Thesis Proposal

Rendering courtesy of Devrouax & Purnell Architects

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Date: 12/12/2014

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Executive Summary

The objective of this proposal is to present alternative mechanical design characrteristics with the goal of improving system efficiency and reduce cost of operation. Elementary School One current design meets all required standards and codes of the state. Though requirements are met, the system's efficiency can still be improved.

The existing school building was renovated and an addition was built on the west side of the building. Elementary School One modernization finished in 2011 reaching 84,400 gsf. The building is three stories above grade and one below. The current mechanical system includes three dedicated outside air units (DOAS) that serve the majority of the building. The spaces served by the DOAS are conditioned by an air-cooled VRF system. The other spaces are conditioned by packaged roof top units along with radiate and cabinet heaters.

The redesign of the system will implement a geothermal heat pump with water-cooled VRF condensers. The water-cooled condenser will transfer loads to the geothermal heat pump by using a heat exchanger. The redesign will impact the construction process so an evaluation of changes to site layout, schedule and coordination will be done. Also, an acoustical anaylsis will be done to check and promote comfort of certain spaces.

The proposal will investigate the efficiency and cost savings of the redesign. This evaluation will occur during the spring semester and use software such as Trace Trane and Dynasonics AIM. A detailed work schedule that will be followed throughout the semester can be found below at the end of the report.

Building Overview

Building Name:	Elementary School One
Location and Site:	Town, Maryland
Dates of Construction:	2010 – August 2011
Size:	84,400 sq. ft.
Number of Stories:	3 above and 1 below grade

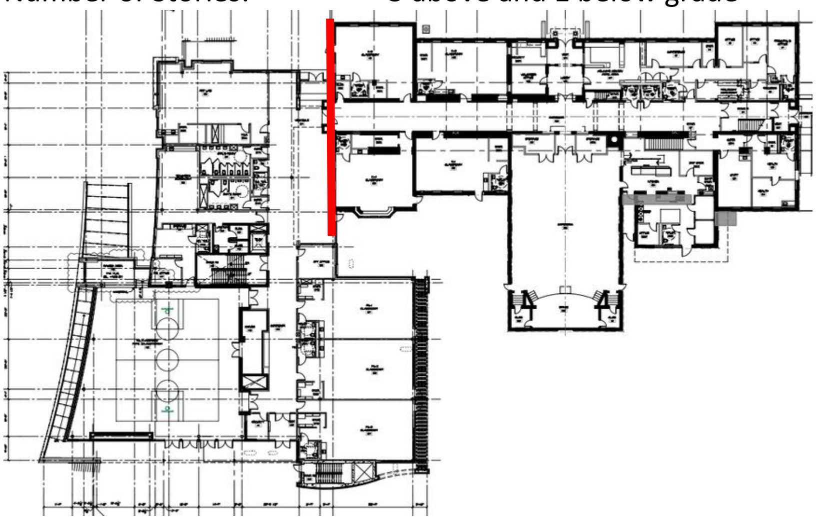


Figure 1: First Floor Plan.

The red line separates the existing building and the addition. The existing is on the right and the addition is on the left.

Mechanical Systems Summary

Elementary School One modernization involved a renovation of the existing building and adding an addition on the west side. All new mechanical systems were applied to both the existing and the addition. The mechanical system has three dedicated outside air RTUs that supply VAV boxes in each space. Each space then exhausts air back to the RTUs for heat wheel. There are three air-cooled VRF systems that condition these spaces with dedicated outside air.

Two RTUs serve the cafeteria and two serve the multipurpose room. There are also base board radiators and cabinet heaters in some of the spaces near the exterior. In the administrative section of the existing building, an AHU conditions the spaces with its own outside air intake. There are small AHUs that serve the computer room and telecom room, but they were not included in my analysis because of the insignificant impact.

The figures below show the areas each unit serves.

Blue-	RTU-1 and 2 serve cafeteria
Orange-	RTU-3 and 4 DOAS serve the existing building (heat wheel)
Purple-	RTU-5 DOAS serve the addition (heat wheel)
Green-	RTU-6 and 7 serve the multipurpose room
Red-	AHU serves administrative offices

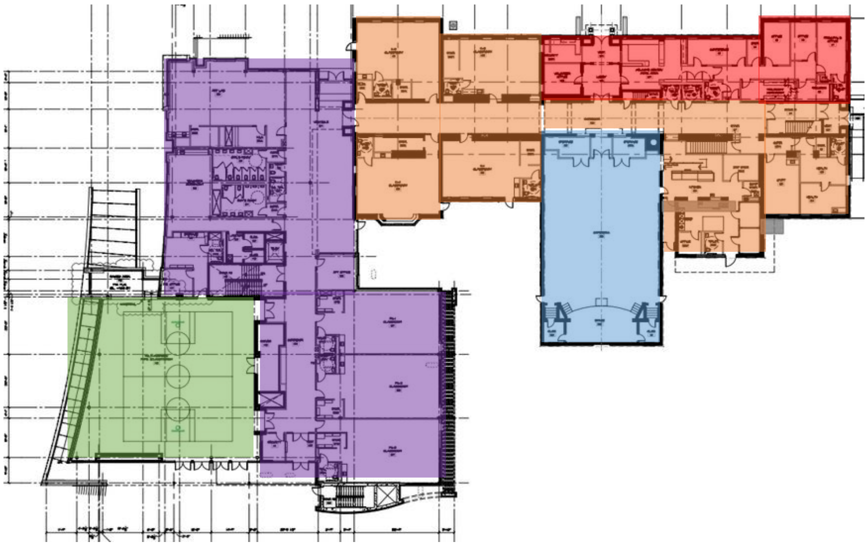


Figure 2: First Floor Block Layout

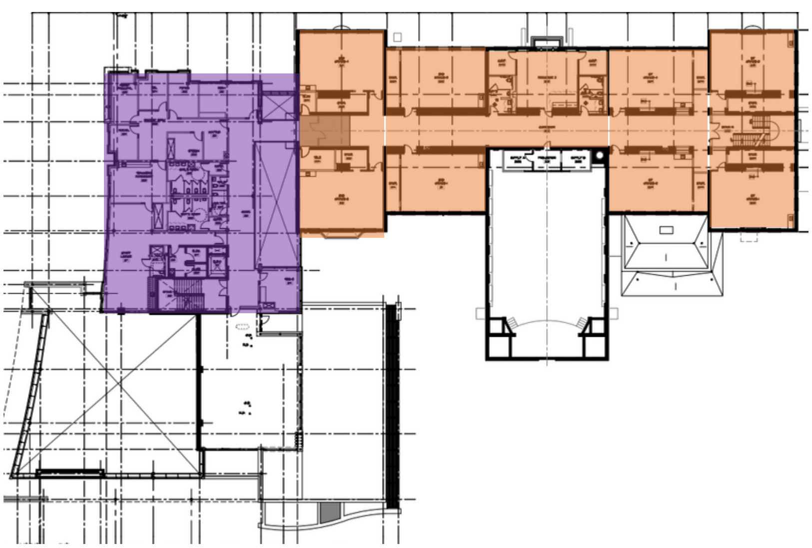


Figure 3: Second Floor Block Layout

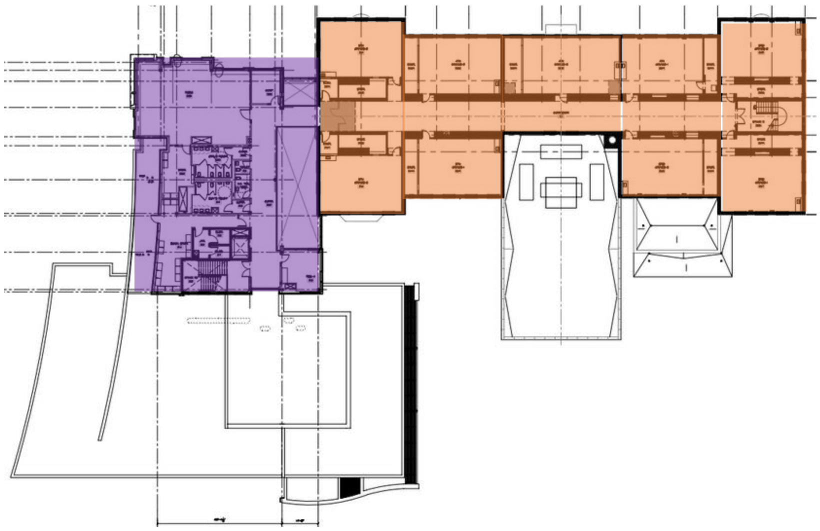


Figure 4: Third Floor Block Layout

Equipment Summary

The rooftop units and air conditioning units combine to serve all the spaces in the building. RTU-3, 4 and 5 are dedicated outside air units. The DOAS units serve the spaces using VAV boxes. There are 59 VAV boxes in the building ranging from 75 cfm to 600 cfm. RTU-1, 2, 6 and 7 are packaged units that condition and provide OA to the space. These spaces are provided with extra heating from 10 electric unit heaters and electric baseboards. The AC units serve individual spaces that needed different loads and schedules. The AC units are part of a split system with air cooled condensing units.

There are three variable refrigerant flow systems that condition the spaces served by the DOAS. The VRF is air-cooled to three units on the roof. The spaces served by the DOAS can receive conditioned outside air from the RTUs and then the VRF can supply any further conditioning. There are 13 cabinet heaters that serve vestibules, corridors and stairwells if extra heating is needed.

Alternatives Considered

Several ideas were considered for the redesign of the mechanical system of Elementary School One. During the decision process, many factors were considered including: construction cost, operating cost, maintainability, energy consumption and feasibility. The alternatives considered are listed below:

- Building Envelope Evaluation
    - Thermal Performance
    - Structural Impact
    - Architectural and Historic considerations
- Using chilled beam system instead of VRF system
- Changing VRF air-cooled to water-cooled
    - Ground source heat pump
- On-site renewable energy sources
    - Solar power
    - Wind power

The options considered have different impacts and feasibility due to the current system types and site location. Not all alternatives can be investigated because of time and information limitations. The alternative selected will have an impact on several disciplines and have educational value.

Proposed Alternatives

The following alternatives were chosen to compare cost and energy impact to the current design. Also, the alternatives were chosen for educational interest and benefit. The proposed investigations are not meant to imply faults in the original design, but are presented for the educational value.

Depth

The proposed alternative that will be investigated is implementing a geothermal heat pump with the VRF condensers. This will change the VRF condensers from air-cooled to water–cooled. A heat exchanger will transfer the loads between the three condensing units and the geothermal system. A closed loop geothermal system has antifreeze filled pipes that transfer loads between the building and the earth. The pipes will be in vertical wells to exchange heat with the constant temperature of the earth. The earth temperature becomes constant from 20 ft. to 30 ft. below the surface depending on the area.

The alternative design will have an impact on the initial cost and energy consumption of the mechanical system. Water-cooled systems have higher initial cost, but are more energy efficienct than air-cooled systems. The heat transfer properties of water are much better than those of air. The water-cooled has constant performance whereas with air-cooled the performance is dependent on the ambient air temperature. Also, the installation of the geothermal system will be costly, but the system will be using a basically free energy source, the earth.

Breadths

Construction

The construction of the geothermal system will have an impact on the coordination, schedule, cost and site layout of the construction management team. These impacts will be investigated and evaluated throughout the construction process.

Acoustics

The spaces served by the packaged roof top units, cafeteria and multi-purpose room, have not been acoustically addressed. These spaces are served by untreated ducts directly from the roof top units and may produce high background noise levels. An assessment of the spaces will be performed and alternative solutions will be evaluated.

Masters Coursework

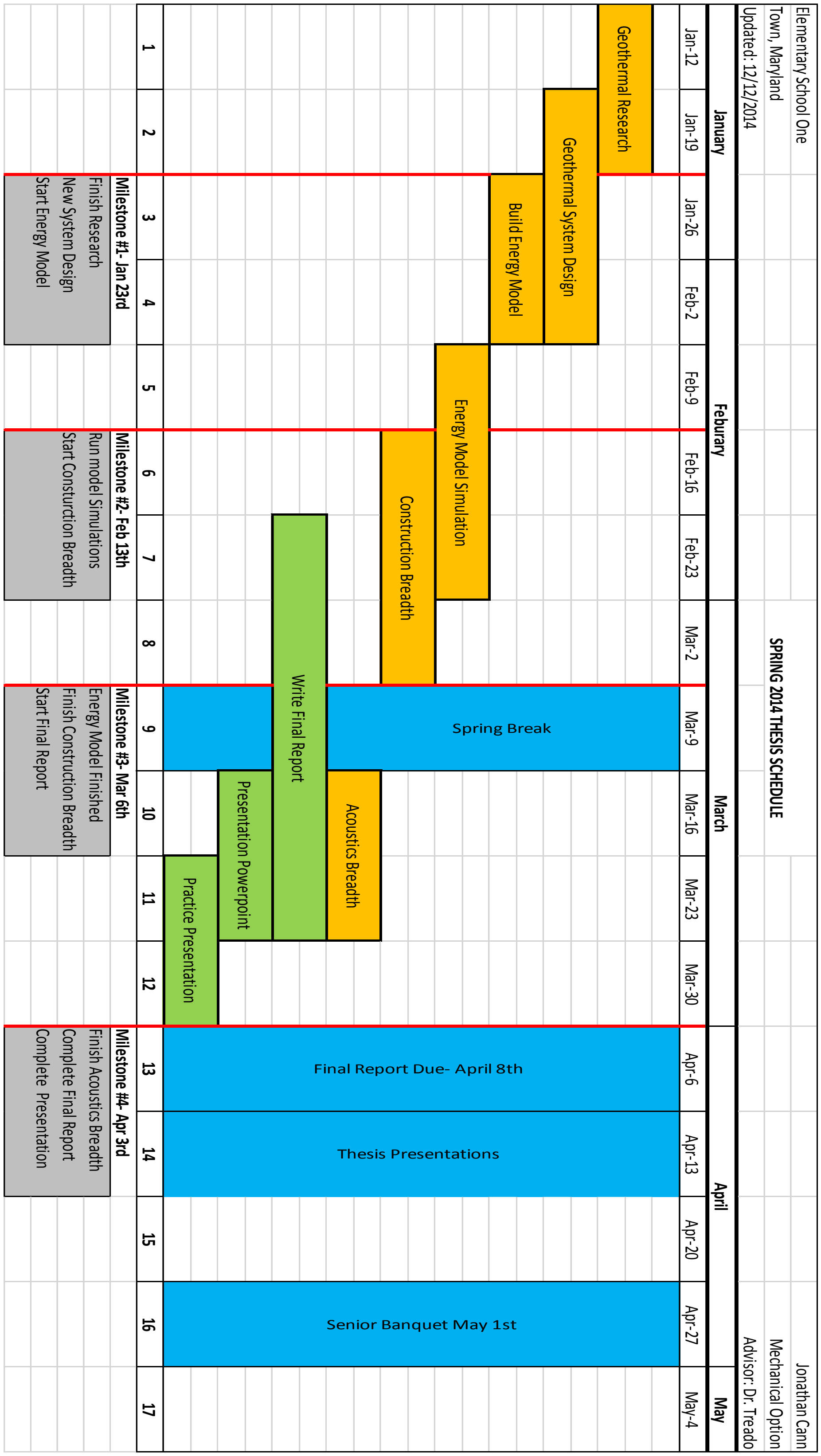
The intregation of the geothermal heat pump to the VRF system will involve knowledge gained from several master courses. Information learned in AE 557 (Centralized Cooling Production and Distribution Systems) will be used in the design and investigation of water-cooled condensers and geothermal systems. AE 552 (Indoor Air Quality) content was used during the evaluation of current ventilation and mechanical systems. AE 557 (Centralized Heating Production and Distribution Systems) content will help in the energy consumption and life-cycle cost analysis.

Tools and Methods

Load simulation and energy analysis will be done using Trace Trane 700 inputting the mechanical system, controls, site orientation, building envelope and materials. Trace Trane software was used to perform load and energy analysis of the current building state in Technical Report Two. There are limitations of input of mechanical systems and controls in the software which need to be accounted for in the conclusion. If time allows, other software will be used to perform the same analysis. The energy analysis will allow for the comparison of initial cost and long term savings.

The acoustical analysis will be performed using the software Dynasonics AIM. The software input includes duct lengths, transitions, air velocity and space properties. This will determine noise levels produced in the space compared to the recommended level. If software limitations are significant, then hand calculations can be done to conclude the analysis.

Thesis Schedule



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