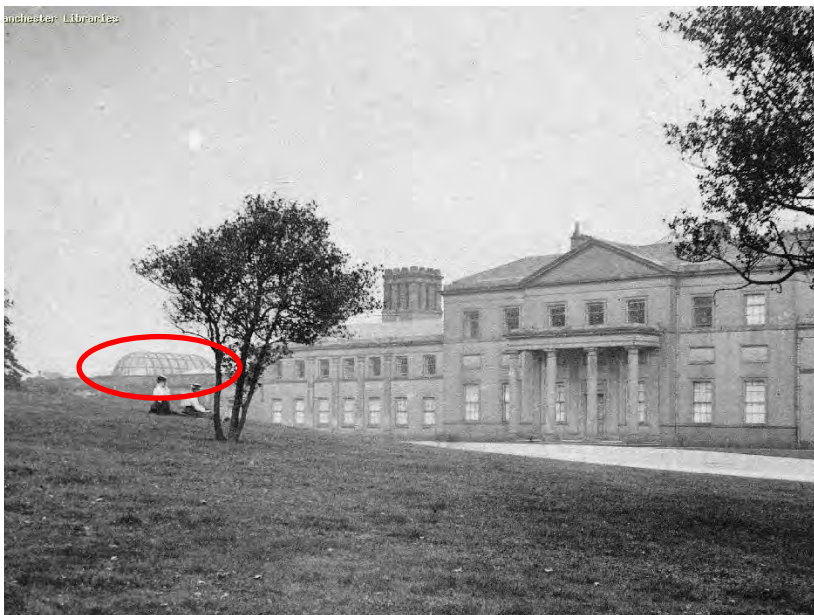


Fig 4:

North elevation; showing a general view of Heaton Hall in 1912. Circled is the north view of the glazed dome to the Orangery's central gallery—this angle highlighting the dome's cylindrical shape

(Source: Manchester City Council Local Image Collection)



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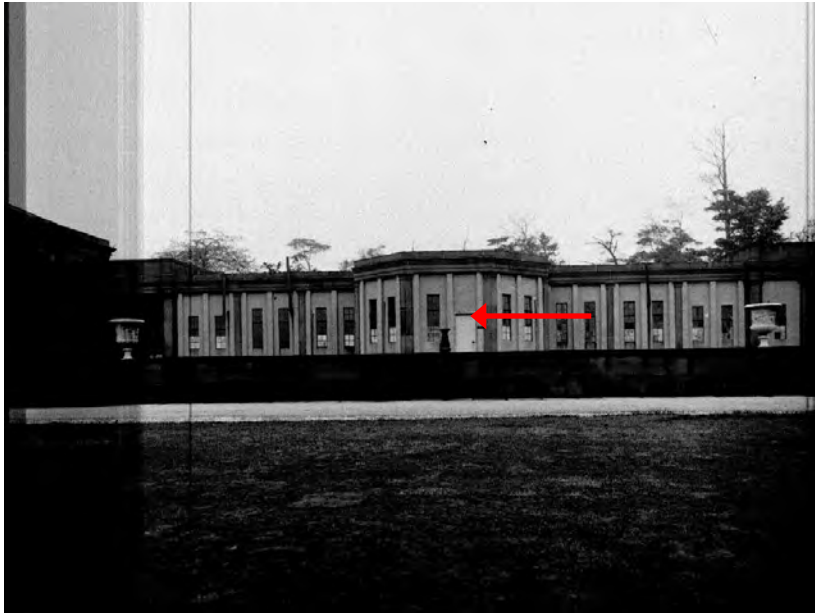


Fig 5:

South elevation; taken in 1920, showing a general view of the first major phase of alteration. The glazed portions of the roof were removed and a flat roof instated in its place. Additionally, much of the glazing to the South elevation was removed and cement panels instated with slender, apparently steel-framed windows. Arrowed is the timber door which was added to the bay

(Source: Manchester City Council Local Image Collection)



Fig 6:

South elevation; taken in 1972, showing the general configuration of the windows to the bay. Arrowed is one of the sand and cement rendered panels which appear to remain today. Likewise, the windows here appear to be of the same dimension as those at present, though with projecting metal rails



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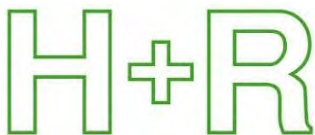
Fig 7:

South elevation; showing a general view of the east end of the Hall's south elevation and the projecting centre of the Orangerie (circled)



Fig 8:

RF-002 (Main roof); showing roof access via a sash window to Heaton Hall. The lower sash opening was relatively small and access may be arduous for some



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Fig 9:

RF-002; showing general view of the main flat roof looking east. The roof was covered with torch-on felt and generally fell to the north. Some minor pooling water was occurring in undulations in the flat roof but this was not a significant problem

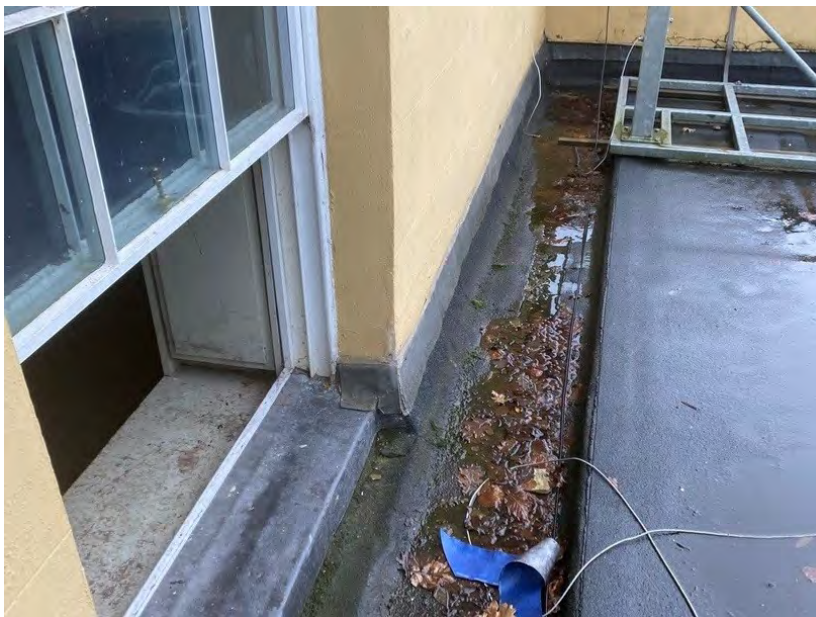
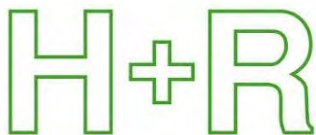


Fig 10:

RF-002; showing vegetation and debris caught in the drainage gully



Heaton Park - Orangery
Photographs
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Fig 11:

RF-002; showing the rainwater downpipe to the north-east corner of Heaton Hall. The downpipe was blocked and rainwater was discharging via the lead overflow, wetting the masonry below



Fig 12:

RF-002; showing rainwater discharging onto the masonry beneath Fig 13. Biological growth was evidence of prolonged wetting



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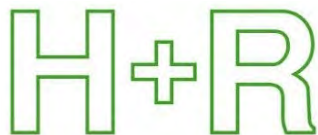
Fig 13:

RF-002; showing debris collecting in the drainage gulley along the north parapet



Fig 14:

RF-002; showing debris collecting in the drainage gulley and in the catchpit of outlet 1



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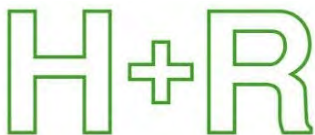
Fig 15:

RF-002; showing deterioration of the stone parapet and previous mortar repairs to the stone. The damage appeared to largely predate the re-bedding of the coping stones



Fig 16:

RF-002; showing cracking and de-bonding of the render from the internal face of the brick parapets



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Photographs
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Fig 17:

RF-002; showing a lead damp-proof course beneath the coping stones. This extended the full width of the parapet indicating the coping stones had been raised to accommodate this



Fig 18:

RF-002; showing the drainage gully between outlets 2 and 4. Water from the central portion of the roof drained toward outlet 4 meaning outlet 2 provided little to no use. A high concentration of debris was noted at outlet 4 resulting in pooling water



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Photographs
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Fig 19:

RF-002; showing overflow facility positioned at ~120mm above catchpit level



Fig 20:

RF-002; showing a typical catchpit outlet of only ~40mm diameter. This is extremely small and highly vulnerable to blockage



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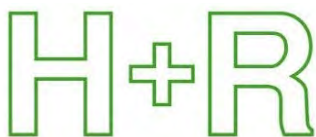
Fig 21:

RF-002; showing close view of outlet
no. 4



Fig 22:

RF-002; showing a general view of the
flat roof over the south projecting bay



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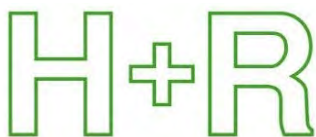
Fig 23:

RF-002; showing pooling water and debris collecting at outlet 6



Fig 24:

RF-002; showing recent replacement metal cramps between coping stones to the head of the parapet. Mortar bedding had generally perished and the cramps had dislodged



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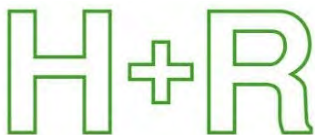
Fig 25:

RF-002; showing the projecting flue vent that serves the kitchen



Fig 26:

RF-003 (Northwest extension roof); showing outlet 1's termination onto the drainage gully beneath



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Fig 27:

North elevation; showing splitting of the older thicker gauge leadwork capping to the base of the parapet. This increased the risk of water penetration via the mortar joints between abutting string course units



Fig 28:

RF-003; showing the perimeter drainage gully, terminating into the eaves gutter to the east elevation



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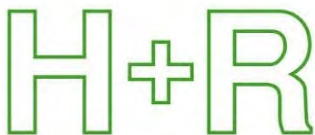
Fig 29:

RF-003; showing pooling rainwater to the south-east corner of the roof. This water was discharging into the eaves gutter to the east elevation



Fig 30:

RF-003; showing the drainage gulley alongside the north elevation of the main building. The gulley was supporting debris and some building materials



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Fig 31:

RF-003; showing the downpipe serving outlet 2. The downpipe clip was screwed into the render rather than the masonry, making its connection tenuous



Fig 32:

RF-003; showing the east eaves gutter



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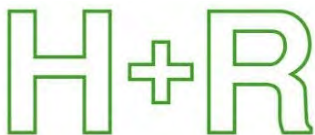
Fig 33:

RF-004 (Northeast extension roof) ;
showing a general view of the mono-
pitch roof



Fig 34:

RF-004; showing the lead pipe serving
outlet 6 at its termination onto the
mono-pitch roof. There was a tear in
the older lead pipe that passes through
the parapet



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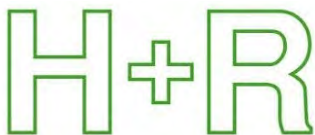
Fig 35:

RF-004; showing a build-up of debris within the gutter



Fig 36:

East elevation; showing the hopper and downpipe that serve the valley gutter to RF-004. The downpipe appeared to discharge directly onto the ground rather than into a drain. Also note the damage to the hopper



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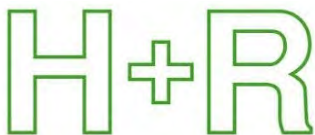
Fig 37:

East elevation; showing the damaged hopper and debris build-up



Fig 38:

West elevation of northeast extension; showing downpipe serving outlet 5 which discharged onto the hardstanding



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Fig 39:

RF-005; showing a copper water pipe penetration through the flat roof. The recent re-roofing had not accounted for this detail and liquid asphalt had been applied for waterproofing. This was ineffective and water penetration was ongoing



Fig 40:

North elevation; showing decay in the base of the frame to the easternmost window. This was likely due to the defective opening surrounding the service pipe adjacent (arrowed). Also note the breakages in the glazing



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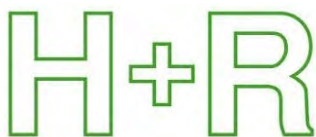
Fig 41:

RF-005; showing poor detailing of the felt upstand at the abutment to the north elevation of the main building. This was vulnerable to water penetration



Fig 42:

North patio; showing trees rooted at the base of the north boundary wall. Roots may be causing damage to the foundations of this wall



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Fig 43:

North elevation; showing the lead downpipe serving outlet 4 that discharged onto the hardstanding



Fig 44:

North elevation; showing an example of one of the typical window forms. These windows show evidence of multiple layers of paint and appear to predate the new windows to the south elevation. Note the mechanical damage to the stone sill which will reduce the sill's ability to shed water



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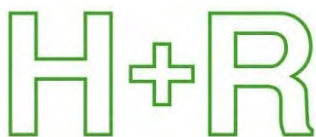
Fig 45:

North elevation; showing de-bonding of the lower 500mm of render



Fig 46:

North elevation; showing de-bonded render revealing the brick substrate



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Fig 47:

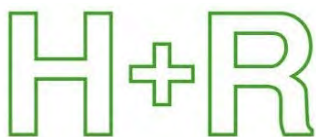
North patio; showing hardstanding that was generally graded towards the north elevation. Plant growth and moss growth indicated poor drainage of the hardstanding

Note the manhole cover was poorly secured and this represented a potential hazard



Fig 48:

East elevation of Northwest extension; showing timber framed fixed and hopper windows. The downpipe serving outlet 4 discharged onto the hardstanding



Heaton Park - Orangery
Photographs
16 February and 15 March 2022



Fig 49:

North elevation; showing raised ground levels to the northwest extension. The lower arrow indicates the approximate height of the internal floor

Note that the downpipe to north-east of Heaton Hall was blocked (see Fig 13-14)



Fig 50:

West elevation; showing cracked render to the lower portion of wall. This may be due to the lack of a window sill to this window, resulting in water penetration behind the render



Heaton Park - Orangery
Photographs
16 February and 15 March 2022



Fig 51:

North elevation of Northeast extension; showing angled bricks supported from an earth retaining wall. The bricks span a ventilated trench



Fig 52:

North elevation of Northeast extension; showing a view inside the ventilated trench. Note the earth-retaining wall is tied to the external wall with brick ties. It is unclear whether this detail is original to the building or was constructed in response to damp



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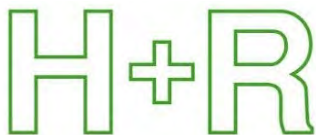
Fig 53:

South elevation; showing a general view



Fig 54:

West colonnade; showing an example of the double doors to the main entrances at each end of the Gallery



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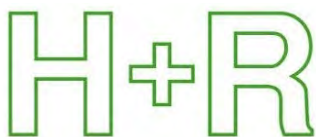
Fig 55:

South elevation; showing an example of a recently installed single glazed timber sliding sash windows. The rendered panels to either side are understood to date from the 1970's



Fig 56:

South elevation; showing area of locally de-bonded render to brick infill panelling



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Fig 57:

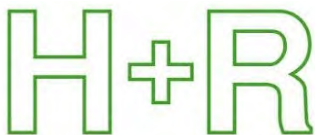
South elevation; showing an indent stone repair to the pilaster with a contrasting stone. Repair can be attributed to corrosion of a metal dowel

Note the cracking directly beneath caused by corrosion of a ferrous metal dowel



Fig 58:

South elevation; showing failure of the stone caused by corrosion of the metal dowel



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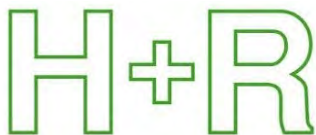
Fig 59:

South elevation; showing approximately 60mm stone cover to the dowel



Fig 60:

South elevation; showing weathering and previous mortar repairs to the delaminating stone sill



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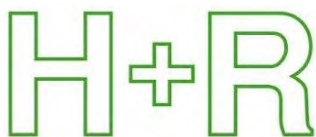
Fig 61:

South elevation; showing delaminating stone sill



Fig 62:

South elevation; showing a surface drain which drained into the brick culvert network



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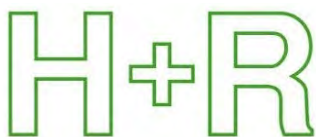
Fig 63:

South elevation; showing brick culvert system visible through a surface drain



Fig 64:

South elevation; showing surface drains which drained into the brick culvert network



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16 February and 15 March 2022



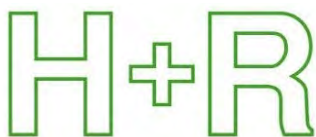
Fig 65:

South elevation; showing a view of the brick culvert system. Detailed construction, condition and extents are unknown



Fig 66:

South elevation; showing a loose plinth stone to the corner of the bay



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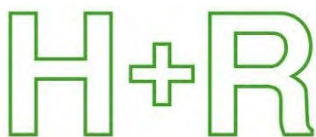
Fig 67:

South elevation; showing cracking and debonding of the render



Fig 68:

South elevation; showing delamination of the stone sill where surface water is able to pool



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Photographs
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Fig 69:

East colonnade; showing a general view



Fig 70:

East colonnade; showing degraded sandstone caused by corrosion of the former door fixings. Note stone indent repairs which probably indicate the locations of former corroded fixings



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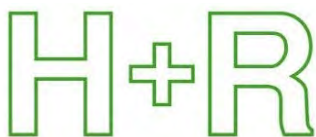
Fig 71:

East colonnade; showing corroded, disused door fixing. Sandstone surrounding is degraded



Fig 72:

East colonnade; showing cracking through the rendered lintel



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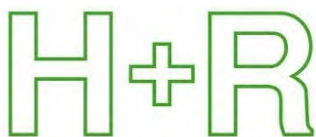
Fig 73:

East colonnade; showing blocked surface water drains



Fig 74:

East elevation; showing a view of the north-east corner of the building where external walls were partially earth-retaining. The arrow indicates the location of the door into the kitchen



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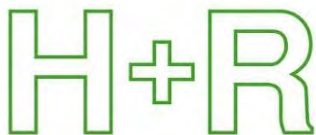
Fig 75:

East elevation of Northeast extension; showing rear entrance. This door was decayed at the base of its casing, due to collected debris and inadequate drainage



Fig 76:

Main gallery; showing a general view of the concrete beam and decked roof/ceiling. Beams were plastered and finished with paint. Note that the west end of the solid floor appeared to slope south



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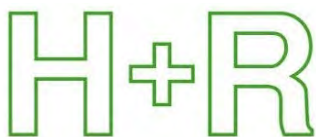
Fig 77:

Main gallery; showing a general view of the south bay. Note the wet system column radiators and additional electric fan heaters



Fig 78:

South elevation; showing double door which was extremely stiff and difficult to open, evidencing lack of use



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Fig 79:

Main gallery; showing previous phases of replastering using gypsum. The gypsum and earlier lime plaster was debonding



Fig 80:

Main gallery; showing double doors to the northwest extension. These and other internal doors were closed during inspection, restricting airflow between different areas of the interiors



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Fig 81:

Northwest extension; showing an internal manhole cover that could not be raised during the survey. Ceramic floor coverings had suffered mechanical damage in this area



Fig 82:

Northwest extension; showing existing internal finishes. Note masonry samples no. 1-4 taken from the west wall



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Fig 83:

Northwest extension; showing the relatively recently installed hot water cylinder and expansion vessel



Fig 84:

Northwest extension; showing curved, external brick wall. Note the lower portion of this wall was earth-retaining. Masonry moisture contents in this area were high and timber skirting boards were generally damp and partially decayed



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Fig 85:

Northwest extension; showing timber roofs joists and wood wool boards. The roof was largely concealed by the plasterboard ceiling but there was a significant risk of timber decay in the bearing ends of the joists



Fig 86:

Northwest extension; showing a general view of the Female WC



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Fig 87:

Northwest extension; showing a mechanical extract fan to the Baby Change Room. There was no background ventilation to this room



Fig 88:

Main gallery; showing an example of the secondary glazing to the double-glazed windows to the north elevation



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Fig 89:

Main gallery; showing poor decorative finishes directly beneath the overloaded rainwater outlet 4. Park staff confirmed this area had recently been subject to water penetration due to blockage in the outlet. Replastering in this area also indicates a history of failure. Masonry moisture contents in this area were high



Fig 90:

Main gallery; showing modern gypsum plasters over earlier lime plasters



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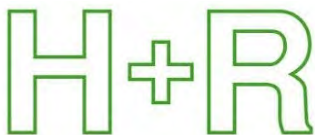
Fig 91:

Main gallery; showing replastering with gypsum in the north-east corner. Note the internal wall was a timber stud partition lined with plasterboard and included a timber skirting board



Fig 92:

Northeast extension; showing plastic sheet wall coverings which prevented access for masonry moisture profiling



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Photographs
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Fig 93:

Northeast extension; showing plastic wall coverings which prevented access for masonry moisture profiling. The lower portion of these walls were earth-retaining and should be assumed to be wet



Fig 94:

Northeast extension; showing an internal drain that was draining water penetration via the leaking valley gutter and where entering beneath the external door



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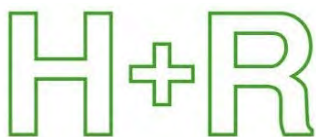
Fig 95:

Northeast extension; showing debris build-up and evidence of water pooling in the north-east corner of the Kitchen



Fig 96:

Northeast extension; showing the relatively recently installed gas combi boiler



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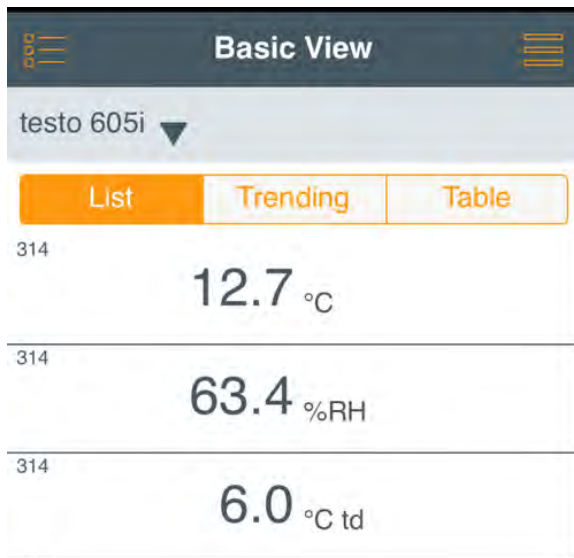


Fig 97:

Main gallery; showing hygrothermal readings taken within the room:

12.7°C - Temperature

63.4% - Relative humidity

6.0°C - Dew point

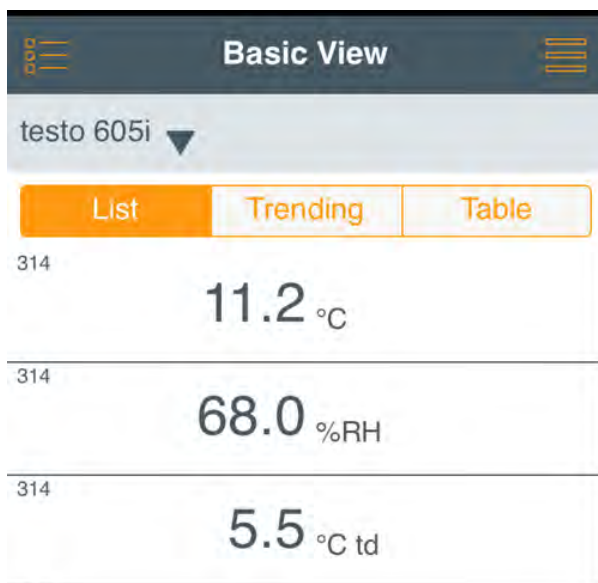


Fig 98:

Northwest extension; showing hygrothermal readings taken within the room:

11.2°C - Temperature

68.0% - Relative humidity

5.5°C - Dew point



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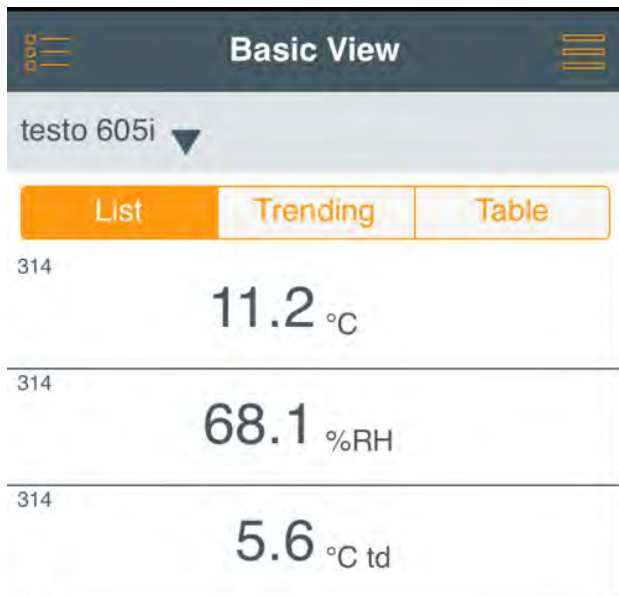


Fig 99:

Northeast extension; showing hygrothermal readings taken within the room:

11.2°C - Temperature

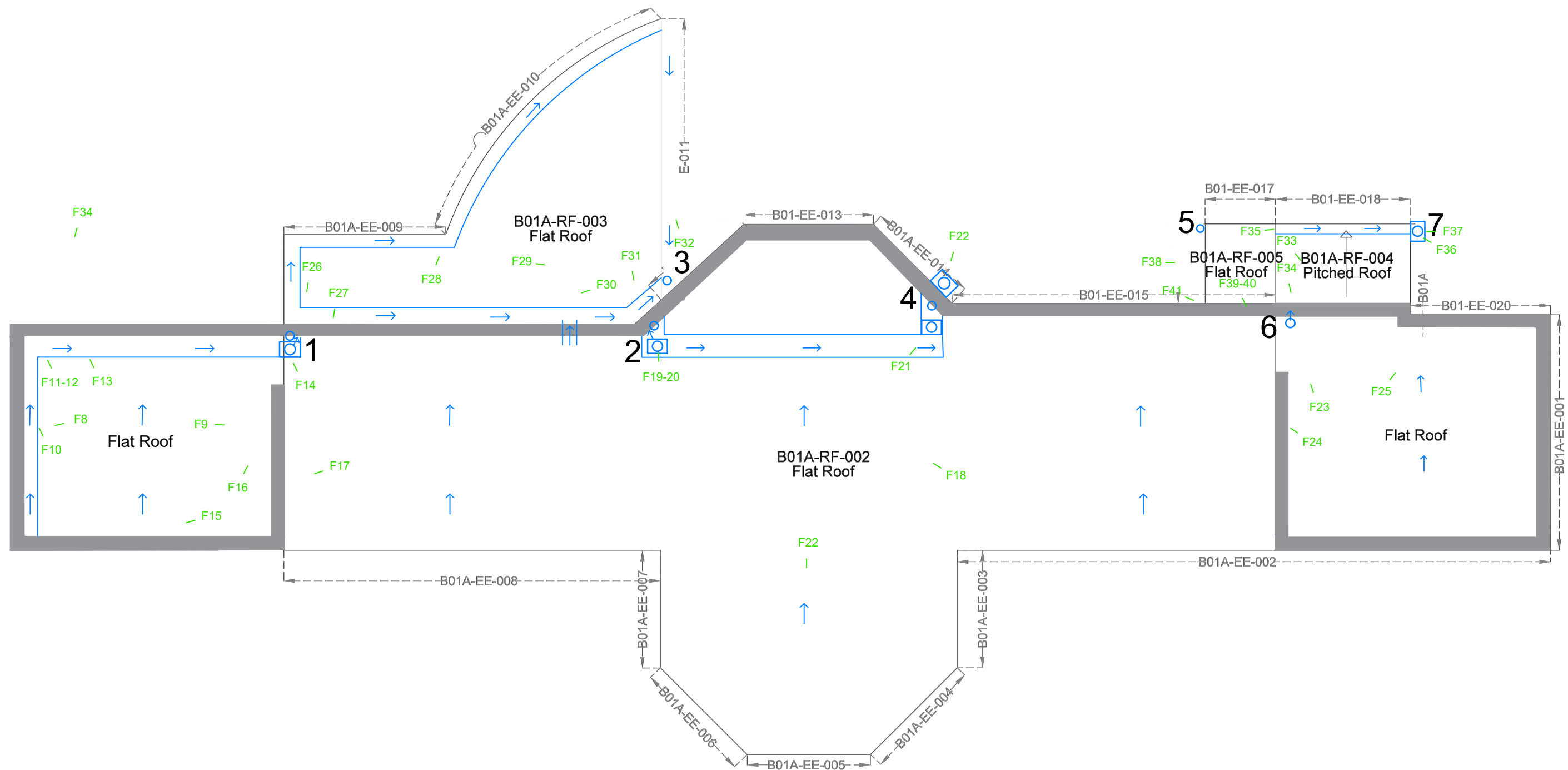
68.1% - Relative humidity

5.6°C - Dew point

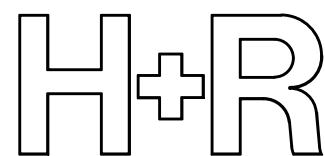


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Photographs
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Appendix F

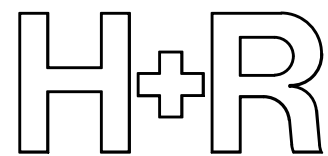
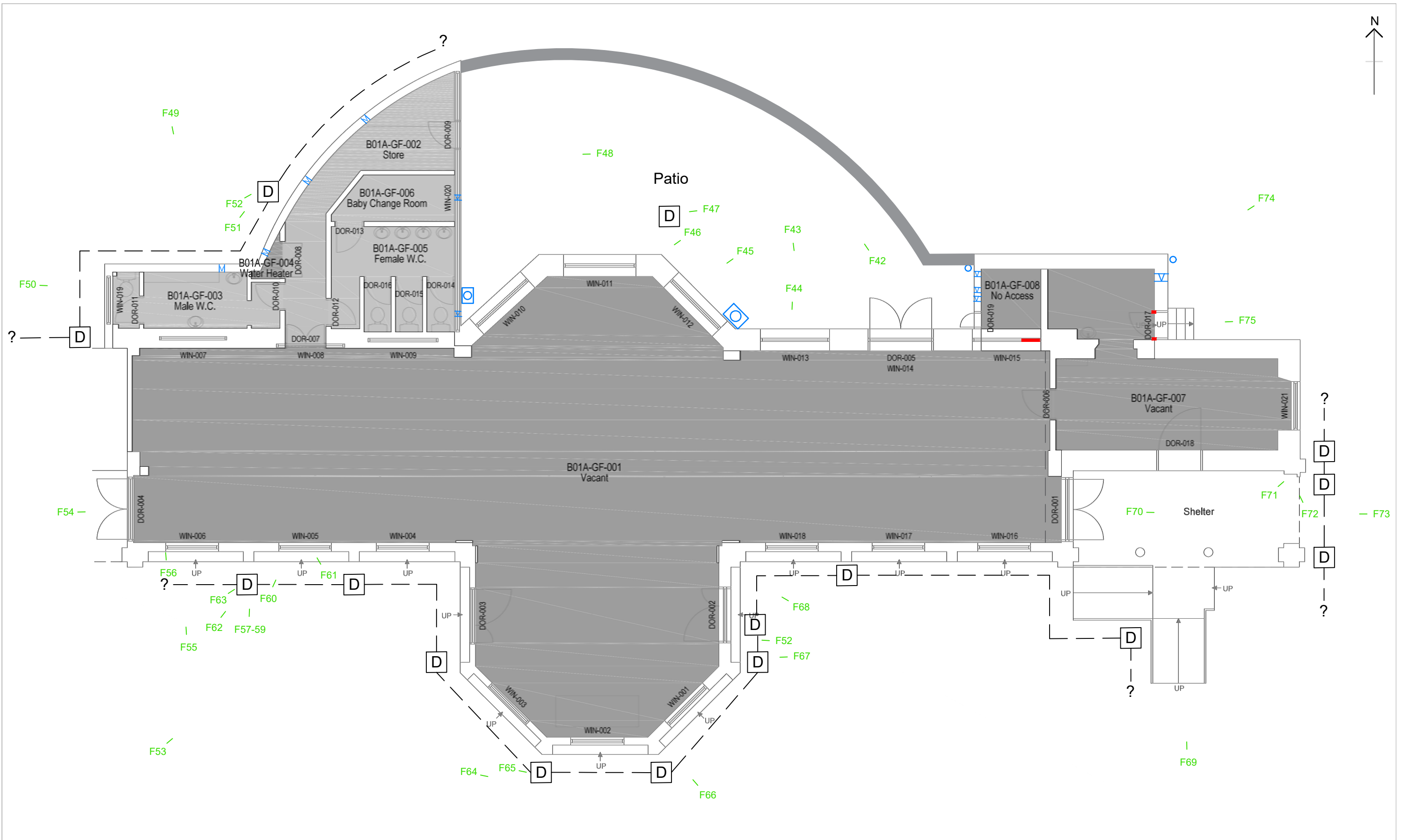


- Key:**
-  Rainwater hopper / catchpit
 -  Rainwater drainage gully / valley gutter
 -  Rainwater flow direction
 -  Rainwater downpipe / overflow pipe
 -  1-7 Rainwater outlet number
 -  F1 Photograph location



Heaton Park - Orangery - Roof coverings
INVESTIGATION OF DAMP
16 FEBRUARY & 15 MARCH 2022

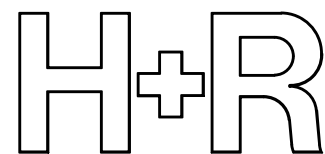
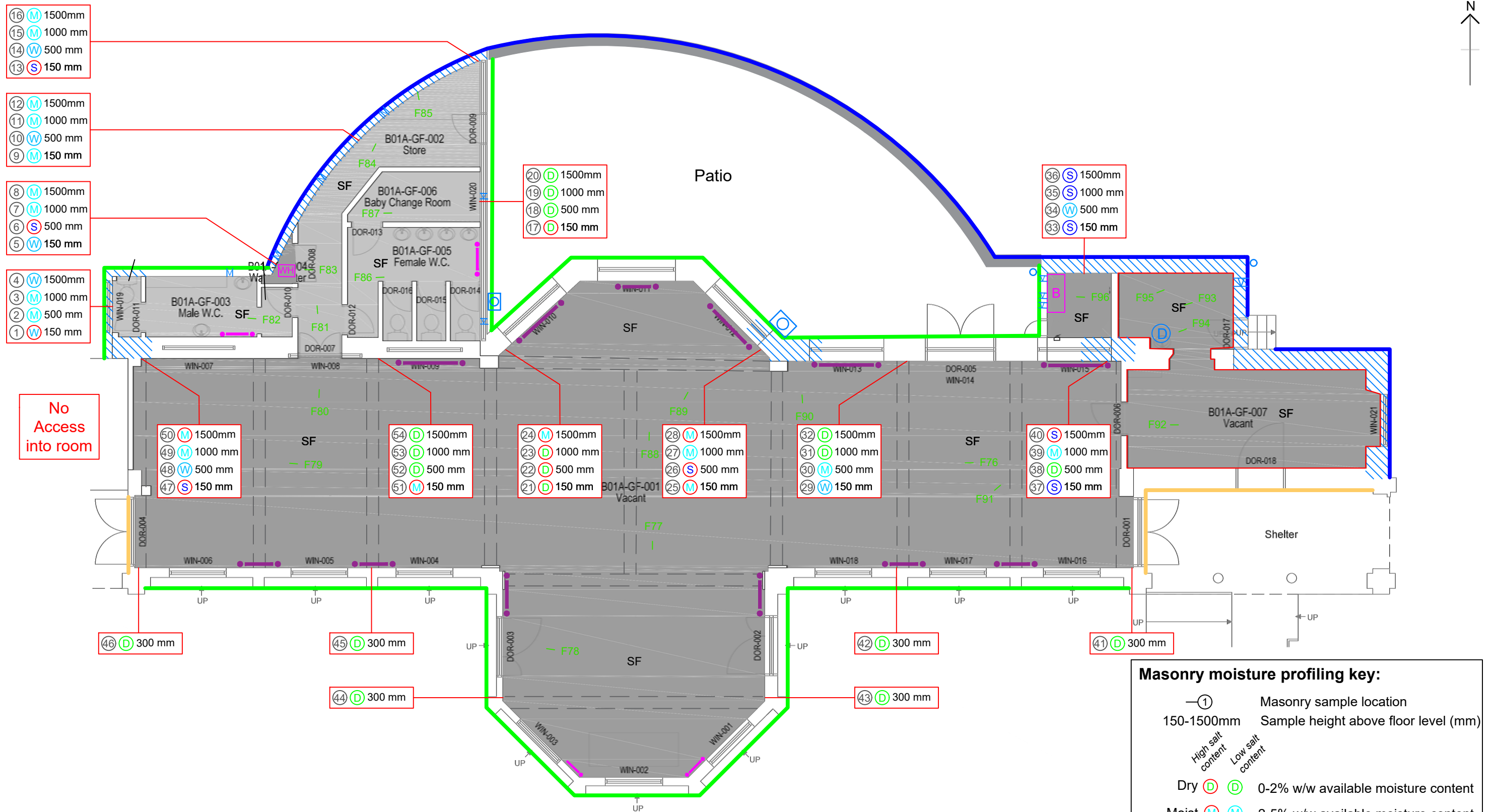
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Heaton Park - Orangery - Exteriors **INVESTIGATION OF DAMP** **16 FEBRUARY & 15 MARCH 2022**

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- Key:**
- Rainwater hopper / catchpit
 - Rainwater downpipe
 - Vent passing through wall
 - Perimeter / surface drain
 - Brick culvert/ below ground drain
 - Photograph location
 - Decay to window / door



Heaton Park - Orangery - Interiors **INVESTIGATION OF DAMP** **16 FEBRUARY & 15 MARCH 2022**

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Key:		Rainwater hopper / catchpit		Radiator (wet system)
		Rainwater downpipe		Radiator (electric)
		Vent passing through wall		Water Heater / Boiler
		Photograph location		External ground above internal floor
		Area subject to water penetration		External ground level with internal floor
		Internal floor beam		External ground level at least 100mm below internal floor
		Solid floor		Wall inaccessible for masonry profiling

Appendix G

Table of material moisture contents

Appendix G

Samples of masonry were drilled from walls in areas vulnerable to damp penetration. The samples were placed in sealed containers and tested at the H+R laboratory in accordance with the procedure for gravimetric measurement of moisture content as described in the appendix to BRE Digest 245

Sample Number/Location	Moisture content % w/w			Hygroscopic moisture content % w/w	Available moisture content % w/w
1	11.21	W	H	4.32	6.90
2	5.22	M		0.64	4.57
3	3.01	M		0.99	2.02
4	6.15	W		0.71	5.44
5	6.94	W		0.49	6.45
6	13.52	S		2.29	11.23
7	4.94	M		0.55	4.39
8	5.84	M		1.63	4.21
9	5.63	M		1.19	4.44
10	7.91	W		1.74	6.17
11	3.18	M		0.87	2.31
12	3.35	M		1.03	2.32
13	17.00	S		3.06	13.94
14	7.61	W		1.19	6.42
15	3.68	M		0.99	2.69
16	2.96	M		0.84	2.12
17	4.22	D		2.57	1.64
18	0.78	D		0.56	0.21
19	0.64	D		0.36	0.28
20	0.53	D		0.27	0.27
21	4.61	M		2.05	2.56
22	6.11	D	H	6.79	-0.68
23	3.99	D	H	4.03	-0.04
24	2.48	D		2.44	0.03
25	10.94	M	H	8.06	2.87
26	13.97	S	H	5.68	8.29
27	4.37	M		0.35	4.02

28	8.15	M	H	5.33	2.82
29	6.09	W		0.51	5.58
30	2.81	M		0.75	2.06
31	0.42	D		0.33	0.09
32	0.95	D		0.56	0.39
33	16.09	S		1.27	14.82
34	8.20	W		0.21	7.99
35	10.69	S		0.70	9.99
36	13.25	S		1.18	12.07
37	13.71	S		1.88	11.84
38	2.02	D		0.56	1.46
39	4.20	M		1.96	2.24
40	10.60	S		2.06	8.54
41	0.64	D		0.56	0.08
42	0.56	D		0.33	0.23
43	2.84	D		2.54	0.30
44	0.56	D		0.35	0.22
45	0.58	D		0.42	0.17
46	2.40	D		1.35	1.05
47	14.71	S		2.58	12.13
48	7.31	W		1.36	5.94
49	6.37	M		1.79	4.57
50	6.46	M		2.07	4.38
51	6.79	M		2.79	4.00
52	1.66	D		1.55	0.10
53	0.76	D		0.64	0.12
54	0.79	D		0.83	-0.05

Notes on the table

Hygroscopic moisture is the 'air dry' moisture content of the sample at equilibrium with 75 per cent relative humidity. Where the 'Available Moisture Content' of the sample is higher than the 'Hygroscopic Moisture Content', there is excess water and a 'damp' condition exists.

For easy of interpretation, we have characterised 'damp' materials into **M = Moist** **W = Wet** **S = Saturated**. Dry materials are characterized as **D = Dry**

Samples providing a hygroscopic moisture content significantly above the norm are indicated with **H = Hygroscopic** to indicate an abnormally high degree of hygroscopicity. In samples 22, 23, 25, 26 & 28 hygroscopic moisture is the dominant fraction. This is probably caused by salt contamination of the substrates