CONSULTING
ENGINEERS

TRABUE, HANSEN & HINSHAW, Inc.

1901 Pennsylvania Drive
Columbia, MO 65202

August 13, 2014

Dave Culp
Chase Environmental Group, Inc.
109 Flint Road
Oak Ridge, TN 37830

Re: Pickard Hall Structural Condition Assessment – Decommissioning Activities
THHinc #7461
MU Project No. CP132141

Mr. Culp,

On Tuesday April 8th I, along with two other ***THHinc*** engineers, John L. Smith, PE and T. Patrick Earney, PE, performed a visual observation of the Pickard Hall structural framing. The purpose of the observation was to gather information with regard to the existing structural framing, and its condition. This document is focused on the specific information you need in order to assist with the development of Chase's work describing various decommissioning scenarios. Although our General Condition Assessment is not intended to be a stand-alone document, we fully expect that it will be attached to, or otherwise included with, your final product.

As the title implies, our visual observation was limited to those items that were readily visible. Typically, at a minimum, this would include a look behind select partition walls and in the ceiling plenums. However, complicating this project are the restrictions that have been set by the NRC and/or MU EHS. During our visit we were not permitted to perform *any* selective demo whatsoever which, considering that most all structural framing was concealed during the 1974 museum renovation, resulted in an unusually high number of assumptions. Therefore, to a large extent, our recommendations are based solely on information gathered from historical documents provided by the University.

At this time it appears as though there are realistically five possible decommissioning scenarios that will result from this work. The building will be "cleaned" of all radioactive contamination and released by the NRC, once it's released it might be restored to its current condition, it could be renovated to current MU standards, it may be remediated and then demolished, or the structure could be razed with radioactive materials present. The structural implications of each scenario are discussed in the body of this report.

Sincerely,
Trabue, Hansen & Hinshaw, Inc.

Kris Bezenek, P.E., S.E.
Structural Team Leader / Principal

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Structural Assessment &
Related Decommissioning Activities

Pickard Hall
University of Missouri, Columbia

for

Chase Environmental Group, Inc.
Oak Ridge, Tennessee

August, 2014

THHinc #7461

I hereby certify that this engineering observation report has been prepared by me or under my direct supervision. I am a Professional Engineer in good standing in the State of Missouri.

Kris L. Bezenek, P.E., S.E. Mo. Reg. No. 2007002765

THHinc

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STRUCTURAL ASSESSMENT & RELATED DECOMISHIONING ACTIVITIES

Pickard Hall - University of Missouri, Columbia
for
Chase Environmental Group, Inc.

On Tuesday April 8, 2014 a field visit was made to Pickard Hall located on the University of Missouri campus in Columbia, Missouri. The purpose of the observation was to gather information with regard to the structural framing and its existing condition. Additionally, work that may be required as part of an overall decommissioning process was considered during the time of the observation.

The observation was conducted at 9:00 AM in the company of:
Chase Environmental Group, Inc.
MU Environmental Health & Safety
(including others from MU Facilities, and Otis)

Engineers present representing Trabue, Hansen & Hinshaw, Inc. were:
Kris L. Bezenek, PE, SE
John L. Smith, PE, SE
T. Patrick Earney, PE

Pickard Hall Background

Also known as the "Old Chemistry Building", Pickard Hall was designed by Architect M. Fred Bell and the original construction was completed in 1892. There are known activities that took place, mainly in the basement, in the early 1900's that resulted in radioactive contamination of various areas and components of the building. This is well-documented and is beyond the scope of this report. However, the existing radioactive contamination, and providing a remedy for the situation, is the reasoning behind this current work.

The potential remedies include removing the contamination so that the building may be reoccupied or the structure might be razed and all contaminated materials removed from the site. The condition of the existing building will have an influence on which remedy is chosen. Additionally, with either solution there will likely be required activities that will have an impact on the structural framing.

Onsite Structural Observations

With the exception of the roof framing, most all of the interior structural components were concealed behind furring walls and other architectural "hard" finishes. Additionally, due to the sporadic and unknown extent of radioactive contamination, we were not permitted to move objects or perform any selective demo during our observation. Therefore, to a large extent, our recommendations are based solely on information gathered from historical documents provided by the University.

From the exterior the building appears to be in very good condition. The exposed brick façade was repaired and the mortar joints repointed during an extensive exterior renovation in 2000. The windows, window wells, doors, roof and one exterior stair were also replaced at that time. No cracks or other signs of distress were observed in the exterior brick and stone façade indicating that, at least since 2000, no significant foundation settlement has occurred.

Figure 1: Front of Pickard Hall (Facing East)

According to historical documents the structural framing of Pickard Hall consists of stone rubble foundation/basement walls, 22in wide exterior and 18in wide interior unreinforced masonry walls, centralized interior steel beam and cast iron column frames supporting 2x14 floor joists, and a conventionally framed roof with 2x rafters and ties.

Only a small sample of the inside face of the exterior stone rubble foundation wall was observed. The exterior foundation wall in mechanical rooms 13 and 15 were found to be in good condition. Some very minor signs of water intrusion were noted but, considering the age of the structure, nothing concerning was observed.

The inside face of the exterior foundation wall was not accessible throughout the building and, was therefore, not observed. The interior 18in brick wall framing was visible in a couple of areas. The condition of the brick in the basement elevator equipment room and throughout the interior of the elevator shaft was found to be marginal. Although no signs of distress were noted, the face of the brick was observed to be porous and brittle and the lime mortar was very soft and unstable. With that said, nothing was found that was considered to be “unusual” or otherwise structurally detrimental to the overall integrity of the building. Considering the width of the walls, the resulting compressive stresses on the brick and mortar are very low. Even in the basement where accumulated loads would be the highest, no signs of distress related to compressive gravity loads were found.

All of the interior beams were concealed by architectural finishes and, were therefore, not observed. Only one small section of one of the cast iron columns was visible, in Gallery 214 on the 2nd floor, and nothing remarkable was found. Similarly, a very short section of one floor joist was observed and, once again, nothing unusual was found.

Unlike the rest of the building, the attic was completely open and all framing was exposed to view. The roof framing was composed of 2x rafters and ties of various depths. The rafter framing was observed fairly extensively and no signs of distress or significant overloading were found.

Historic Document Review

Considering the lack of visible framing and the absence of observed distress (cracks, deflection, etc.) a review of the available historic documents and assessment reports of similar buildings is included as a significant contributor to this report.

The following documents specific to Pickard Hall were made available by the University and were reviewed for their significance to this current work:

- 1892 original construction specifications
- 1892 exterior elevations
- 1895 drawings showing original wall dimensions and ventilation layout
- 1970 structural condition assessment
- 1974 museum renovation drawings
- 1988 exterior and interior renovation drawings
- 1996 exterior and drainage renovation drawings
- 1999 exterior repair drawings and specifications

The following reports and assessments of similar buildings were made available by the University and were reviewed for their significance to this current work:

- 2006 masonry evaluation report for Old Sociology Building
- 2006 masonry assessment of Reynolds Journalism Institute
- 2006 masonry testing reports of Reynolds Journalism Institute
- 2013 masonry and wood structural assessment for Swallow Hall

Assessment of Existing Structural Conditions

The existing foundation appeared to be in good condition. Signs of current water intrusion were noticed in the mechanical room and one of the offices but, for a foundation of this age constructed with rubble stone, it was less than would normally be anticipated. With that said, the exterior ground level features and stormwater drainage systems underwent extensive renovations and upgrades during the 1996 work. Those construction documents appear to show that the foundation at that time was in much worse condition. Settlement did not appear to be a problem but water intrusion and related deterioration were certainly significant issues at that time.

Due to the information gathered from other similar buildings of the same era, the structural integrity of the existing brick and mortar is a substantial concern. The 2006 Sociology Building, 2006 Reynolds Journalism Institute, and 2013 Swallow Hall assessments, all expressed concern regarding the integrity of the brick and mortar materials, as well as the original construction workmanship in general. Complicating the matter, it appears as though there were several vertical and diagonal cracks in the exterior brick face of Pickard Hall that were repaired as part of the 1999 exterior renovations. Although no notable signs of distress were currently observed, the information above makes it difficult to assume with any certainty that the existing brick and mortar has different properties than those found at the other buildings.

Although the walls appear to be performing adequately in their current geometric and loading arrangement, it seems likely that any activity that would disturb the current conditions may be detrimental to their structural integrity. Over time, and as the grout deteriorates, the bricks shift and settle into position resulting in a fairly uniform bearing surface. Distributing the loads in this manner results in very low bearing pressures imposed on the brick and mortar. As long as the loading and geometries remain intact the existing framing would likely last for many years. On the other hand, if point loads are introduced, loads are increased, or lateral bracing is changed, the confidence in the performance of the existing walls would be very low. There are procedures that can provide additional structural capacity (i.e. grout injection) but these are very expensive and the realized benefits are usually somewhat minimal.

The floors are framed with 2x14 floor joists spaced at 16in centers. These joists are supported with pockets into the brick walls and several double 12in S-shaped beams. The beams bear on pilasters and columns in the brick walls and on 6in cast iron columns in the center of the rooms. The 1970 Structural Condition Assessment suggested that the joists, assuming perfect conditions, could support 125 to 150 PSF. That report also described and showed signs of shear failures at the bearing ends caused by concentrated bearing loads. Then, in the 1974 Museum Renovation, the joists were shimmed and the shear cracks were repaired. Considering the lack of deflection and relative stiffness of the floors it is likely that these repairs were adequate and seem to have performed well for the past 40 years. If we assume that the existing floors have a load-carrying capacity of 125 PSF that would allow for a live load of between 85 and 100 PSF.

As described above, the attic and roof structure is exposed and was carefully observed. The existing framing appears to have performed well throughout the life of the structure and no specific areas of distress were noted. Additionally, the review of the available historic information (renovations, assessments, etc.) did not indicate that the integrity of the framing itself was ever in question. The existing rafters, ridge beams and ties would likely continue to perform well for several more years without the need for structural repairs.

The attic floor appears to have been installed sometime after the original construction. From looking at the decking boards, and other observed conditions, it seems as though this floor may have been framed as part of the 1974 renovation when the elevator was installed. Before then it’s likely that the attic did not have a solid floor and that the top of the ceiling joists were exposed.

Structural Considerations and Estimated Costs of Decommissioning Activities

In general, there are three possible decommissioning scenarios being considered:

Scenario 1: Save Pickard Hall and receive NRC release

a) Restore building to its current condition
b) Renovate building to current MU standards

Scenario 2: Remediate the Building; then Demolish

Scenario 3: Treat Entire Building as Radioactive and Demolish

Each of these scenarios has unique challenges and tradeoffs however the scope of this report focuses only on those items that may affect the building structural integrity. In all cases, and because the building has not been adequately Characterized, the assumptions made are mostly conservative.

The process of remediation for Scenarios 1 & 2 will include attempts to remove contamination from the exposed surfaces. Although the stone and brick can be scrubbed, those materials are so porous that it is unlikely that surfaces that have come in contact with a radioactive substance in liquid form could be adequately cleaned. Therefore, it is assumed that any contaminated stone or brick will likely need to be removed and replaced.

Considering there was no ceiling present in the basement in the early 1900's it is likely that some of the wood framing members may have been contaminated by airborne materials. Wood surfaces can be planed in order to help remove contamination. However, in the case of the floor joists, they are already marginally undersized and any loss of section would only worsen the condition. "Light sanding" would be fine but, at least for now, we cannot recommend planing of the first floor joists.

What appeared to be light and spotty contamination of some of the attic joists and/or rafters was noted in earlier surveys. As described above, planing can help to remove residual radiation that is near the surface. Considering the condition and sizes of the ceiling joists, rafters and beams, surface planing that would remove up to ¼" of material in the attic would be acceptable.

The following EOPC (Engineer's Opinion of Probable Costs) do not account for any inflated or extra costs resulting from the radioactive nature of the project. These values should be adjusted accordingly in order to create a more realistic picture of the overall anticipated costs.

Because of the uncertainty surrounding the transport and offloading of the potentially contaminated building rubble, all values assume that the materials are loaded into large dump trailers located adjacent to the site. *Transportation and disposal costs are not included.*

It should be noted that the following activities and associated costs may (or may not) be revised significantly if Characterization is initially completed.

<u>Scenario 1: Remediate building to receive NRC release and leave in place</u>

The first step for this scenario would be to perform a complete Characterization of the building. This includes the removal of all interior finishes and non-structural walls in order to detect and map any residual radioactive contamination. From the limited surveys that have already been completed it appears likely that the drains under the basement slab are contaminated. Therefore, the slab, in its entirety, would be removed in order to distinguish the contaminated drains from any possible surrounding soil.

The next phase of this scenario would be to clean, replace, or otherwise remediate all contamination found as a result of the Characterization. At this stage it is impossible to tell the extent of the contamination however the existing surveys make it probable, if not likely, that the following structural items may be affected:

- One or more vertical brick ventilation shafts
- Original first floor framing
- Trench connecting basement to the steam tunnel
- Basement slab, drains and subgrade
- Basement stone walls (interior and exterior)
- Exterior soil adjacent to, and beneath, the foundation walls

Several of these activities would prove to be very challenging. The vertical ventilation shafts are framed integral with the structural brick wall framing. This means that the work would have to be completed in phases; shoring the affected framing as one moves upward (or downward). Also, the removal and replacement of the 1st floor framing would have to be completed in phases as well. This floor provides lateral bracing of the exterior walls and interior columns, and if it were removed all at once, it would be nearly impossible to maintain the building in a structurally stable condition without elaborate wall and column bracing. And finally, the removal and replacement of the basement stone walls and foundations would be exceptionally difficult. Considering the brittle nature of the existing brick and mortar walls, the work would need to be completed in small sections, shoring the wall above in very close intervals. And, although the contractor would take great care, it is possible, if not likely, that they might create extensive cracking or lose a section of wall altogether during the process.

The following EOPC includes those items which would likely require removal & replacement as part of the remediation work:

• Remove interior coverings and framed walls for Characterization	$100,800
• Remove vertical brick shafts and shore as required (3 assumed)	$125,000
• Remove original first floor wood framing and shore exterior walls	$305,000
• Remove and feeder to steam tunnel & patch tunnel wall	$15,000
• Remove basement slab and footings (replace footings only)	$55,000
• Remove and replace basement stone wall and foundation	$662,000
Total estimated *structural* costs for Scenario 1	**$1,262,800**
• Related site/civil work including earthwork, sidewalks & parking	$186,500
Total estimated *building* costs for Scenario 1	**<u>$1,449,300</u>**

<u>Scenario 1a: Remediate and restore building to current condition</u>

Once the building has been released by the NRC the interior could be restored to its current condition. This would include the reconstruction of the basement and first floor slabs and all interior mechanical and electrical equipment and finishes.

The following EOPC includes those items which would need to be completed once the NRC release has been recieved:

• Replace vertical brick shafts (3 assumed)	$166,000
• Replace original first floor wood framing	$114,500
• Replace feeder to steam tunnel	$10,000
• Replace basement footings	$32,200
Additional estimated *structural* costs for Scenario 1a	**$322,700**
• Restore interior space & repair damage to exterior walls	$2,952,000
• Initial costs to remove radioactive material (Scenario 1)	$1,449,300
Total estimated *building* costs for Scenario 1a	**<u>$4,724,000</u>**

<u>Scenario 1b: Bring building up to current MU standards</u>

The recent renovation of Reynolds Journalism Institute and current work related to Swallow Hall have supported the general goals of improving the academic performance and incorporating new safety features in the Red Campus historic buildings. In order for Pickard to be a viable building that is compliant with current University Codes and standards it would need to undergo similar renovations as well. At this point it is assumed that the following changes/additions would be necessary:

• Addition of an enclosed, external stair tower at the northeast corner	$725,000
• Addition of an enclosed, external stair tower and elevator at the south wall	$1,150,000
• Removal of all wood structural framing, including roof, and replace with steel braced frames and concrete floors	$1,425,000
• Fortify exterior brick walls and laterally brace from steel frames	$220,000
• New elevator to access attic area (4 stops)	$85,000
• Renovation of existing attic space to usable (occupied) interior area	$965,000
• Additional restrooms at all levels	$95,000
• Renovate HVAC, Electric and Fire Suppression systems	$1,950,000
• General restoration work not unique to upgrade renovations	$1,798,700
Total renovation / updating costs for Scenario 1b	**$8,413,700**
• Initial costs to remove radioactive material (Scenario 1)	$1,449,300
Total estimated *building* costs for Scenario 1b	**<u>$9,863,000</u>**

Scenario 2: Demolish the building *after* remediation

Once again, the first step for this scenario would be to perform a complete Characterization of the building. Once this is completed then the various elements from Scenario 1 would still apply except that the "replaced" items would instead be temporary shored or patched.

The next phase of this scenario would be to demolish the structure in its entirety. Since the contamination would have already been removed, this activity could be completed in fairly typical fashion, working from the roof down.

The following EOPC includes those items which would likely require removal & temporary shoring as part of the remediation work; followed by complete demolition:

• Remove interior coverings and framed walls for Characterization	$100,800
• Remove and shore vertical brick shafts (3 assumed)	$110,000
• Remove first floor framing and install elaborate wall bracing	$175,000
• Remove feeder to steam tunnel & patch tunnel wall	$10,000
• Remove basement slab and footings – temporarily shore columns	$40,000
Total estimated structural remediation costs for Scenario 2	**$435,800**
• Complete building demolition	$160,000
• Related site/civil work including earthwork, sidewalks & level site	$120,500
Total estimated remediation & demo costs for Scenario 2	**$716,300**

Scenario 3: Demolish the building *without* remediation

Once again, the first step for this scenario would be to perform a complete Characterization of the building. Once this is completed and the extent of contaminated materials is known the building structure would be demolished in its entirety.

• Remove interior coverings and framed walls for Characterization	$100,800
• Complete building demolition	$160,000
• Related site/civil work including earthwork, sidewalks & level site	$120,500
Total estimated building-related costs for Scenario 3	**$381,300**

In order to help establish estimated transportation and disposal costs, the following building material gross volumes and associated weights can be assumed:

➢ Stone, Brick and Mortar (Incl. Floors):	1,980 CY	3,207.6 T
➢ Concrete Basement Floor:	104 CY	210.6T
➢ Wood Floors (Incl. Sheathing & Joists):	170 CY	80.3 T
➢ Wood Roof and Attic Framing:	118 CY	55.8 T
➢ Other (Gyp, Tile, Ceilings, Plumbing, Etc.):	N/A	18.0 T

Based on the information gathered to-date the following material quantities can be assumed to be contaminated at least to some extent:

➢ Stone, Brick and Mortar:	396 CY	641.5 T
➢ Concrete Basement Floor:	104 CY	210.6 T
➢ First floor (Wood Sheathing & Joists):	85 CY	40.2 T
➢ Other (Gyp, Ceilings, Etc.):	N/A	2.5 T
➢ Contaminated Soil (Interior & Exterior):	790 CY	1,173 T

General Thoughts Regarding Potential Liabilities

Regardless of which of these three options are selected the decommissioning activities will be a lengthy and difficult process. The confinements of the project site alone create unique challenges for all scenarios and the proximity of the existing steam tunnel in the quad should prove to be especially problematic considering the weight limitations above and adjacent to the tunnel lid. However, beyond the cost implications, this particular project has the potential to create some unusual liabilities that are difficult to predict or quantify.

Of all of the prospective construction activities, the prospect of shoring the building and replacing the foundations is the most worrisome. Although assurances have been made by contractors that the work can be completed safely, considering the age and condition of the framing materials involved, it would seem very possible that a circumstance may develop that could result in a significant life/safety hazard. Regardless of the means and methods employed the work will require personnel to be active both inside and outside the structure in the direct vicinity of the shored walls. As described previously, although the contractor would take great care, it is possible, if not likely, that they might create extensive cracking or lose a section of wall altogether during the process. With all of that said, it should be noted that this work may only be required *if* the Characterization finds that it is necessary. This kind of information should be accounted for during the decision process.