14 January 2019

Mr. Michael E. Handler
Director of Administration
City of Stamford
Stamford Government Center
888 Washington Boulevard, 10th Floor
P.O. Box 10152
Stamford, CT 06904

Project 182094 – Building Enclosure Investigation and Consulting Services, City of Stamford Public Schools, Stamford, CT

Dear Mr. Handler:

Per your request, this report provides the results of our investigation of the reported water leakage at the Julia A. Stark Elementary School in Stamford, CT. It includes our summary of background information provided by others, a summary of our field observations and test results, a discussion of pertinent issues, conclusions as to the sources of the water leakage, and conceptual recommendations for remedial repair options.

1. INTRODUCTION

The City of Stamford retained Simpson Gumpertz & Heger Inc. (SGH) to investigate reported water leakage at the Julia A. Stark Elementary School (Stark). We understand that a certified industrial hygienist (CIH) has confirmed biological growth or high mold spore concentration in various areas at this building.

1.1 Objective

The objective of our investigation is to determine the source(s) of water infiltration through the building enclosure and to provide conceptual remedial repair options.

1.2 Scope of Work

Our scope of work includes the following tasks:

- Review the available drawings and other construction documentation provided by the City of Stamford.
- Visual observations of the interior and exterior of the building from grade, the roof, and exterior access such as ladders or a personnel lift.
- Perform diagnostic water testing and make interior and exterior exploratory openings at a sample of locations where Stark reports active water leakage to determine the source(s) of water infiltration.
- Provide this written letter report documenting our investigation, findings, and conceptual remedial options.

1.3 Description of Building

The Julia A. Stark Elementary School is a two-story masonry-clad building originally constructed in 1953. Two additions have been added to the building that create an exterior courtyard between wings. The original wing has brick masonry cladding and terra-cotta cladding, and the first addition has brick masonry cladding. The most recent addition is the main focus of our investigation and was completed in 1997. This addition includes a south wing, second-floor bridge, media center, and classrooms in the northwest corner of the building. This addition has a structural steel frame with concrete masonry unit (CMU) back-up wall, and brick masonry cladding. All wings of the building have aluminum-framed mulled windows with outswinging awning lites that were installed during the 1997 addition's construction. The building includes various roofs levels with steep-sloped slate roofing, single-ply EPDM membrane roofing, or modified-bitumen roofing covered with stone ballast.

2. DOCUMENT REVIEW

We did not receive architectural drawings or other design documentation for the original building construction or the construction of the first addition.

2.1 Original Drawings for 1997 Building Addition and Renovation

We reviewed Fuller and D'Angelo, P.C.'s 2 May 1994 architectural drawings (with a 6 December 1994 revision titled "Bid") for the 1997 addition and renovation titled, "Stamford Public Schools, Expansion and Renovation of Julia A. Stark Elementary School, Glenbrook Road, Stamford, CT." These drawing show the following pertinent information (see Appendix A for typical details):

- The structural drawings show that building addition's structure is a steel frame with CMU infill walls. The brick masonry above window openings is supported by steel shelf angles hung from the structural steel framing above using double angle hangers with braces.

- The wall sections show the exterior wall construction as follows, from interior to exterior:

  - 8 in. CMU back-up wall.
  - 1-1/2 in. rigid insulation.
  - 1-3/8 in. air gap.
  - Brick masonry veneer with masonry ties spaced 16 in. o.c.

- The column plan details show that the flanges of the structural steel columns are in line with the outboard surface of the CMU back-up wall. Column flange ties extend into the brick masonry veneer. The CMU back-up wall is built around the structural steel with voids between the CMU block and steel column. No water resistive barrier (WRB) is shown in the details.

- The wall sections show fabric through-wall flashings with pea gravel at floor lines and above wall openings.

- The elevations and window schedule indicate that the existing windows in the original building and first addition were removed and replaced with new aluminum-framed windows as part of this building renovation.

- The typical window details show new aluminum-framed windows sealed to the window openings with interior and exterior sealant joints with backer rod. Some windows, generally mulled units, include thermally-broken sill receptors, while single unit replacement windows in the original building include trim pieces around the window perimeters.

- The drawings do not show a weather-resistive barrier (WRB) over the CMU backup wall.

3. INFORMATION FROM OTHERS

3.1 Plans Showing Areas of Identified Biological Growth or High Mold Spore Concentration

The City of Stamford provided a floor plan with markups indicating the areas of the building where the CIH confirmed the presence of biological growth or high mold spore concentration (the plan does not indicate the author or date of the markups; Appendix B). The plan identified such areas that appear to be at exterior walls in the following areas:

- South Hallway connecting original building to 1997 addition, first and second floors.
- Room 102 – First-Floor Classroom, 1997 addition.
- Room 168 – First-Floor Classroom, first addition.
- Room 170 – First-Floor Classroom, first addition.
- West Hallway and Bridge connecting first addition to 1997 addition – second floor only.
- Room 249 – Second-Floor Classroom, original wing.
- Room 252 – Second-Floor Classroom, original wing.

3.2 Building Management Staff

We discussed locations of active leakage with Tom Perretta, from Stark's facilities department, and other building management staff during our 27 and 28 December 2018 field investigation. They provided the following pertinent information:

- Water leakage primarily occurs in the 1997 addition, with some locations of leakage in the first addition. Water leakage does not occur in the original wing.
- Water leakage occurs at the windows in Room 172 during precipitation events.
- Water leakage occurs into the first-floor media center. Water leakage previously occurred along the entire roofing expansion joint between the first addition and the 1997 addition; however, the school repaired the roof and the majority of the leakage has ceased. One location below the expansion joint continues to leak.
- Water leakage occurs into the first-floor computer lab at the exterior wall.
- Approximately 3 yrs ago, the school performed flashing and masonry repairs above eight windows on the north elevation of the first addition to mitigate water leakage. These windows are in Rooms 168, 170, 252, and 254. The facilities staff are not certain of the effectiveness of these repairs.
- Many of the existing stains on ceiling tiles are from previous leaks or from plumbing or mechanical system leaks.
- Building management staff suspect that water leakage occurs through the exterior walls at planters.

4. FIELD OBSERVATIONS

Kelsey A. Dunn and Monica Chen of SGH visited the site on 27 and 28 December 2018 to investigate the reported water leakage through the building enclosure. We performed interior and exterior surveys of the building, performed diagnostic water testing at a sample of reported leak locations to identify leakage paths, and made interior and exterior exploratory openings with the help of an assisting contractor, Bismark, to review concealed conditions. Rain occurred throughout the day on 28 December 2018 during our investigation. Weather records indicate approximately 0.74 in. of precipitation between 7:00 a.m. and 5:00 p.m.[1]

We focused our investigation on the 1997 addition, due to Stark's facilities reports that water leakage to the interior primarily occurs in this wing, as well as due to time and weather constraints while we were at the site.

4.1 Interior Observations

We made the following interior observations in the building:

- Interior finishes are deteriorated in the following locations. Deterioration typically includes loose wallpaper and apparent biological growth on the gypsum wall board (GWB) behind the paper.
  - Above the floor at door jambs in various locations throughout the building, including locations not indicated in Appendix A (Photos 1 and 2).
  - Above doors in various locations in the building additions (Photo 3).
  - At window jambs in various locations in the building additions (Photo 4).
  - Above windows in various locations in the additions, including locations not indicated in Appendix A (Photo 5).
- While we were on site, the CIH and Bismark were removing and replacing interior finishes in the second-floor west hallway and bridge, and in the first- and second- floor south hallways. We made the following observations in the areas where interior finishes were removed:
  - We observed removed GWB below windows, at window jambs, and extending approximately 4 ft up from the floor between windows (Photo 6).
  - The existing interior wall construction is as follows, from exterior to interior:
    - 8 in. thick CMU.
    - Light-gage steel-framing infilled with 1-1/2 in. mineral wool insulation.
    - Two layers of GWB (Photo 6).
- The light-gage steel framing is corroded at the base of the wall on both floors of the south hallway (Photo 7). On the first floor, the corrosion is more severe adjacent to the exterior door (Photo 8).
- No WRB or flashing membrane turns into the rough opening at the window jambs (Photo 9). Based on the configuration at the jambs, the gypsum wallboard returns (removed in Photo 9) were adhered directly to the CMU and abutted the window frames.
- No interior sealant joints between the window frames and CMU at the jambs or sills, and no sheet metal or membrane sill flashings below the sill receptors (Photo 10).
- The sill receptors are open at the ends, with no end dams at the jambs (Photo 11).

[1] http://www.wunderground.com

- Daylight is visible at window jambs between the window frame and CMU in numerous locations where interior finishes are removed (Photo 12).

- We observed removed interior trim from an intermediate vertical mullion on the 1997 addition's second floor. The mullions have aluminum reinforcement (Photo 13) and the sill receptors are continuous below the intermediate mullions (Photo 14). We observed a gasket installed between the upturned leg of the sill receptor and the window sill frame (Photo 15). The windows in the second-floor south hallway of this addition do not have gaskets between the sill receptors and window units.

- Water leakage to the interior from the head of the westernmost window in Room 251 during the 28 December 2018 rain event (Photos 16 and 17).

- Water leakage to the interior through the door glazing in the 1997 addition's first-floor south hallway and in Room 102 during the 28 December 2018 rain event.

4.2 Exterior Observations

We made the following interior observations on the building:

- Most window and door exterior perimeter sealant joints are open/split or debonded at the jambs on the building additions (Photos 18, 19, and 21). In several locations, the gaps between the window frame and adjacent brick masonry are up to 1/2 in. wide. In locations where interior finishes have been removed due to abatement, we could see through the open sealant joint directly to the interior (Photos 19 and 20).

- Various apparent sealant repairs on the building (Photo 21). In many locations, the sealant repairs have also failed.

- Sealant joints around the window and door perimeters on the west elevation of the original building are generally in good condition (Photo 22).

- Sealant joints in masonry expansion joints are generally cracked, crazed, and deteriorated in all three wings (Photo 23).

- Flexible EPDM flashing membrane is exposed at the edges of the steel lintel above the windows. Lintels stop short of the window jambs. The flashing membrane extends past the lintel's termination and into the brick masonry at the window jamb (Photo 24). The brick masonry above the flashing is typically wept using either rope or plastic weep tubes (Photo 25). We observed several locations with no weeps.

- The steel lintels above doors extend into the adjacent brick masonry (Photo 25).

- Gaps between the EPDM flashing membrane and brick masonry above the windows. Pea gravel is visible between the flashing membrane and brick masonry (Photo 26).

- Sheet metal through-wall flashing above the windows on the north elevation within the first addition at Rooms 168, 170, 252, and 254, where building management personnel reported that flashing repairs were previously performed (Photos 27 and 28).

- The windows appear to be a "combination assembly," in which individual window units are combined and butted together (i.e., mulled) at the jambs with a cover plate (Photo 29).

- The windows are a "wet-glazed" system, with a sealant joint between the glass and the sash (Photo 30).

- The brick masonry is deteriorated at the eastern interior building corner between the second-floor bridge and first building addition (Photo 31). The mortar joints in the brick masonry are deteriorated, the brick is cracked, sealant is applied over the steel lintel, and the steel lintel appears corroded. Staining on the brick indicates heavy water flow over this location.

  - The sheet metal and membrane roof flashing above the expansion joint does not overlap the expansion joint and lacks a mechanical termination. The flashing membrane is peeling from the brick masonry (Photo 32).

- Stone sills below windows in the first addition. The transverse joints between the stones are open (Photo 33).

- Areas of deteriorated brick masonry cladding in several locations on the building additions including deteriorated mortar joints, cracked mortar joints, step cracking, and displaced brick units (Photos 34 and 35). This deterioration generally occurs adjacent to where steel lintels or shelf angles are shown in the construction drawings.

4.3 Water Infiltration Testing

We performed water infiltration testing at a sample of locations or reported water leakage or observed evidence of possible water leakage. We performed our testing in general accordance with ASTM E2128 – Standard Guide for Evaluating Water Leakage of Building Walls. We used spray racks calibrated according to ASTM E1105 – Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, and handheld nozzles calibrated according to AAMA 501.2 – Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls, and Sloped Glazing Systems to perform our testing.

We performed diagnostic water leakage tests at seven locations on the exterior walls including one planter, one door, and six windows. See Appendix C for test locations. We summarize the results of our water testing below.

Exterior Wall at Planter

We used a spray rack to apply water to the exterior wall at the planter on the north elevation of the south hallway. The interior finishes were removed due to the abatement work that was ongoing during our testing (Photo 36). The CIH and Bismark reported biological growth on the interior finishes adjacent to the planter. We observed corrosion on the light-gage steel framing in this area (Photo 8). During testing, we isolated the planter wall from the adjacent door by covering the door with a plastic sheet. We performed the test for 1 hr and observed approximately 2 in. of accumulated water on top of the plater soil during testing, which then slowly drained down into the soil. We did not observe leakage to the interior.

1997 Addition Non-Repaired Windows

We tested three windows without head flashing repairs on the 1997 addition using both spray racks and handheld nozzles (Photo 37). We installed plastic sheets over windows or perimeter sealant joints to isolate conditions for testing (i.e., test the head flashing, perimeter joints, or sections of the perimeter joints only). We observed water leakage to the interior at the following locations:

- Through the wall/flashing system above one window (Photo 38).

- Through open or debonded exterior sealant joints on all three windows (Photos 39 and 40).

- From the end of the sill receptor on two windows (Photo 41).

Repaired Window within First Building Addition

We tested the sheet metal through-wall flashing repair on one window on the first building addition. We isolated the head flashing by installing a plastic sheet over the window and perimeter seals (similar to our test procedure at the window head for the windows on the 1997 addition, described above). We applied water above the window using a spray rack for 30 min. and did not observe leakage to the interior (Photo 42).

Original Building Window

We tested one window on the original building using a handheld nozzle. We applied water spray to all joints in the window assembly at a rate of 1 min. per foot, generally following the procedure in AAMA 501.2) and did not observe water leakage to the interior (Photo 43).

1997 Addition Door

We used a spray rack to apply water to the brick masonry above the door (Photo 44). We isolated the head flashing by installing a plastic sheet over the door frame and split perimeter seals (to prevent water leakage through the perimeter seals from affecting our results, since our previous testing showed water penetration through split and open perimeter seals around the windows). We performed the test for 30 min. and did not observe leakage to the interior. During our testing, the plastic sheeting allowed some water penetration and we observed water leakage through the glazing in the exterior door (Photo 45, we also observed water leakage around this glazing during the 28 December 2018 rain event).

4.4 Exploratory Openings

We directed the assisting contractor to make two exterior exploratory openings in the brick masonry cladding. See Appendix C for our opening locations.

Exterior Opening No. 1 – Door Head

We removed brick above the door to Room 102 in the 1997 addition (Photos 46 and 47). We observed the following conditions at this opening:

- The steel lintel extends beyond the door opening, with 6 in. of bearing surface on the brick masonry to either side of the door.

- A continuous EPDM flashing membrane installed in the bed joint of the CMU back-up wall turns down and extends over the vertical and horizontal legs of the steel lintel. The flashing membrane extends beyond the steel lintel's termination in the brick masonry bed joint. We looked into the wall cavity but could not see the membrane's termination.

- The field of the CMU back-up wall lacks a WRB.

Exterior Sample Opening No. 2 – Window Head

We removed brick above the window on the 1997 addition first-floor south hallway's south elevation (Photo 48). We observed the following conditions at this opening:

- The steel lintel terminates approximately 1 in. short of the brick masonry at the window jamb (Photo 48).

- The steel lintel is supported by double steel angle hangers that hang from the second-floor structural steel framing above the window; these hangers interrupt the CMU backup wall above the window. Where the hangers interrupt the CMU back-up wall, there is a gap between the CMU and the steel framing (Photo 49).

- The flexible flashing membrane extends into the CMU bed joint above the steel lintel. The double steel angle hangers penetrate the flexible flashing membrane, which is cut to accommodate the hangers. In this location, the cut EPDM flashing membrane is folded over itself leaving an opening between the flashing membrane and the steel hangers (Photo 49).

5. DISCUSSION

We first discuss the 1997 addition because this wing is the focus of our investigation and the only wing to show water leakage to the interior during our testing (we note that we tested only one location each on the original wing and first addition due to time constraints on our investigation and weather).

5.1 1997 Addition – Brick Masonry-Clad Walls

The exterior walls on the 1997 addition are a brick masonry veneer/cavity wall system. This type of wall system anticipates that some water will penetrate the exterior cladding and uses through-wall flashings to drain that water out the wall system to the exterior. In current construction, this type of wall is a “rain screen” system that typically also includes a dedicated continuous WRB inboard of the wall cladding that covers the structural back-up wall (typically a self-adhered sheet or fluid-applied product). This WRB provides a waterproofing and drainage plane on the wall to protect the back-up wall from water infiltration that can flow to the interior, especially at large voids in the wall such as those which occur around the embedded steel hangers. When installed well and with the WRB integrated properly with the through-wall sheet metal, membrane flashings, and with fenestration framing, this type of system has an established track record of reliable long-term performance. The walls on Stark lack a WRB to provide a continuous waterproofing membrane and lack sheet metal through-wall flashings in most locations, but do include flexible through-wall flashings. For these walls to resist water leakage, the following conditions of the wall must be maintained:

- The exterior cladding must be maintained in good condition to minimize water penetration through it.

- Water must not be able to cross the gap between the brick cladding and the back-up wall.

- The flexible through-wall flashings must be continuous, without damage, and fully bedded in or continuously anchored and sealed to the back-up wall.

- Weep paths from the flashings must be open and drain freely.

We observed open and debonded sealant joints and deteriorated mortar, cracks, and displaced brick in areas on the wall’s brick masonry cladding, especially around windows and doors. These conditions increase the amount of water that can enter the wall cavity, increasing the wall’s potential for leakage. We also observed openings at the top edge of the window head through-wall flashing, where the flashing spans across the steel hangers that support the lintels, that can allow water that enters the wall cavity to leak to the interior.

Without the redundancy of a dedicated WRB and sheet metal through-wall flashings (which are more robust than flexible membrane flashings), the wall system is inherently vulnerable to water leakage at openings in the flashings or if a sufficient volume of water accumulates in the wall and soaks through the CMU back-up wall. However, similar buildings that lack a dedicated WRB but have reliable sheet metal through-wall flashings have performed adequately in climates similar to that of the building’s location with regular maintenance and periodic (although potentially annual or an even shorter timeframe) repairs to the cladding, exterior seals, and flashings.

5.2 1997 Addition – Windows

We did not receive window shop drawings and we did not dismantle any windows to determine their construction, but our observations show that the windows are a wet-glazed system. Also, the windows appear to be a combination assembly, in which individual window units are mulled together at their jambs with a cover plate. This type of window typically does not include internal water management and drainage provisions, or any internal water management provisions are limited. For this type of window system to perform reliably, the seals between the window components must be maintained to minimize the amount of water that can enter the window system.

Where present, a sill receptor below the window can act as a sill flashing to collect and drain water that penetrates the windows; however, to function properly, the sill receptor must have sealed and fastened end dams where it terminates at the jambs. The end dams contain water that flows down onto the sill receptor and prevent it from flowing off the ends of the receptor into the interior wall cavity at the window jambs (rather directing it to weeps to the exterior). We observed missing end dams and water leakage from the ends of the sill receptors at two of our window water test locations, showing that the window system allows water penetration and that the missing end dams allow this water to leak to the interior.

An improved approach to waterproofing at window sills is a sheet metal and membrane sill “pan” flashing below the windows to collect and drain water that penetrates the window. This type of flashing includes riveted and fully soldered end dams and an upturned back leg to create a watertight pan below the window. Installing a sill pan flashing as a remedial measure would require the windows to be removed and reinstalled and may require alterations to the rough opening at the window sill, but installed correctly, it would provide more reliable long-term performance than the sill receptor.

Our water testing showed water leakage through open and debonded perimeter sealant joints at window and door perimeters. The window assemblies rely on a single exterior sealant joint between the window frame and the brick cladding to remain watertight and lack any water management provisions inboard of this sealant joint, such as a secondary sealant joint or flashing membrane integration with the surrounding wall system. The perimeter sealant joints are generally deteriorated throughout the 1997 addition and provide a direct path for water to flow to the interior. The windows have no apparent provisions to drain water that bypasses the exterior sealant joints (e.g., sill pan flashings). We observed interior finish damage at window jambs throughout the1997 addition that is consistent with water leakage through the exterior perimeter joints. Maintenance of these sealant joints is critical to mitigate water leakage, especially because the windows lack reliable sill flashings.

5.3 1997 Addition – Mold Growth

At the window jambs, we observed a relatively diffuse pattern of apparent mold growth on the surface of the GWB returns, behind the vinyl wallpaper. Given that the apparent mold is likely resulting from moisture, this pattern is not what we would expect if water leakage was only occurring through the open joints at the perimeter of the windows. In that case, we would expect to see water damage heaviest adjacent to the window, with little-to-no damage on the innermost edge of the returns. The diffuse pattern is more consistent with moisture migration (i.e., water vapor migration) through the GWB that becomes “trapped” on the interior by the vinyl wallpaper, which is a strong water vapor retarder, condensing into liquid water and providing an impetus for mold to grow. Given the construction of the exterior walls, with no weather barrier on the exterior of the CMU, and the leakage that we observed, we believe that wetting of the CMU at the jambs, not necessarily liquid water leakage, is contributing to the apparent mold growth on the jamb finishes.

Although we did not observe this same phenomenon in other areas, the presence of vinyl wallpaper on the interior GWB reduces the durability of the exterior walls, as its vapor retarding properties mean that even minor water leaks can result in damage as the water will be trapped within the finishes and can build up over time. In these areas, if the GWB were painted with typical interior paint (latex base), the wall would be able to dry out before water accumulates to the point of causing damage. Large water leaks are still problematic, but the increased drying ability of the wall would still be improved over the current construction.

5.4 Original Wing and First Addition

Due to the limited time that we had on site and Stark's facilities' report that leakage primarily occurs in the 1997 addition, we performed limited investigation of the original wing and first addition. Our water testing did not show water leakage to the interior at our test locations on the original wing and the first addition (one test location for each wing). We did not make exploratory openings in these two wings to show the concealed wall construction (again, due to time and weather restraints), and we did not receive drawings for these two wings for review. Therefore, we do not know the wall construction for these two wings. However, we understand that the windows in these two wings were replaced concurrent with the 1997 building's construction; therefore, we expect similar conditions for these windows that might be vulnerable to water leakage – it may just be the case that the exterior seals on these windows are fully intact, providing the required exterior barrier to water penetration. We understand from Stark facilities staff that some leakage does occur in the first addition, and we suggest that further investigation of this wing be performed to determine the wall's construction, particularly around windows.

5.5 Roof Expansion Joint

We did not perform water testing of the roof expansion joint where Stark Facilities reports water leakage. However, our observations of this expansion joint show that it's membrane flashings lack a mechanical anchorage (i.e., termination bar) and sheet metal counterflashings. As a result, the expansion joint is vulnerable to leakage through peeling flashing membrane or at the wall expansion joint's integration with the roof expansion joint. Replacing the peeling membrane with new flashing membrane that includes sealed termination bars and riveted and soldered sheet metal counterflashings will improve this expansion joint's resistance to water penetration.

6. CONCLUSIONS

Based on the results of our investigation and analysis to date, we conclude as follows:

- The primary source of water leakage is through deteriorated sealant joints at window and door perimeters. The windows and doors rely on a single exterior sealant joint to remain watertight and have no other water management provisions inboard of this sealant joint. The exterior sealant joints are consistently deteriorated throughout the building additions, but are more intact on the original wing.

- Water leakage also occurs through the windows themselves. Water that enters the window assemblies is drained to wept sill receptors. Water that collects on the sill receptors migrates to the interior at the jambs, where the sill receptors do not have properly sealed end dams to contain the water.

- The existing flexible flashing membrane installed above windows and doors is not a durable, reliable through-wall flashing. The membrane is discontinuous where it is penetrated by the steel structure at the typical window heads.

- The 1997 addition does not include a WRB and the CMU back-up wall is discontinuous at the steel structure. Water that bypasses the brick masonry cladding can flow to the interior through openings in through-wall flashings or through the backup wall itself, if sufficient volume accumulates within the wall. We do not know the wall construction for the original wing or first addition.

7. RECOMMENDATIIONS

7.1 1997 Additions Exterior Walls and Windows

Due to the majority of reported and/or observed leakage occurring in the 1997 addition, we provide more developed conceptual recommendations for this wing. We present conceptual remedial options for the exterior wall and windows on the 1997 addition, and our analysis of each, in the following table. These options are presented in generally decreasing order of reliability, scope, and cost. We do not include replacement of the existing windows as part of these repairs, as the window leakage issues can be addressed separately with new flashings and end dams on the existing sill receptors. However, given the age of the existing windows, if the City had planned to replace the windows within the next 5 yrs, it would make financial and practical sense to include that work in the full-scale repairs (Option 1) rather than perform repairs now and window replacement later.

Repair Option		Advantages	Disadvantages
Option 1 – Full Exterior Wall Reconstruction	Remove all brick masonry cladding and remove and store all windows, doors, and exterior wall insulation on both building additions. Infill voids between steel structure and CMU back-up wall as required to provide continuous support for a continuous self-adhered bituminous WRB. Provide sheet metal through-wall flashings at floor lines and above all wall openings, and sheet metal sill pan flashings below all windows. Reinstall the windows and doors integrated with the surrounding WRB. Reinstall the exterior insulation and install new brick masonry wall cladding.	• Addresses all documented and concealed defects in exterior walls. • Provides long-term redundancy and reliability against water leakage.	• High design and construction costs. • Long design and construction schedule. • Very disruptive – noise, dust, debris, etc. • Unlikely that construction could be completed over one summer. Would need to relocate building occupants or phase work. • May not be practical due to cost, duration, and disruption to building operations.
Option 2 – Targeted Flashing and Sealant Repairs	Remove brick masonry above all wall openings and at all floor lines, and install continuous sheet metal and self-adhered membrane through-wall flashings. Remove and replace exterior sealant joints surrounding all fenestration assemblies	• Lower design and construction costs than Option 1. • Shorter design and construction schedule than Option 1. • Less disruptive than Option 1.	• The repairs lack redundancy. Watertightness of window and door assemblies will rely on exterior sealant joints. Water that bypasses the window seals may leak to the interior. Regular maintenance is critical.

Repair Option		Advantages	Disadvantages
	and all other sealant joints in the exterior walls (e.g., expansion joints). Remove and replace all sealant joints within the window system. Replace the removed brick masonry cladding.	• Does not require the school operations to cease during work, although noisy operations may require specific scheduling. • Addresses areas of current, documented defects at windows and doors, including improving the reliability of the window head flashings. • May be more practical than Option 1.	• Does not address potential leakage at wall areas that are not around fenestration or at floor lines.
Option 3 – Sealant Repairs and Water-Resistive Coating	Install a water-resistive elastomeric coating over the brick masonry cladding to reduce the potential for water to enter the wall cavity. Remove and replace exterior sealant joints at windows and doors. Remove and replace all sealant joints within the window system.	• Lowest design and construction costs. • Shortest design and construction schedule. • Least disruptive option. • Addresses areas of current, documented defects at windows and doors.	• The repairs lack redundancy. The watertightness of the wall and fenestration assemblies will rely on the coating and exterior sealant joints to function as a complete barrier to water penetration. Water that bypasses either of these components may leak to the interior (due to the lack of reliable flashing, a WRB, and end dams on the window sill receptors). Regular maintenance will be critical. • May be perceived as a "band-aid" repair and not a longer-term repair.

Interior Finishes

Regardless of the type of repairs performed, we recommend against replacement of the existing vinyl wallpaper in kind. While durable and easy to clean, the risk of moisture accumulation and microbial growth (as we observed and the CIH confirmed) is much greater with these finishes than with more typical, vapor permeable materials. We recommend replacing any removed finishes with "paperless" gypsum wallboard (Dens Armor Plus by Georgia Pacific, or similar), finished with latex paint and primer. This configuration will allow the walls to "breathe" and dissipate moisture, as opposed to trapping it. Vapor permeable interior finishes will be more critical if the full building repair from Option 1 is not implemented, given the remaining risk of leakage, but even in the case of Option 1 we still recommend this approach to improve overall durability.

7.2 Original Wing and First Addition

We understand that Stark reports limited water leakage through the walls and windows in these two wings, and our investigation of these two wings was limited but did not show leakage. We recommend that they be monitored for water leakage, and if water leakage occurs, that diagnostic water testing and exploratory openings be performed to determine the source(s) of water leakage and the wall and window's construction.

As a preemptive measure, you could consider implementing the three repair options listed above for the 1997 addition at the original wing and first addition, too. Doing so would reduce the potential for water leakage to occur in these two wings. It also would provide the building with a more uniform appearance if you select Option 3 (i.e., all walls covered with the same elastomeric coating). If you consider installing these repairs, for Options 1 and 2 we recommend exploratory openings in the exterior walls in these two wings to determine the walls' construction for detailing the repairs.

7.3 Roof Expansion Joint

We recommend that the roofing flashing membrane above the expansion joint be removed and replaced with new membrane that includes a sealed continuous termination bar at both its horizontal and vertical terminations. We also recommend that reglet-set riveted and soldered sheet metal counterflashings be installed over the flashing membrane to improve their resistance to water leakage. Due to time and weather restraints, we did not perform water testing of this joint, so we recommend that it be monitored after completing these repairs to determine if they effectively mitigate the leakage or if further investigation and repairs are necessary.

Sincerely yours,

Sean M. O'Brien, P.E.
Senior Principal
CT License No. PEN.0026742

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Encls.

Photo 1

Deteriorated interior finishes above floor at door jamb in Room 104 (red arrow).

Photo 2

Deteriorated interior finishes at door jambs in 1997 addition hallway (red arrows).

Photo 3

Deteriorated interior finishes above the door in Room 102.

Photo 4

Deteriorated interior finishes along the window jamb in Room 172, 1997 addition.

Photo 5

Deteriorated interior finishes above a window in Room 170, first addition (wallpaper removed prior to our reviewing this room).

Photo 6

Area of abatement in the north hallway on the second floor. Note interior wall construction exposed at a window jamb.

Photo 7

Corrosion on light-gage steel framing on the first floor of the west hallway.

Photo 8

Corrosion on light-gage steel framing on the second floor of the west hallway.

Photo 9

Typical construction at window jamb in 1997 addition. No WRB or flashing membrane turns into the rough opening over the CMU.

Photo 10

Window frame is not sealed to CMU (red arrows). Note lack of sill flashing below window frame.

Photo 11

Sill receptors lack end dams at window jambs (red arrow).

Photo 12

Daylight visible between the window frame and CMU (red arrow).

Photo 13

Steel reinforced intermediate mullion at location where interior trim was removed.

Photo 14

Steel reinforced intermediate mullion at location where interior trim was removed. Note that the sill receptor is continuous below the intermediate mullion (red arrow).

Photo 15

Gasket between sill receptor and window units (red arrow).

Photo 16

Leakage into Room 251 on 28 December 2018 due to rain.

Photo 17

Leakage into Room 251 on 28 December 2018 due to rain (red arrow).

Photo 18

Open sealant joint at window jamb (red arrow).

Photo 19

Open sealant joint at window jamb. Note that interior is visible through sealant joint (red arrow).

Photo 20

Area of unadhered sealant at window sill (red arrow).

Photo 21

Failed sealant repair at window jamb.

Photo 22

Sealant joints around window perimeters in original building are generally in good condition.

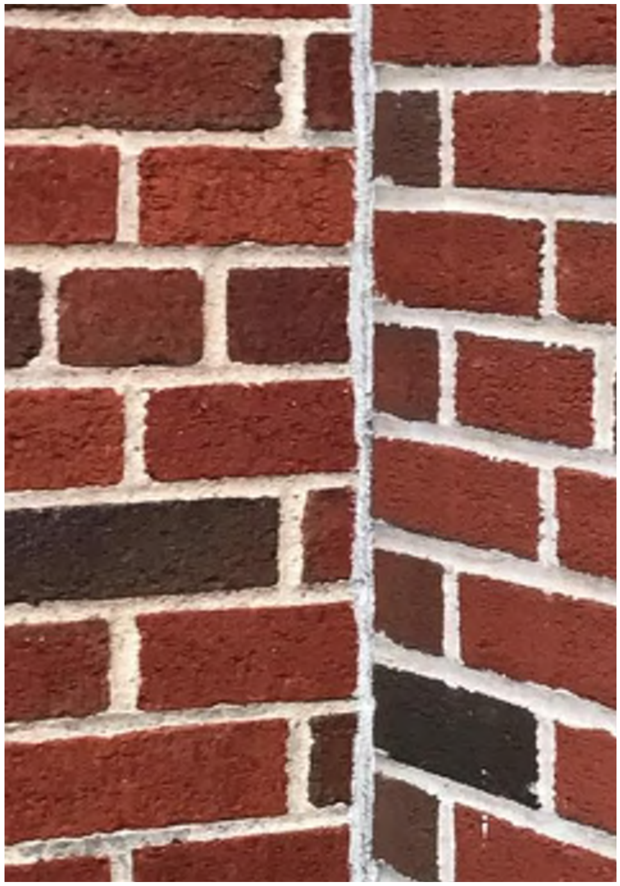


Photo 23

Deteriorated sealant expansion joint in brick masonry cladding.

Photo 24

EPDM membrane flashing between steel lintel and brick masonry at window jamb (red arrow).

Photo 25

Weep tube above window head flashing (red circle).

Photo also shows steel lintel above the door extends into the brick masonry at the jamb (red arrow).

Photo 26

Pea stone between EPDM flashing membrane and brick masonry (red arrow).

Photo also shows open sealant at window jamb.

Photo 27

Windows on the east elevation where masonry and flashing repairs were previously performed. Note lighter mortar above window heads (red arrow).

Photo 28

Sheet metal through-wall flashing installed above windows on the east elevation.

Photo 29

Typical window assembly shows individual window units mulled together.

Photo 30

Typical “wet glazing” seal between glass and window sash (red arrow).

Photo 31

Deteriorated masonry at interior building corner between bridge and first building addition.

Photo 32

Expansion joint termination on masonry wall. Note that flashing is not secured or integrated with roof edge flashing and is peeling (red arrow).

Photo 33

Open transverse joint at stone sill on first building addition (red arrow).

Photo 34

Cracked and displaced mortar joint on the south elevation of the bridge in the 1997 addition (red arrow).

Photo 35

Missing brick and step cracking at head of window on the west elevation of the first addition.

Photo 36

Water Test Location No. 1 at planter.

Photo 37

Water test at window on second-floor north elevation of the bridge with handheld nozzle.

Photo 38

Water leakage to interior above window at Room 172 (water-indicating paper turns pink when it contacts water).

Photo 39

Water leakage along window jamb through open/deboned exterior sealant joint at Room 172.

Photo 40

Water leakage to interior through open/deboned exterior sealant joint at first-floor west hallway.

Photo 41

Water leakage to interior from end of sill receptor at window on second-floor north elevation of the bridge.

Photo 42

Water testing window outside Room 168 with spray rack.

Photo 43

Water testing window in Room 117 with handheld nozzle.

Photo 44

Water testing Door in Room 102 with spray rack.

Photo 45

Leakage through window in exterior door (red arrows).

Photo 46

Exterior Opening No. 1.

Photo 47

Exterior Opening No. 1. Note that the flashing membrane extends into the bed joint of the CMU (red arrow) and the CMU lacks a WRB (blue arrow).

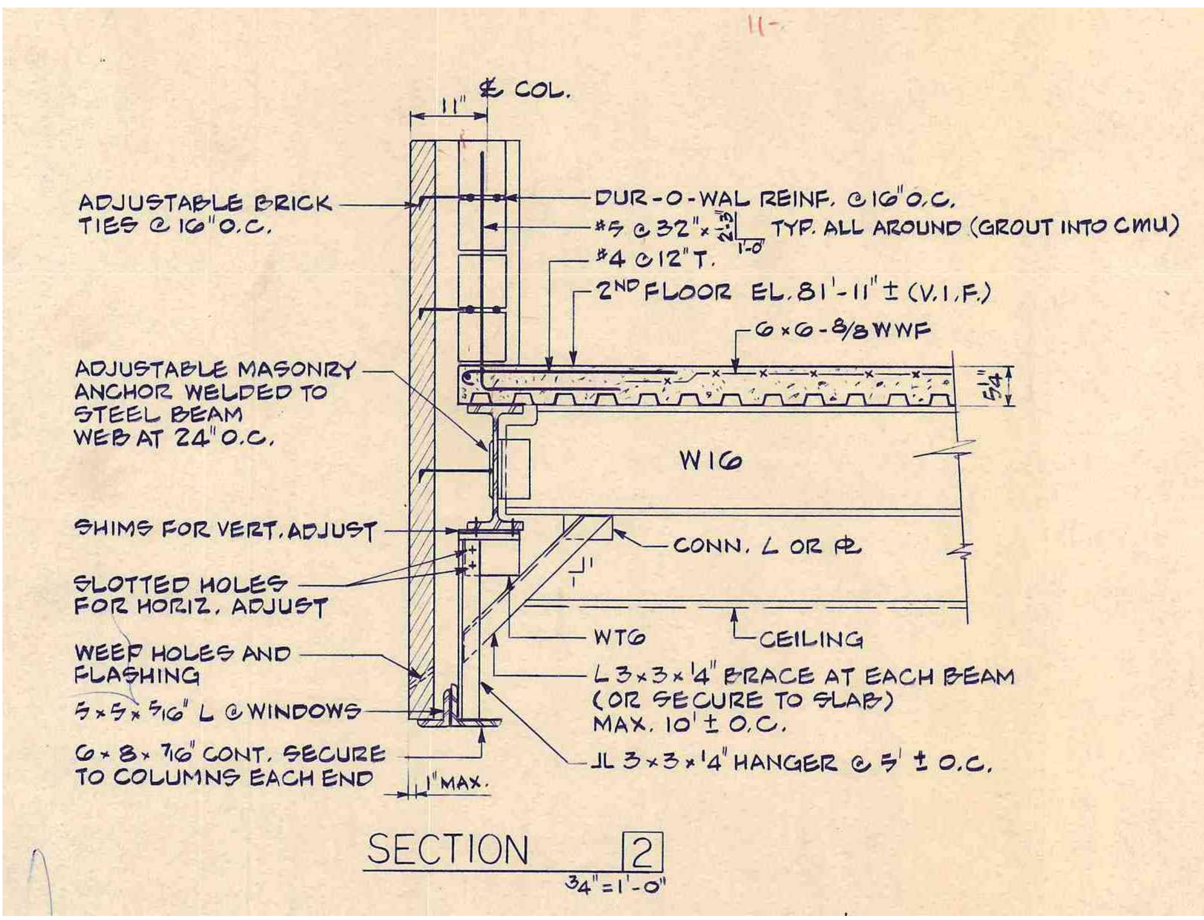
Photo 48

Exterior Opening No. 2. Steel lintel terminates short of window jamb.

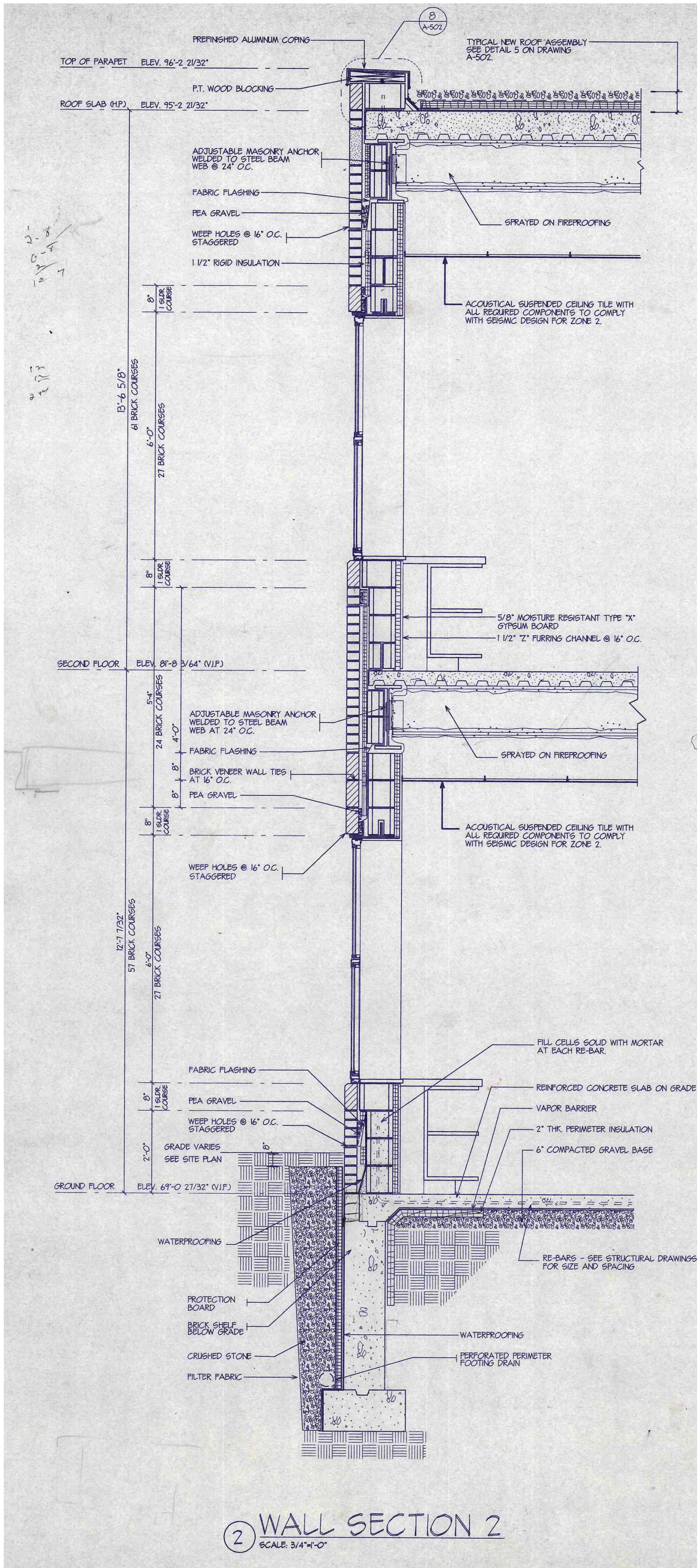
Photo 49

Flexible flashing membrane at steel hanger penetration. Note gap between CMU and steel hanger (red arrow) and between flashing membrane and steel hanger where flashing membrane is folded over (blue arrow).

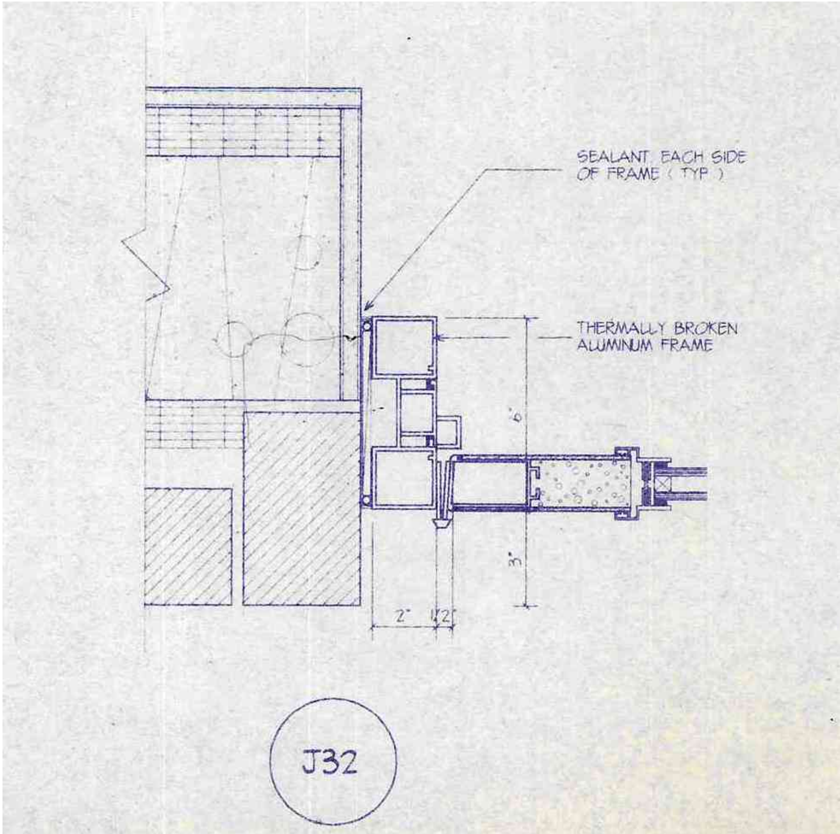
APPENDIX A

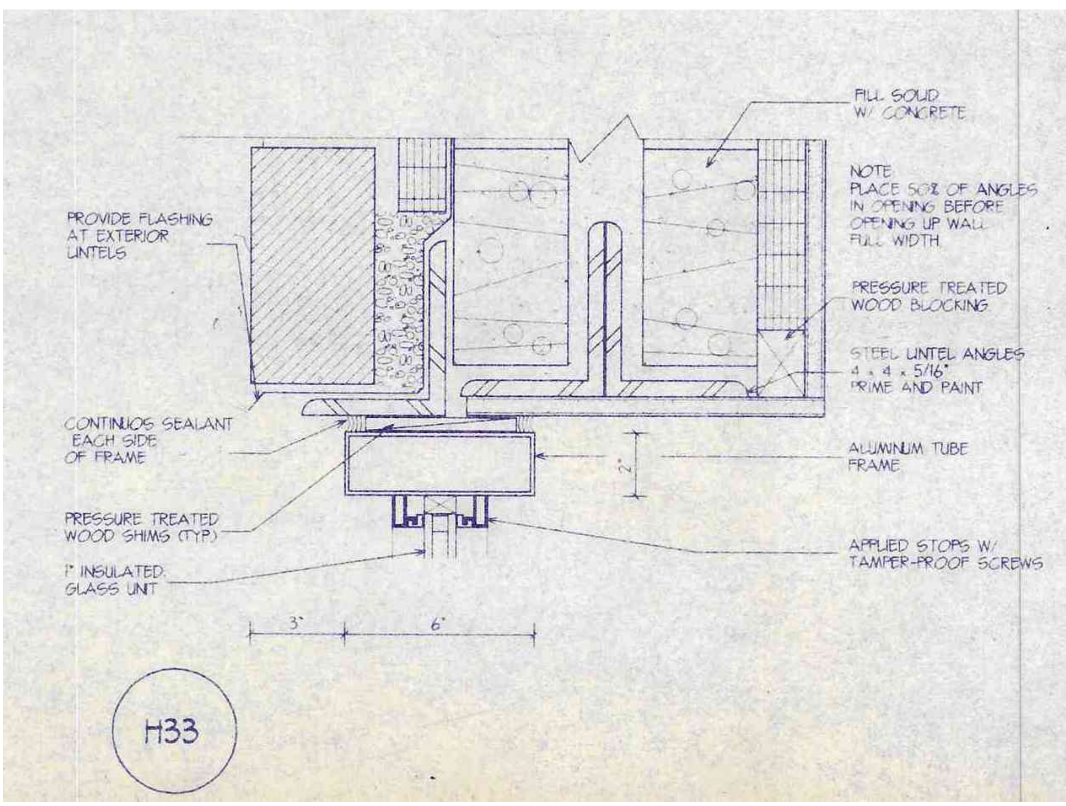


TYPICAL STRUCTURAL SECTION FROM
DRAWING SHEET S-4

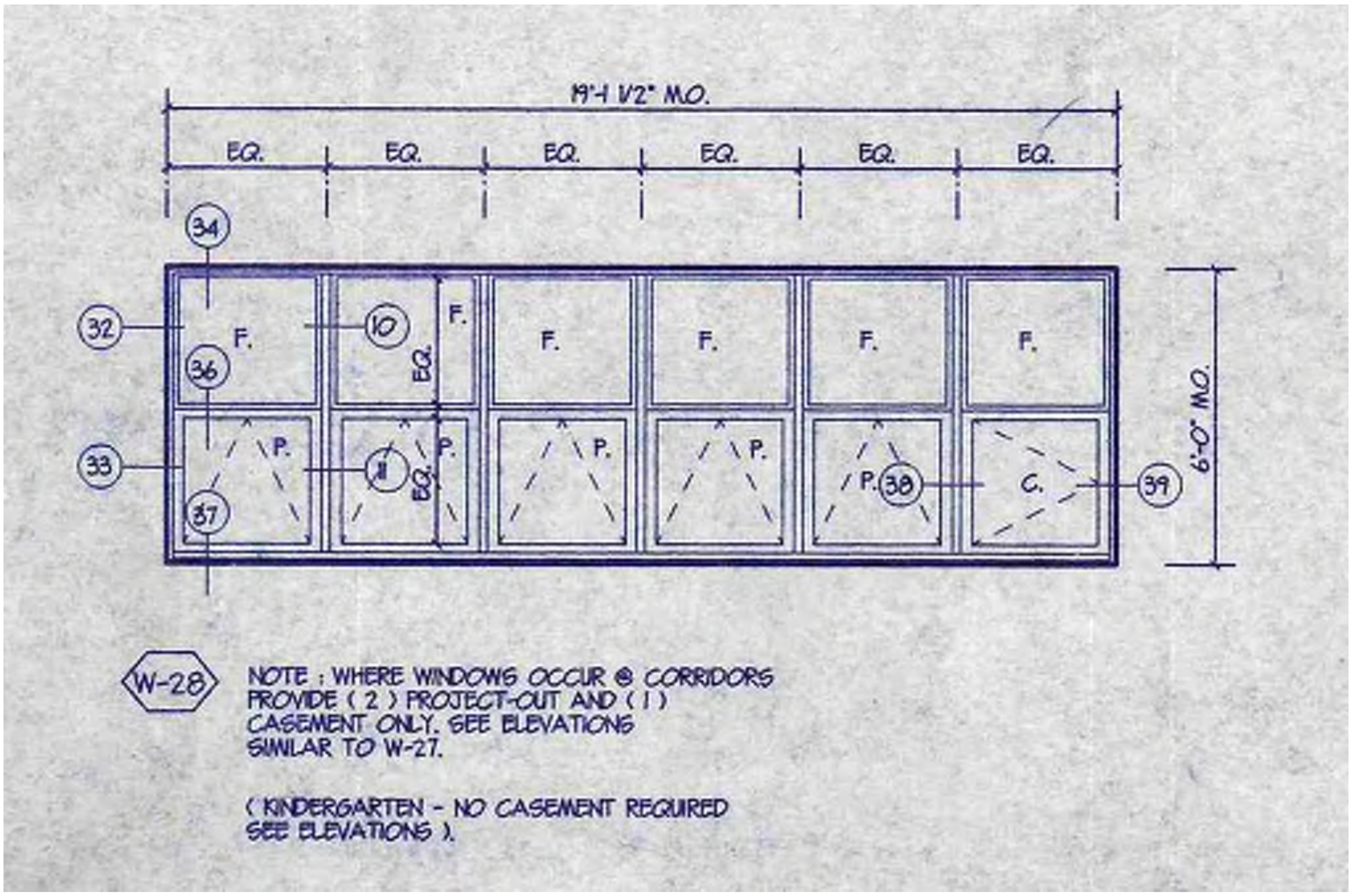


TYPICAL WALL SECTION FROM
DRAWING SHEET A302

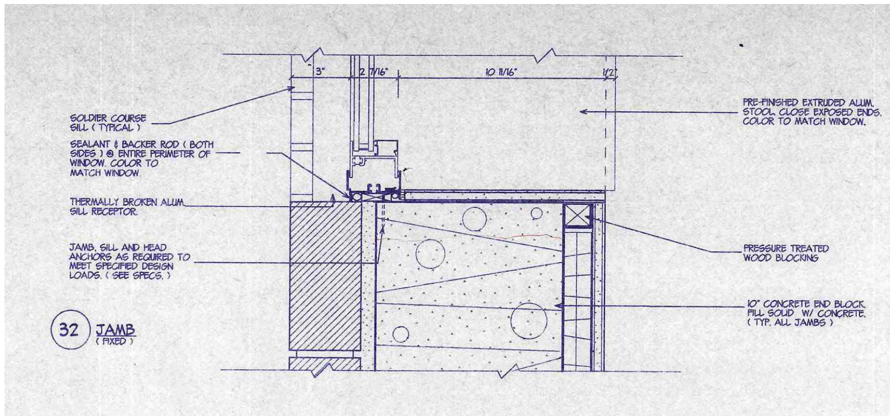


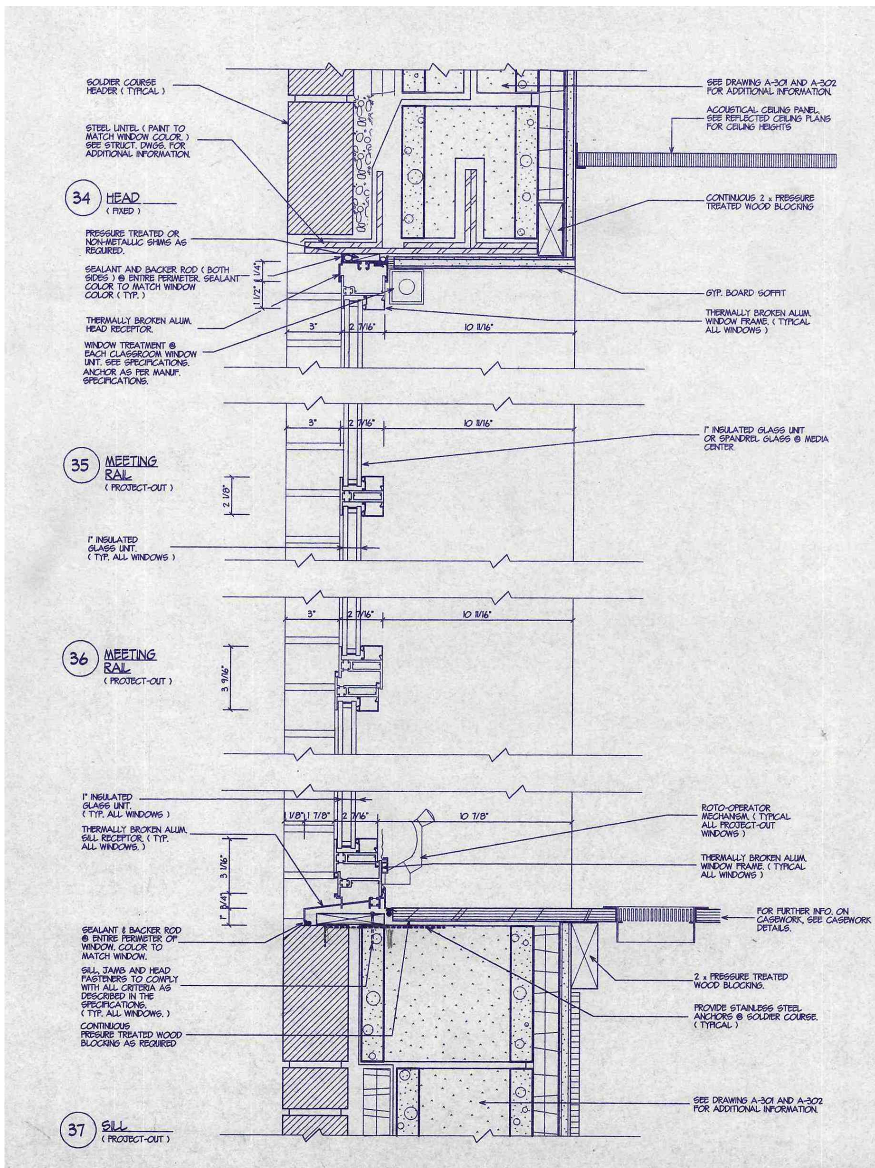


<u>TYPICAL EXTERIOR DOOR DETAILS</u>
<u>FROM DRAWING SHEET A602</u>

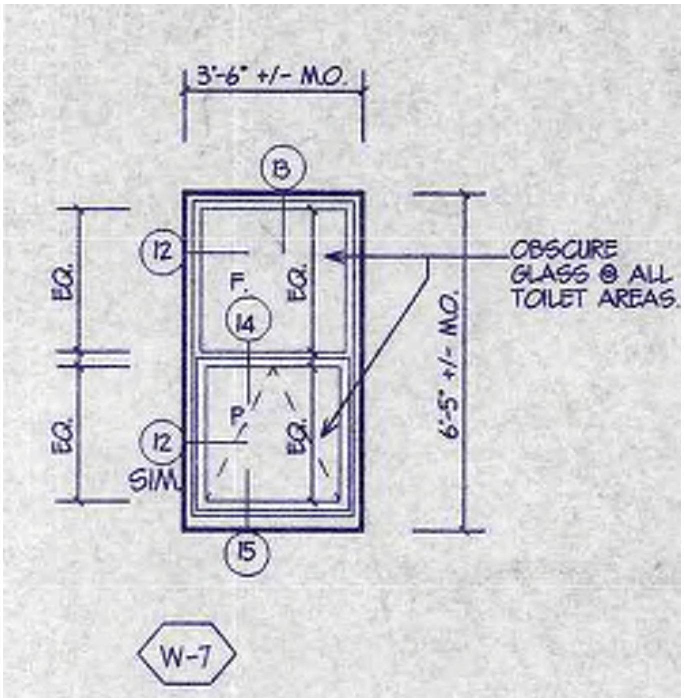


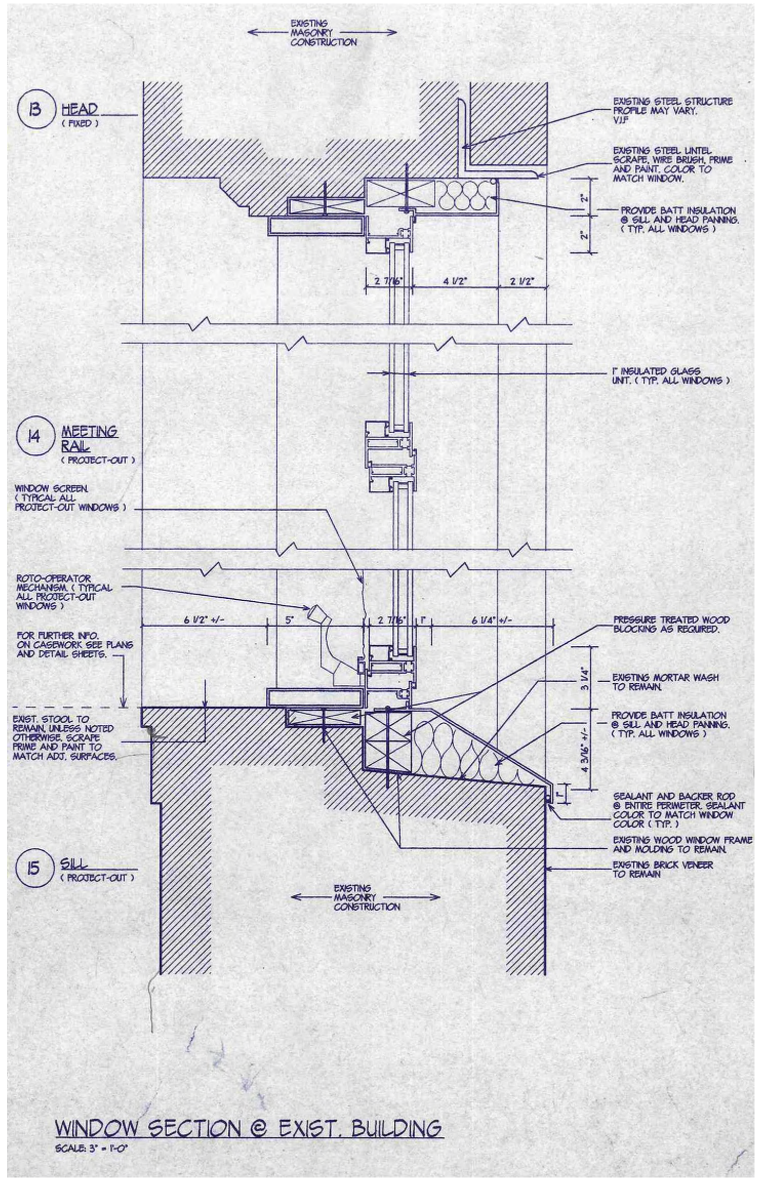
TYPICAL WINDOW CONFIGURATION -
DETAIL W-28/A701

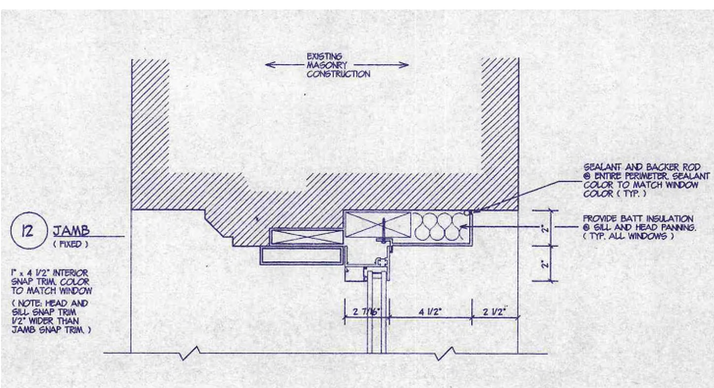




TYPICAL WINDOW DETAILS FROM DRAWING SHEET A703

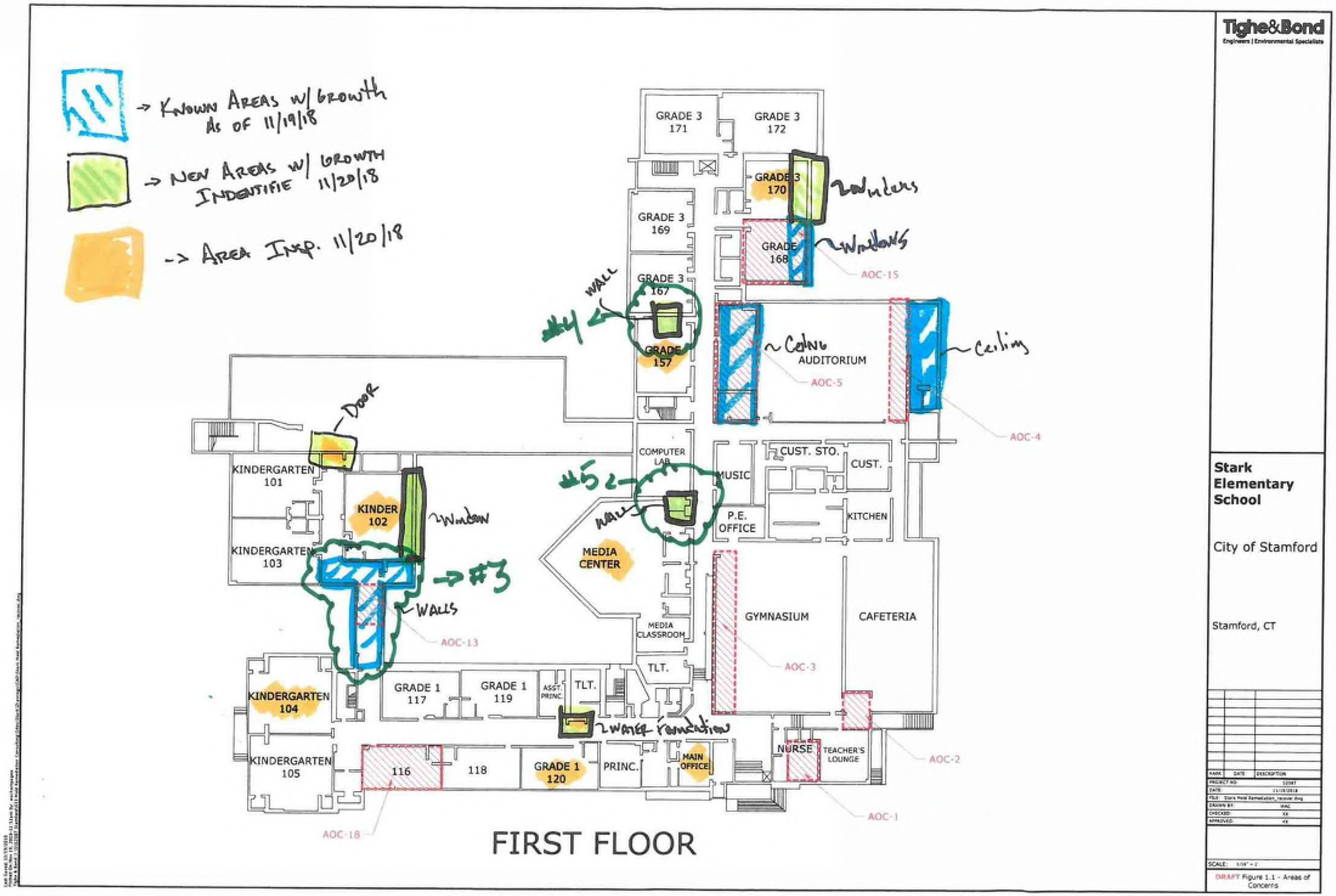




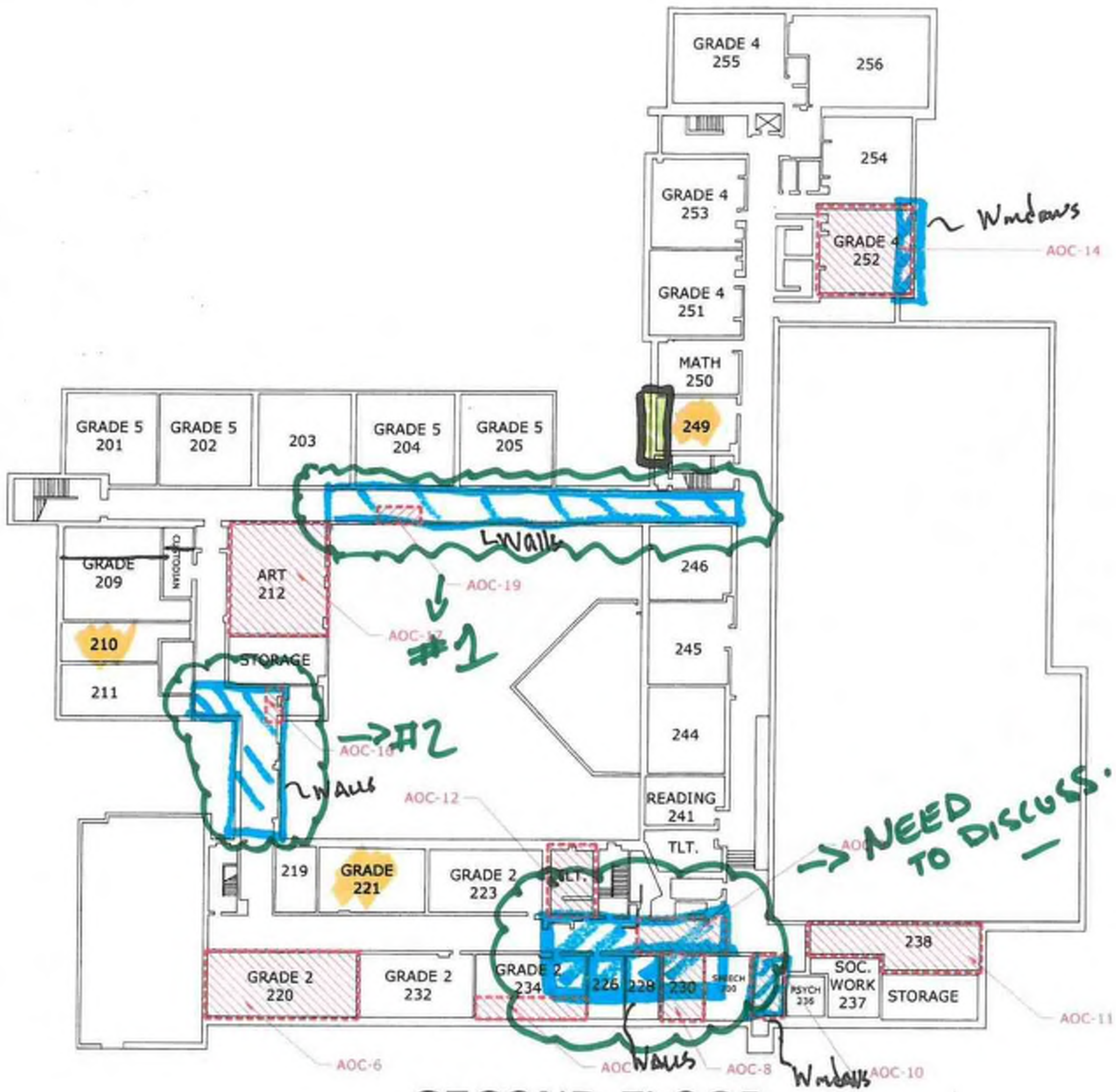


WINDOW CONFIGURATION W-7/A701
AND TYPICAL WINDOW DETAILS FROM
DRAWING SHEET A702

APPENDIX B



Tighe&Bond
Engineers | Environmental Specialists
→ Known Areas w/ Growth As of 11/19/18
→ New Areas w/ Growth Indentifie 11/20/18
→ Area Insp. 11/20/18
GRADE 3 171
GRADE 3 172
GRADE 3 170
2 windows
GRADE 3 169
GRADE 168
Windows
AOC-15
GRADE 3 167
WALL
#4
GRADE 157
Ceiling
AUDITORIUM
AOC-5
Ceiling
AOC-4
DOOR
KINDERGARTEN 101
KINDER 102
Window
KINDERGARTEN 103
#3
WALLS
AOC-13
COMPUTER LAB
#5
WALL
MUSIC
CUST. STO.
CUST.
P.E. OFFICE
KITCHEN
MEDIA CENTER
MEDIA CLASSROOM
GYMNASIUM
CAFETERIA
AOC-3
TLT.
KINDERGARTEN 104
GRADE 1 117
GRADE 1 119
ASST. PRINC.
TLT.
water remediation
AOC-2
KINDERGARTEN 105
116
118
GRADE 1 120
PRINC.
MAIN OFFICE
NURSE
TEACHER'S LOUNGE
AOC-1
AOC-18
FIRST FLOOR
Stark Elementary School
City of Stamford
Stamford, CT
DRAFT Figure 1.1 - Areas of Concerns



SECOND FLOOR

Tighe&Bond
Engineers | Environmental Specialists

Stark Elementary School

City of Stamford

Stamford, CT

SCALE: 1/16" = 1'

DRAFT Figure 1.2 - Areas of Concerns

APPENDIX C


MASONRY/FLASHING
REPAIRS PERFORMED
ABOVE WINDOWS
WATER TEST
LOCATION NO. 2
WATER TEST
LOCATION NO. 3
EXISTING BUILDING
NEW ADDITION
KEY PLAN
ELEVATION - 1
SCALE: 1/8" = 1'-0"
ELEVATION - 2
SCALE: 1/8" = 1'-0"
A-200

NOTE:
1. FOR SYMBOLS, NOTES AND ABBREVIATIONS SEE DRAWING G
2. E.E.W. - DESIGNATES EMERGENCY ESCAPE WINDOWS
KEY PLAN
NEW ADDITION
NEW ADDITION
WATER TEST LOCATION NO. 5
SOLDIER COURSE @ WINDOW HEAD AND SILL (TYP)
GLAZED BLOCK (TYP)
CONTROL JOINT
BRICK VENEER
E.E.W.
ROOF SLAB EL. 95'-2 23/32"
SECOND FLR. EL. 81'-8 3/64"
GRND. FLR. EL. 69'-0 27/32"
STONE VENEER TO MATCH EXISTING
TOP OF PARAPET EL. 92'-9 23/64"
SECOND FLOOR EL. 79'-7 13/64"
GROUND FLOOR EL. 65'-9 23/32"
SOLDIER COURSE AND STACKED BRICK
BRICK SHELF EL. 65'-4 19/32"
BRICK SHELF EL. 65'-9 13/32"
ALT. NO. A-6
ELEVATION - 3
SCALE: 1/8" = 1'-0"
NEW ADDITION
EXTERIOR SAMPLE OPENING NO. 2 (E.S.O.2)
STAIR ROOF SLAB EL. 107'-10 23/32"
STONE VENEER TO MATCH EXISTING
BRICK VENEER
ALUMINUM INSULATED WINDOW UNITS (TYP)
TOP OF PARAPET EL. 92'-9 23/64"
ROOF SLAB EL. 95'-2 23/32"
SECOND FLOOR EL. 81'-8 3/64"
GROUND FLOOR EL. 65'-9 23/32"
STAIR GROUND FLOOR EL. 67'-8 19/64"
BRICK SHELF EL. 65'-4 27/32"
BRICK SHELF EL. 62'-10 19/32"
BELOW GRADE MINIMUM
SECOND FLOOR EL. 81'-8 3/64"
GROUND FLOOR EL. 69'-0 27/32"
ELEVATION - 4
SCALE: 1/8" = 1'-0"
S.D.E. NO 135-160
PROJECT TITLE
STAMFORD PUBLIC SCHOOLS
EXPANSION AND RENOVATION OF
JULIA A. STARK ELEMENTARY SCHOOL
GLENBROOK ROAD, STAMFORD CT.
DRAWING TITLE
12/6/94 BID
9/8/94 REV.
6/3/94 REV.
5/2/94 FINAL
DATE
ISSUED TO
SCALE AS NOTED
DRAWING NO. A-201
DRAWN BY F&D
CHECKED BY F&D
FILE NO.
PLOT DATE

NOTE:
1. FOR SYMBOLS, NOTES AND ABBREVIATIONS SEE DRAWING G
2. E.E.W. - DESIGNATES EMERGENCY ESCAPE WINDOWS
NEW ADDITION
MEDIA CENTER ELEVATION - 5
SCALE: 1/8" = 1'-0"
NEW ADDITION
COURTYARD ELEVATION - 6
SCALE: 1/8" = 1'-0"
WATER TEST LOCATION NO. 7
NEW ADDITION
MEDIA CENTER ELEVATION - 7
SCALE: 1/8" = 1'-0"
COURTYARD ELEVATION - 8
SCALE: 1/8" = 1'-0"
NEW ADDITION
KEY PLAN
NEW ADDITION
EXTERIOR SAMPLE OPENING NO. 1 (E.S.O.1)
WATER TEST LOCATION NO. 6
WATER TEST LOCATION NO. 1 (PLANTER)
WATER TEST LOCATION NO. 4
COURTYARD ELEVATION - 9
SCALE: 1/8" = 1'-0"
NEW ADDITION
SHOT INSIDE
81.67
81'-8 1/8
SHOT INSIDE
79.60
79'-7 3/16
COURTYARD ELEVATION - 10
SCALE: 1/8" = 1'-0"
A-202