STRUCTURAL EVALUATION OF

VERDE ELEMENTARY SCHOOL

WEST CONTRA COSTA UNIFIED SCHOOL DISTRICT (WCCUSD)

For

WLC Architects
Kaiser Building
1300 Potrero Avenue
Richmond, CA 94804

By

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10.1 Introduction

The purpose of this report is to perform a seismic assessment of the Verde Elementary School in Richmond, CA. The structural assessment includes a site walk through and a limited study of available architectural and structural drawings. The purpose of the structural assessment is to identify decay or weakening of existing structural materials (when visible), to identify seismic deficiencies based on our experience with school buildings, and to identify eminent structural life-safety hazards.

The school campus has had a walk-through site evaluation and a limited study of available architectural and structural drawings. The general structural condition of the buildings and any seismic deficiencies that are apparent during our site visit and review of existing drawings are documented in this report. This report includes a qualitative and quantitative evaluation of the buildings. A limited lateral (seismic) numerical analysis was performed to identify deficient lateral elements, which could pose life safety hazards.

The site visits did not include any removal of finishes. Therefore, identification of structural conditions hidden by architectural finishes or existing grade was not performed.

10.2 Description of School

The school is located in the city of Richmond and was built in multiple stages. The original campus consisted of two, single story wood-framed classroom buildings, Unit D, constructed in 1950. This construction included covered walkways connecting the classroom buildings. In 1952, two additional single story wood-framed buildings, Unit B (multipurpose/administration building) and Unit C (classroom building), were added to the campus. Additionally, another classroom was added to one of the existing buildings, and more covered walkways were constructed at this time. Although the exact construction date is unclear, it appears that the classroom building, Unit E, was added to the campus sometime after 1952 and before 1965. This structure, for which the construction drawings are unavailable appears to have been built by a modular (perhaps portable) type construction. It is identified as a “permanent portable” on the school layout plan (see figure 1). The construction of the campus was completed in 1968 with the construction of the wood-framed library in Unit D, the hybrid wood/steel-framed classroom building, Unit A, and an addition to the administration building in Unit B. Additionally, the campus has one typical portable building, located at Unit E and erected in 1998. The total square footage of the permanent structures is about 37,877 square feet.

10.3 Site Seismicity

The site is a soil classification S_D in accordance with the 1998 California Building Code (CBC) and as per the consultants, Jensen Van Lieden Associates, Inc.

The classroom buildings have an educational occupancy (Group E, Division 1 and 2) and the multi-purpose building has an assembly occupancy (Group A, Division 2), both of which have an importance factor in the 1998 CBC of 1.15. The campus is located at a distance of 2.2 kilometers from the Hayward fault. The wood-framed buildings described above utilize diagonally sheathed or plywood shear walls to resist lateral loads. The response modification factor for these systems is as follows: R=4.5 (diagonal sheathing) and R=5.5 (plywood sheathing). The 1998 CBC utilizes a code level earthquake, which approximates an earthquake with a 10% chance of exceedance in a 50-year period or an earthquake having a 475-year recurrence period.

The seismic design coefficient in the 1998 CBC for diagonally sheathed buildings is:

$$V = \frac{2.5C_a IW}{R} = \frac{2.5(0.44x1.48x1.15)W}{4.5} = 0.416W$$

The seismic design coefficient in the 1998 CBC for plywood sheathed buildings is:

$$V = \frac{2.5C_a IW}{R} = \frac{2.5(0.44x1.48x1.15)W}{5.5} = 0.340W$$

The site seismicity is used to provide a benchmark basis for the visual identification of deficient elements in the lateral force resisting systems of campus buildings. The calculated base shear was used to perform a limited lateral analysis of the school buildings as described in section 10.7.

10.4 List of Documents

1. Unit D, Classroom Buildings: Dragon, Schmidts, & Hardman Architects, Sheets 1 – 12, October 25, 1949.
2. Unit A, Classroom Building, Library Addition: Barbachano, Ivanitsky and Associates, Inc. Architects, A.I.A., Sheets A-2, A-6 – A-9, March 18, 1968; Frank E. McClure & David L. Messinger Consulting Structural Engineers, Sheets S-1 – S-8, S-10, March 18, 1968.
3. "Measure M" – WCCUSD Elementary School – UBC revised parameters by Jensen- Van Lienden Associates, Inc., Berkeley, California.
4. "Geological Hazard Study – Recently constructed portable buildings – 24 school sites for Richmond Unified School District," by Jensen – Van Lienden Associates, Inc. dated March 7, 1990.
5. "Measure M" roofing report by "The Garland Company Inc.", Orinda, California.

10.5 Site Visit

DASSE visited the site on October 23rd, 2001 and March 8th, 2002. The main purpose of the site visit was to evaluate the physical condition of the structure and in particular focus on the lateral force resisting elements of the building. The following items were evaluated during the site visit:

1. Type and Material of Construction
2. Type of Sheathing at Roof, Floor, and Walls
3. Type of Finishes

4. Type of Roof
5. Covered Walkways
6. Presence of Clerestory Windows
7. Presence of Window Walls or High Windows in exterior and interior walls
8. Visible cracks in superstructure, slab on grade and foundation

The Unit A pod classroom building is a wood-framed structure with stucco exterior wall finishes (figure 11). The single story building is built on a slab on grade with spread footings. A built-up asphalt roof is used. The single story Unit B houses the multipurpose room and administrative offices (figures 2 and 10). It is a wood-framed building that includes roof trusses. Most of the building's exterior is stucco, but there are significant portions of brick veneer at the front of the building, including ground to roof veneer in some locations and a 20 foot tall brick pier at the entry canopy. Multiple windows and other wall openings limit the seismic shear strength of the building in the longitudinal direction to the extent that a life safety hazard is observed.

Unit C is a single story classroom building, also wood-framed with a stucco exterior (figures 5 and 6). A covered walkway runs the entire length of the building on the south side, and the north wall is a window wall. The lack of shear wall resistance due to these windows constitutes a life safety hazard. The classroom buildings of Unit D are very similar wood-framed structures (figures 3, 4, 8, and 9). The exterior walls and interior corridors are finished with a brick veneer up to five feet tall, and stucco above. Similar to Unit C, the north walls of the classrooms are window walls creating a life safety hazard. Unit D also includes the library addition, which ties the classroom wings into one structure.

The final classroom building, Unit E, was built as a modular-type structure with vertically ribbed plywood siding. The large extent of window openings in the longitudinal walls represents a life safety hazard. This building's foundation system consists of an intermittent foundation typical of portable construction. The inability of this foundation system to transfer seismic loads creates a life safety hazard. At the long classroom buildings and connecting the various buildings, covered walkways are framed with wood beams and steel pipe columns, and are supported by multiple structures. The inability of this system to withstand differential displacements of the buildings to which it is tied represents a life safety hazard. Electrical conduit was found to be running along the covered walkways and between multiple buildings. Similarly, the inability of this conduit to withstand these differential movements, this is also identified as a life safety hazard.

10.6 Review of Existing Drawings

Units A is a symmetrical, single story pod building (see figure 11). The pod-type classroom configuration of these buildings in plan results in some walls skewed relative to the orthogonal directions. The structure is framed with 2x12 roof joists at 24" on center that are supported by wood bearing walls and four 3-pinned steel arches. Plywood sheathing (1/2") covers the roof framing to provide a continuous roof diaphragm across some significant spans (up to 57'-6"). Lateral forces are resisted primarily by plywood shear walls, most of which occur at the exterior walls. There appears be a substantial length of shear wall in both directions. It is also noted that the 3-pinned arches will provide a secondary lateral force resisting system. While double top plates are provided at the top of the wood framed walls, the splice connection is deficient for the prescribed forces. Additionally, collector elements are not detailed for the interior shear walls. The building is founded on a typical 1'-2" wide reinforced concrete spread footings with grade beams used to tie the arch bases together. A positive connection between this foundation and the wood shear walls for the purpose of resisting uplift forces has not been provided. The life safety hazards identified at Unit A are the inadequate collector strength and the lack of shear wall tie downs. The existing roof of Unit A is about 5 years old and appears to be in acceptable condition.

Construction drawings for Unit B are not available for review at this time. The existing roof of Units B is about 3 years old and appears to be in acceptable condition.

Construction drawings for Unit C are not available for review at this time. However, because the construction of Unit C is very similar to the construction of Unit D, it is most likely that the conditions identified below as life safety concerns at Unit D, can be expected to exist at Unit C as well (see figures 2 and 3). The existing roof of Unit C is about 3 years old and appears to be in acceptable condition.

Unit D was originally constructed as two separate classroom buildings, but with the addition of the library the two structures were combined into one. The resultant structure has a plan geometry with severe re-entrant corners, and the diaphragm does not have a continuous tie at these locations. The original classroom buildings were framed with wood trusses built from 2x8 and 2x10 members and spaced at 24" on center. These trusses span transversely between wood-framed bearing walls and are covered with diagonal sheathing. The central library portion of Unit D is framed with 2x8 joists at 24" on center carried by W14 and W18 steel beams and girders. The roof here is sheathed with 1/2" plywood. The combined structure resists seismic loads through the original diagonally sheathed wood shear walls and plywood shear walls added during the addition. The addition of the library included the removal of some walls previously used to resist seismic forces. This removal was compensated for by the addition of plywood sheathing to the remaining portions of wall. Along with the minimal longitudinal shear walls, these reduced transverse shear walls are vulnerable to seismic loading. Continuity of the chord/collector elements is provided through a variety of means including double top plates at the transverse walls and spliced headers in the longitudinal direction. The capacities of these chord/collector splices are inadequate at some locations. The building foundation is composed of reinforced concrete spread footings from both construction phases ranging in width from 11" to 3'-0". Some of the shear walls are anchored to these footings, but this type of positive connection is lacking at other locations. The life safety hazards identified in Unit D are the re-entrant corners, inadequate shear wall length, and inadequate collector strength. The existing roof of Unit D is about 3 years old and appears to be in acceptable condition.

Construction drawings for Unit E are not available for review at this time. The existing roof of Units E is about 3 years old and appears to be in acceptable condition.

As the campus has grown in stages, the covered walkways have been constructed in phases to connect the various buildings. The covered walkways connecting the two classroom wings of Unit D are framed with 2x8 joists at 16" on center supported by 6x6 beams and 3" diameter steel pipe columns. As mentioned above, these walkway structures have positive ties to multiple adjacent buildings, which supports the framing under both gravity and lateral loads and constitutes a life safety hazard. Construction drawings for remainder of the covered walkways are not available for review at this time.

10.7 Basis of Evaluation

The document FEMA 310, Federal Emergency Management Agency, *"Handbook for the Seismic Evaluation of Buildings – A Prestandard,"* 1998, is the basis of our qualitative seismic evaluation methods. The seismic performance levels that the FEMA 310 document seeks to achieve are lower than the current Building Code. However, it attempts to identify the potential for building collapse, partial collapses, or building element life safety falling hazards when buildings are subjected to major earthquake ground motion.

The California Building Code (CBC 1998) is the basis of our quantitative seismic evaluation methods. Base shears identified in section 10.3 were used to perform a limited lateral seismic analysis of the school buildings. The scope of the analysis was not to validate every member and detail, but to focus on those elements of the structure determined to be critical and which could pose life safety hazards. Member *strength* values are based on the document FEMA 356, Federal Emergency Management Agency, *"Prestandard and Commentary for the Seismic Rehabilitation of Buildings"* 2000.

10.8 List of Deficiencies

Building deficiencies listed below have corresponding recommendations identified and listed in Section 10.9, which follow the same order as the itemized list of deficiencies identified below. The severity of the deficiency is identified by a *"structural deficiency hazard priority"* system based on a scale between 1.0 and 3.9, which is described in Section 10.11. These priority ratings are listed in section 10.9. Priority ratings between 1.0 to 1.9 could be the causes for building collapses, partial building collapses, or life-safety hazards, if the corresponding buildings are subjected to major earthquake ground motions, which are possible at these sites. It is strongly recommended that these life safety hazards are mitigated by implementing the recommendations listed below.

Item	Building Structural Deficiencies
1.	Unit A (classroom building): Strength and continuity of chord/collector elements is inadequate to resist prescribed forces.
2.	Unit A (classroom building): Positive connection of shear walls to foundation is lacking.
3.	Unit B: Wood shear walls at longitudinal walls are likely to be inadequate to resist prescribed forces.
4.	Unit C and D (classroom buildings): Wood shear walls at locations in both directions are inadequate to resist prescribed forces.
5.	Unit C and D (classroom buildings): Strength of chord/collector elements is

	inadequate to resist prescribed forces.
6.	Unit D: Diaphragm continuity is lacking at severe re-entrant corners.
7.	Unit E (classroom buildings): Wood shear walls at longitudinal walls are likely to be inadequate to resist prescribed forces.
8.	Unit E (classroom building): Discontinuous foundation at rear lacks the ability to transfer lateral forces to the ground.
9.	Covered Walkway: Structure is tied to multiple adjacent buildings with no provision to accommodate differential movement.
10.	Covered Walkway: Electrical conduits are connected to adjacent buildings with no provision to accommodate differential movement.

10.9 Recommendations

Items listed below follow the same order as the itemized list of deficiencies identified in section 10.8 above.

Item	Recommended Remediation	Priority	Figure Number
1.	Provide new strapping and blocking at inadequate locations.	1.5	N/A
2.	Provide new holdown anchors into existing foundation.	1.5	N/A
3.	Replace existing diagonal sheathing with new plywood sheathing at inadequate locations and/or remove some windows and replace with new stud framing and plywood sheathing. Provide new collectors and holddowns as required.	1.1	N/A
4.	Replace existing diagonal sheathing with new plywood sheathing at inadequate locations and/or remove some windows and replace with new stud framing and plywood sheathing. Provide new holddowns as required.	1.1	3, 4, 5, 6
5.	Provide new strapping and blocking at inadequate locations.	1.5	N/A
6.	Provide new continuous ties with new joists, strapping, and blocking.	1.5	3
7.	Replace existing diagonal sheathing with new plywood sheathing at inadequate locations and/or remove some windows and replace with new stud framing and plywood sheathing. Provide new collectors and holddowns as required.	1.1	7
8.	Provide new reinforced concrete spread between existing, intermittent footings at discontinuous foundation.	1.9	N/A
9.	Provide new beams and columns to support the covered walkway framing near each adjacent building.	1.9	N/A
10.	Provide new flexible electrical conduits in covered walkway and between adjacent buildings.	1.9	9

10.10 Portable Units

In past earthquakes, the predominant damage displayed by portable buildings has been associated with the buildings moving off of their foundations and suffering damage as a result. The portables observed during our site visits tend to have the floor levels close to the ground, thus the damage resulting from buildings coming off of their foundation is expected to be minimal. The life safety risk of occupants would be posed from the potential of falling 3 feet to the existing grade levels during strong earthquake ground shaking. Falling hazards from tall cabinets or bookshelves could pose a greater life safety hazard than building movement. The foundation piers supporting the portable buildings tend to be short; thus the damage due to the supports punching up through the floor if the portable were to come off of its foundation is not expected to be excessive.

Because of their light frame wood construction and the fact that they were constructed to be transported, the portable classrooms are not in general expected to be life safety collapse hazards. In some cases the portables rest directly on the ground and though not anchored to the ground or a foundation system could only slide a small amount. In these instances the building could slide horizontally, but we do not expect excessive damage or life safety hazards posed by structural collapse of roofs.

The regulatory status of portables is not always clear given that portables constructed prior to 1982 will likely have not been reviewed by DSA and thus will likely not comply with the state regulations for school buildings. Portables constructed after about 1982 should have been permitted by DSA. The permits are either issued as temporary structures to be used for not more than 24 months or as permanent structures.

10.11 Structural Deficiency Prioritization

This report hazard rating system is based on a scale of 1.0 to 3.9 with 1.0 being the most severe and 3.9 being the least severe. Based on FEMA 310 requirements, building elements have been prioritized with a low rating of 1.0 to 1.9 if the elements of the building’s seismic force resisting systems are woefully inadequate. Priority 1.0 to 1.9 elements could be the causes for building collapses, partial building collapses, or life-safety falling hazards if the buildings were subjected to major earthquake ground motion.

If elements of the building’s seismic force resisting system seem to be inadequate based on visual observations, FEMA 310 requirements and limited lateral (seismic) calculations, but DASSE believes that these element deficiencies will not cause life-safety hazards, these building elements have been prioritized between a rating low of 2.0 to 3.9. These elements could experience and / or cause severe building damage if the buildings were subjected to major earthquake ground motion. The degree of structural damage experienced by buildings could cause them not to be fit for occupancy following a major seismic event or even not repairable.

The following criteria was used for establishing campus-phasing priority:

First, the individual element deficiencies which were identified during site visit and review of existing drawings were prioritized with a rating between 1.0 to 3.9 and as described in this section.

The next step was to arrive at a structural deficiency rating between 1 and 10, with a rating of 1 representing a school campus in which the building's seismic force resisting systems are woefully inadequate.

Based on the school district's budgetary constraints and scheduling requirements, each school campus was given a phasing number between one and three. Phase I represents a school campus with severe seismic deficiencies, Phase II represents a school campus with significant seismic deficiencies and Phase III represents a school campus with fewer seismic deficiencies.

10.12 Conclusions

1. Given the vintage of the building(s), some elements of the construction will not meet the provisions of the current building code. However, in our opinion, based on the qualitative and limited quantitative evaluations, the building(s) will not pose serious life safety hazards if the seismic deficiencies identified in section 10.8 are corrected in accordance with the recommendations presented in section 10.9.

2. Any proposed expansion and renovation of the buildings should include the recommended seismic strengthening presented in section 10.9. Expansion and renovation schemes that include removal of any portion of the lateral force resisting system will require additional seismic strengthening at those locations. It is reasonable to assume that where new construction connects to the existing building(s), local seismic strengthening work in addition to that described above will be required. All new construction should be supported on new footings.

3. Overall, this school campus has a seismic priority of 2 and we recommend that seismic retrofit work be performed in Phase I.

10.13 Limitations and Disclaimer

This report includes a qualitative (visual) evaluation and a limited quantitative seismic evaluation of each school building. Obvious gravity or seismic deficiencies that are identified visually during site visits or on available drawings are identified and documented in this report. Elements of the structure determined to be critical and which could pose life safety hazards are identified and documented during limited quantitative seismic evaluation of the buildings.

Users of this report must accept the fact that deficiencies may exist in the structure that were not observed in this limited evaluation. Our services have consisted of providing professional opinions, conclusions, and recommendations based on generally accepted structural engineering principles and practices.

DASSE's review of portable buildings has been limited to identifying clearly visible seismic deficiencies observed during our site visit and these have been documented in the report. Portable buildings pose several issues with regard to assessing their life safety hazards. First, drawings are often not available and when they are, it is not easy to associate specific drawings with specific portable buildings. Second, portable buildings are small one story wood or metal frame buildings and have demonstrated fairly safe performance in past earthquakes. Third, there is a likelihood that portable buildings (especially those constructed prior to 1982) are not in compliance with state regulations, either because they were not permitted or because the permit was for temporary occupancy and has expired.

Figures

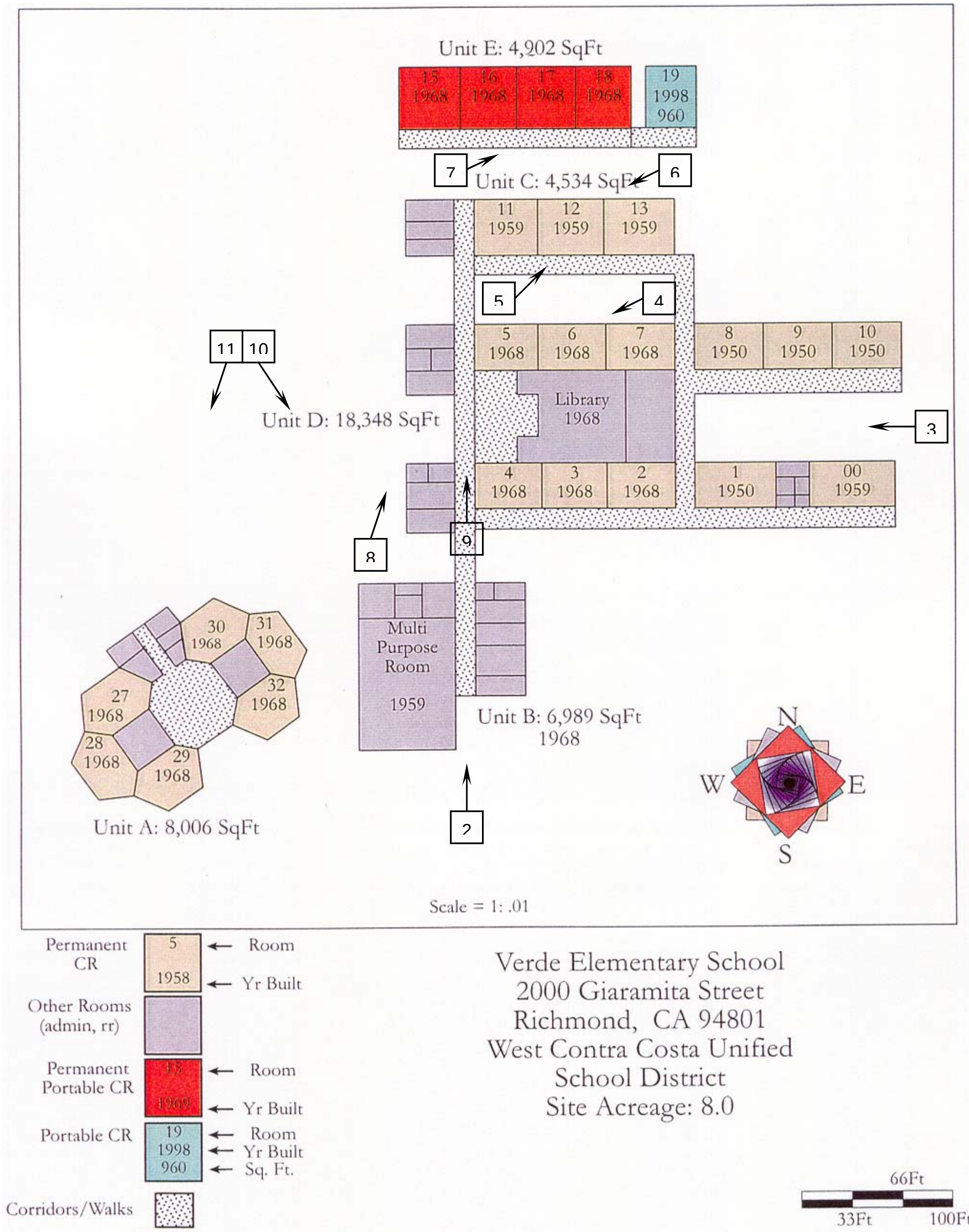

Figure 1: School Layout Plan

Figure 2: Main Entrance

Figure 3: Unit D (classroom buildings) east face

Figure 4: Unit D (classroom buildings) north face

Figure 5: Unit C (classroom building) south face

Figure 6: Unit C (classroom building) north face

Figure 7: Unit E (classroom building) south face

Figure 8: Units C, D, & E west face

Figure 9: Unit D (classroom buildings) hallway

Figure 10: Unit B (multipurpose building) north face

Figure 11: Unit A (classroom building) north face