Minneapolis Public Schools
Special School District #1

Air Conditioning Cost Estimating Study Field Community School

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INTRODUCTION / KEY INFORMATION:

Wold Architects and Engineers was hired May 2021 to develop options with a recommended approach and construction cost estimate to expand the air conditioned area at Field Community School. The study also reviewed dehumidification capabilities and outlines additional work necessary to provide active dehumidification control. The study approach included a tour of the building site, review of available building construction documents, and a review of previous ventilation studies. Wold collaborated with the District's facility leadership team to establish criteria and guiding principles for developing options and to determine the recommended approach. Cost estimates are developed to reflect construction bids to be received on January 1, 2022 and includes a semi-annual cost inflation escalation to extend bids to January 1, 2025. .

Key Information:

- Building Address: **Field Community School**
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  Minneapolis, MN 55419
  Phone: (612) 668-1122
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EXECUTIVE SUMMARY:

Wold Architects and Engineers completed a study to determine the recommended approach and project budget to expand the air-conditioned area at the Field Community School. The options developed are organized around the priorities established by the District based on the use of each space and by grouping areas within each building geographically as served by common systems. In collaboration with the District, the recommendation was developed to serve the highest priority areas within the overall budget constraints. In addition, the building as a whole was evaluated to determine additional features and systems that are required to provide active dehumidification control.

Criteria / Guiding Principles:

Initial discussions provided a common understanding of the guiding principles to be used to develop options and a hierarchy of priorities based on the use of each space.

Guiding Principles:

- High quality proven system solutions preferred
- Systems shall be easy to operate and maintain
- A high level of temperature zone control required
- Centralized systems preferred
- Vertical unit ventilators may be an option depending on site factors
- DX or chilled water may be options depending on site factors
- Separate systems to serve administration areas should be considered
- COVID risk mitigation measures to focus on ventilation and filtration
- Window AC unit are not an option. Mini-splits may be is limited applications
- Heating for systems may be steam or hot water depending on site factors
- Systems shall be configured to allow for active dehumidification

Air conditioning classrooms is the primary goal of this study. Additional spaces may be considered where possible within the overall budget constraints. Options were considered where space adjacencies allow opportunities to economically include additional areas. Gymnasiums are not typically air-conditioned but options were considered where they are central to a building and/or used as gathering spaces. It is not an intended outcome of the study to add ventilation and air conditioning to all spaces where it does not currently exist. The summary diagrams for each building identify the remaining unconditioned areas.

In addition, opportunities within each option were determined to provide added value scope where it is economically feasible to accomplish additional deferred maintenance needs within the scope of the air conditioning project i.e. ceilings, lights, and other room finishes.

Recommended Scope Summary:

Classrooms Building Areas #1 and #2 (34,150 Sq Ft): Install a new central variable air volume system with remote DX cooling to serve the classroom areas in area #1. Install the new central VAV classroom systems in the existing mechanical room to the extent possible. Install vertical unit ventilators with remote DX for the rooms in area #2. Provide a steam-to-hot water convertor located in the boiler room to provide hot water for the system heating needs and a high efficiency boiler for summer operation. Install new insulated ductwork serving area #2 along the same duct pathways as the existing. The base project includes routing supply ductwork exposed within the classrooms and similar areas. For consideration, an added scope option is included for providing a new lay-in ceiling and new LED lighting and controls. A perimeter soffit is included as may be required to accommodate the height of the exterior windows.

The cost estimate includes a design contingency to cover risks identified that require further investigation. Identified risks include the following:

- Space heating and cooling loads are estimated to determine preliminary equipment selections as a basis for cost estimating. Final heating and cooling loads need to be completed.
- The optimal new air-handling unit configuration. A guiding principal is to locate as much of the new equipment inside the existing fan room as possible. Options to optimize the space include combining air-handling zone, determining and alternate outside airflow path, and maybe alternate locations for heat recovery equipment
- Integrity and capacity of the existing steam and condensate systems. Modifications are necessary for the installation of the steam-to-hot water heat exchanger.
- Locations for the remote DX condensing units need to be determined within the constraints of the maximum allowed refrigerant piping lengths.

Construction Cost Estimate: $ 4,065,000
Add for Ceiling and Lights: $ 715,000

Cafeteria Building Areas #3 (7,530 Sq Ft): The area is served by a constant volume gas fired single zone unit installed in the 2000 construction. The unit is a rooftop air-handling unit with provisions for a future 30 ton cooling coil. Install a new DX coil in the existing unit with a remote DX condensing unit mounted on the roof.

- Adequacy of the existing structure to support the new rooftop unit. Resolution of this risk requires a specific air handling unit selection and an analysis by a structural engineer.

Construction Cost Estimate: $ 98,000

Gymnasium Building Area #4 (4,690 Sq Ft): Replace the existing air handling unit with a new air handling unit in the same location. Provide a remote DX condensing unit for cooling and connect to the existing steam distribution system. Access to the existing mechanical room is very difficult and options to improve access need to be explored. Install new insulated supply ductwork in the same location as the existing above a lay-in ceiling in the gymnasium. For consideration, added scope options are included to provide new LED lighting and controls and de-stratification fans.

The cost estimate includes a design contingency to cover risks identified that require further investigation. Identified risks include the following:

- Space heating and cooling loads are estimated to determine preliminary equipment selections as a basis for cost estimating. Final heating and cooling loads need to be completed.
- Adequacy of the existing structure to support the new rooftop unit. Resolution of this risk requires a specific air handling unit selection and an analysis by a structural engineer.

Construction Cost Estimate:	**$**	**382,000**
Add for Ceiling and Lights	**$**	**115,000**
Add for De-stratification Fans	**$**	**14,000**

EXISTING BUILDING INFORMATION

The original building was constructed in 1921. Major renovations and additions were completed in 1924,1964, 1971, 1974, and 2000. 1961 replaced the original mechanical systems and installed horizontal steam unit ventilators throughout the building. A project in 2015 renovated the office area and added mini-split systems for cooling. The gymnasium air handling system was replaced in 2020 with steam heat and DX cooling.

There is not a centralized cooling plant. A roof mounted variable air volume system installed in 2000 provides cooling for the media center. The adjacent cafeteria and auditorium system was installed in 2000 with provision for a future cooling coil. A multi-zone system installed in 1974 provides cooling for the main office. Window AC units or mini-split units serve a portion of the rest of the building.

The building is heated with two large dual fuel fire tube steam boilers.

A complete summary of the existing building systems is shown graphically in Appendix A.

Building Area Summary:

Year	Area (sq. ft.)
1921	14,191
1924	22,581
1964	13,920
1971	2,973
1974	8,565
1999	7,300
Total	**69,530**

AIR CONDITIONING OPTIONS SUMMARY

The Primary driver of the overall project scope and budget is the decision about the air delivery method. The size of the equipment and the configuration within the building affects the work scope of multiple trades to provide pathways for ductwork and piping and to restore building finishes. With each air delivery method, there are multiple options to provide cooling and multiple options to provide heating which typically are part of the overall building central heating and cooling plant strategy. There are long-term benefits to the overall maintenance and operation of the facility to consider the heating and cooling approach for each air delivery option within the overall plan for the central heating and cooling plants that serve the building.

The range of air delivery options presented in this summary are narrowed to those that fit the District's criteria that includes centralizing systems to the extent possible to minimize regular and periodic maintenance. These options typically include vertical unit ventilators, variable air volume central air handling, and dedicated outside air displacement systems. The full range of options are discussed in more detail in the "Air Conditioning Options Detail" section of this report.

In addition to the first cost, the attributes of each system also have an effect on the quality of the learning environment and the on-going operational costs related to energy efficiency and the requirements for regular and periodic maintenance. As an aid for discussion, each of the air delivery options presented are rated relative to each other in terms of good, better, best in each of these performance categories as follows.

Attribute	Vertical Unit Vents	Central VAV	DOAS / Displacement
Environment Quality	Good	Better	Best
Energy Efficiency	Good	Better	Best
Maintenance	Good	Better	Best

A summary of the cost range for viable options for each of the air delivery methods is as follows. The options prioritize adding cooling to the classrooms and are summarized in total to cover all of the currently unconditioned classrooms in the building. Other areas that may include gymnasiums, auditoriums or other common areas are listed separately. All cost are presented as construction costs.

Vertical Unit Ventilators:

Install a vertical unit ventilator along the perimeter of each classroom. The work will include installing a new exterior louver through either a window or cutting a louver through the exterior wall. The range of costs includes is defined by the following approach to heating and cooling.

Low Cost Option: Integral DX, Modify existing hot water system

Medium Cost Option: N/A, The proximity to adjacent neighbors presents risks in meeting the noise ordinance that will require further study.

High Cost Option: Geo-thermal chilled water and hot water plant

Vertical Unit Ventilators					
Building Area	**Serves**	**Area SF**	**Construction Budget**		
			Low	**Medium**	**High**
#1	Classrooms	32,545			
#2	Classrooms	1,605			
Total		**34,150**	**$1,318,000**	**$2,002,000**	**$3,153,000**

Central Variable Air Volume:

Install a variable central air handling system in each of the building areas. Install a new air-handling unit in the location of the existing. Replace the existing ductwork with new insulated ductwork along the same pathways. Building Are #2 is an addition to the building and is not served by the existing central air handling unit. Determining duct pathways to serve Area #2 will be very difficult. Consideration should be given to serving this are with vertical unit ventilators even if a central variable air volume system serves Building Area #1.

Low Cost Option: Remote DX, Modify existing Steam System, Cooling only VAV's. The proximity to adjacent neighbor's presents risks in meeting the noise ordinance and will require further study.

Medium Cost Option: Remote DX, Steam service to AHU's, Hot water service to VAV's from a steam convertor. The proximity to adjacent neighbor's presents risks in meeting the noise ordinance and will require further study.

High Cost Option: Geo-thermal chilled water and hot water plant

Central Variable Air Volume					
Building Area	**Serves**	**Area SF**	**Construction Budget**		
			Low	**Medium**	**High**
#1	Classrooms	32,545			
#2	Classrooms	1,605			
Total		**34,150**	**$2,873,000**	**$4,065,000**	**$4,448,500**

Dedicated Outside Air/Displacement:

Install a central dedicated outside air system to serve all classroom areas. The dedicated outside air unit would be located in the boiler room. Install a new air-handling unit in the location of the existing. Replace the existing ductwork with new insulated ductwork along the same pathways. Building Are #2 is an addition to the building and is not served by the existing central air handling unit. New duct pathways will need to be determined.

Low Cost Option: Displacement requires both chilled and hot water. Work is necessarily required on the central heating plant.

Medium Cost Option: Air-cooled chiller, Steam to HW convertor. The proximity to adjacent neighbor's presents risks in meeting the noise ordinance and will require further study.

High Cost Option: Geo-thermal chilled water and hot water plant

Dedicated Outside Air / Displacement					
Building Area	**Serves**	**Area SF**	**Construction Budget**		
			Low	**Medium**	**High**
#1	Classrooms	32,545	N/A		
#2	Classrooms	1,605			
Total		**34,150**	N/A	**$3,784,500**	**$4,418,000**

Additional Scope:

Additional work that may be considered with each of these options includes the following:

New Ceilings and LED Lights: **Construction Budget** **$ 715,000**

AIR CONDITIONING SCOPE DETAIL

The following options to expand air conditioning are noted as "Building Area #'s". The area to be air-conditioned is annotated on the Proposed Systems Diagrams in Appendix B.

Building Area 1: 1921 / 1924 Classrooms (32,545 Sq. Ft.): The following is a summary of the range of possible options considered.

Options Summary:

Building Area	Air Delivery Method	Cooling Plant	Heating Plant	Option
1 - 1898 / 1906 Classrooms	A - Mini-Split	B - Remote DX	A - None	1-ABA
	B - Vertical Unit Ventilators	A - Integral DX	B - Steam	1-BAB
			C - Hot Water*	1-BAC
		B - Remote DX	B - Steam	1-BBB
			C - Hot Water*	1-BBC
		C - Chilled Water*	B - Steam	1-BCB
			C - Hot Water*	1-BCC
	C - Central VAV	B - Remote DX	B - Steam	1-CBB
			C - Hot Water*	1-CBC
		C - Chilled Water*	B - Steam	1-CCB
			C - Hot Water*	1-CCC
	D - DOAS	C - Chilled Water*	C - Hot Water*	1-DCC

Notes: * There are multiple central plant options for chilled and hot water. Refer to the Central Plant section of this report.

Air Delivery: The original 1921 building construction and1924 Addition included three single zone heating only constant volume systems for ventilation. Supply and return air is distributed to each classroom vertically from the ground floor. The following outlines possible new air delivery methods:

> *Mini-split:* The systems would be installed while leaving the existing heating and ventilation systems in place. Because unconditioned ventilation air is delivered to the space through the existing unit ventilator, there is a risk of creating high humidity conditions.
>
> *Vertical Unit Ventilators:* Install new vertical unit ventilators to replace the existing horizontal unit ventilators in approximately the same location. Modifications will be required to the perimeter steam finned tube radiation. Outside and relief would be available by replacing one of the windows adjacent to each unit ventilator. The perimeter casework is minimal.
>
> *Central Variable Air Volume (VAV):* Replace the existing air handling units in the same location. The existing mechanical rooms will be used to the extent possible for new equipment. The ideal location and design of the space is dependent on the heating and

cooling central plant options implemented. It is anticipated that the current MN Energy code will require heat recovery to be incorporated into the system. The existing duct distribution pathways will be reused. The existing ductwork will be replaced with new insulated ductwork.

Dedicated Outside Air (DOAS): Options for locating a new DOAS unit are similar to locating the VAV unit as describe above. The advantage of a DOAS unit is that the volume of air it is moving is approximately 1/3 as compared to the VAV system. The equipment and associated ductwork are smaller and easier to retrofit.

<u>Cooling Plant:</u> Viable options studied include integral packaged DX, remote DX, and construction of a new central chilled water plant. The tight site and proximity to the neighboring residential areas presents challenges in designing new equipment to meet the noise criteria at the property line. The following outlines possible cooling plant options:

Integral Direct Expansion (DX): Integral DX is an option with the vertical unit ventilators and there is precedent with this type of system in the District. Design considerations need to include meeting the classroom ambient sound levels. Integral cooling systems have an impact on future maintenance by distributing possible failure points of the system.

Remote Direct Expansion (DX): Remote DX in an option for mini-split systems, vertical unit ventilators, and central variable air volume solutions. Condenser locations for remote DX locations need to be determined. Structural constraints of the roof need to be evaluated.

Chilled Water: There are multiple options to generate chilled water to meet the cooling needs of the building. Refer to the central plant options in this report for a discussion of each.

<u>Heating Plant:</u> Viable options include leaving the existing steam systems in place and installing a cooling only system, connecting to the existing steam plant, installing a steam to hot water convertor, or installing a new high efficiency hot water plant. The following outlines possible heating plant options.

Steam: The building is currently heated by a single large dual fuel steam fire tube boiler. The steam option includes modifying steam and condensate distribution piping to accommodate the new systems.

Hot Water HX: Includes the installation of a new steam-to-hot water heat exchanger, pumps and distribution system to deliver hot water to the new systems. Hot water distribution piping is more flexible to route to location as necessary than steam piping. The installation of a heat exchanger will easily accommodate future conversion of the stem plant to hot water.

Hot Water Plant: There are multiple options to generate hot water to meet the heating needs of the building. Refer to the central plant options in this report for a discussion of each.

Dehumidification: Active dehumidification requires a heating source that is currently not available with the existing steam plant during the summer months. Options for active dehumidification will depend on the extent of hot water that is installed with the new systems. If hot water distribution is included as the heating source, the heating coils will be located in the reheat position downstream of the cooling coils. If hot water is generated through a steam-to-hot water convertor, then reheat will only be possible when the steam boiler is in operation. An option to extend the time that hot water is available is to add a small high efficiency gas boiler. If the project include replacing the steam plant, the boiler capacity would be selected to provide adequate turn down during low load periods.

Project Risks: The following are design risks identified in implementing this project. The cost estimate includes a 15% design contingency to cover these risks. Further investigation into each of these could better define the solution and allow the design contingency to be reduced.

- Determining vertical pathways for new ductwork as necessary for the central air handling unit options. The existing vertical pathways will be reused to the extent possible.
- Determining a design solution for outside ventilation air with the central air handling unit options. Pathways for outside air and building relief air need to be determined.
- Space heating and cooling loads are estimated based on typical loads for this type of space. Final heating and cooling loads need to be completed.
- Integrity of the existing steam and condensate systems for options that include steam heating. Piping in poor condition may necessitate additional pipe removal. The best method to mitigate this risk is to pursue the hot water heating solution as outlined in the heating section above.

Additional Scope Considerations: The following items could be considered for inclusion in the project work scope. These items are not directly related to adding air conditioning but there would be cost efficiency by including them in the project scope and the have added value as noted.

- *Provide new ceilings and lights:* Provide new lay-in ceilings typically throughout with new LED lighting and controls. With the vertical unit ventilator options, new ceilings would allow for the air distribution above the ceiling to reduce the system noise. The ceiling condition likely will require a soffit along the exterior walls to accommodate the existing windows elevations.

Typical Photos:

Typical Classroom – Rm 101

Second Floor Corridor – Looking South

Building Area 2 - Room 106 (1,605 Sq. Ft.): The following is a summary of the range of possible options considered.

Options Summary:

Building Area	Air Delivery Method	Cooling Plant	Heating Plant	Option
2 – Room 106	A - Mini-Split	B - Remote DX	A - None	2-ABA
	B - Vertical Unit Ventilators	A - Integral DX	B - Steam	2-BAB
			C - Hot Water*	2-BAC
		B - Remote DX	B - Steam	2-BBB
			C - Hot Water*	2-BBC
		C - Chilled Water*	B - Steam	2-BCB
			C - Hot Water*	2-BCC
	C - Central VAV	B - Remote DX	B - Steam	2-CBB
			C - Hot Water*	2-CBC
		C - Chilled Water*	B - Steam	2-CCB
			C - Hot Water*	2-CCC
	D - DOAS	C - Chilled Water*	C - Hot Water*	2-DCC

Notes: * There are multiple central plant options for chilled and hot water. Refer to the Central Plant section of this report.

Air Delivery: The Area appears to have had multiple renovations to repurpose the space for the current special education use. Horizontal unit ventilators serve two of the three rooms. The following outlines possible new air delivery methods:

Mini-split: The systems would be installed while leaving the existing heating and ventilation systems in place. Because unconditioned ventilation air is delivered to the space through the existing unit ventilator, there is a risk of creating high humidity conditions.

Vertical Unit Ventilators: Install new vertical unit ventilators to replace the existing horizontal unit ventilators in approximately the same location. Outside and relief would be available through he outside wall.

Central Variable Air Volume (VAV): The most practical option would be to combine this area with Building Area 1 if a variable air volume solution is selected.

Dedicated Outside Air (DOAS): The most practical option would be to combine this area with Building Area 1 if a dedicated outside air solution me solution is selected.

Cooling Plant: Viable options studied include integral packaged DX, remote DX, and construction of a new central chilled water plant. The tight site and proximity to the neighboring residential areas presents challenges in designing new equipment to meet the noise criteria at the property line. The following outlines possible cooling plant options:

Integral Direct Expansion (DX): Integral DX is an option with the vertical unit ventilators and there is precedent with this type of system in the District. Design considerations need to include meeting the classroom ambient sound levels. Integral cooling systems have an impact on future maintenance by distributing possible failure points of the system.

Remote Direct Expansion (DX): Remote DX in an option for mini-split systems and vertical unit ventilator solutions. The condensing units could be located on grade adjacent to the building or on the roof.

Chilled Water: There are multiple options to generate chilled water to meet the cooling needs of the building. Refer to the central plant options in this report for a discussion of each.

Heating Plant: Viable options include leaving the existing steam systems in place and installing a cooling only system, connecting to the existing steam plant, installing a steam to hot water convertor, or installing a new high efficiency hot water plant. The following outlines possible heating plant options.

Steam: The building is currently heated by a single large dual fuel steam fire tube boiler. The steam option includes modifying steam and condensate distribution piping to accommodate the new systems.

Hot Water HX: Includes the installation of a new steam-to-hot water heat exchanger, pumps and distribution system to deliver hot water to the new systems. Hot water distribution piping is more flexible to route to location as necessary than steam piping. The installation of a heat exchanger will easily accommodate future conversion of the stem plant to hot water.

Hot Water Plant: There are multiple options to generate hot water to meet the heating needs of the building. Refer to the central plant options in this report for a discussion of each.

Dehumidification: Active dehumidification requires a heating source that is currently not available with the existing steam plant during the summer months. Options for active dehumidification will depend on the extent of hot water that is installed with the new systems. If hot water distribution is included as the heating source, the heating coils will be located in the reheat position downstream of the cooling coils. If hot water is generated through a steam-to-hot water convertor, then reheat will only be possible when the steam boiler is in operation. An option to extend the time that hot water is available is to add a small high efficiency gas boiler. If the project include replacing the steam plant, the boiler capacity would be selected to provide adequate turn down during low load periods.

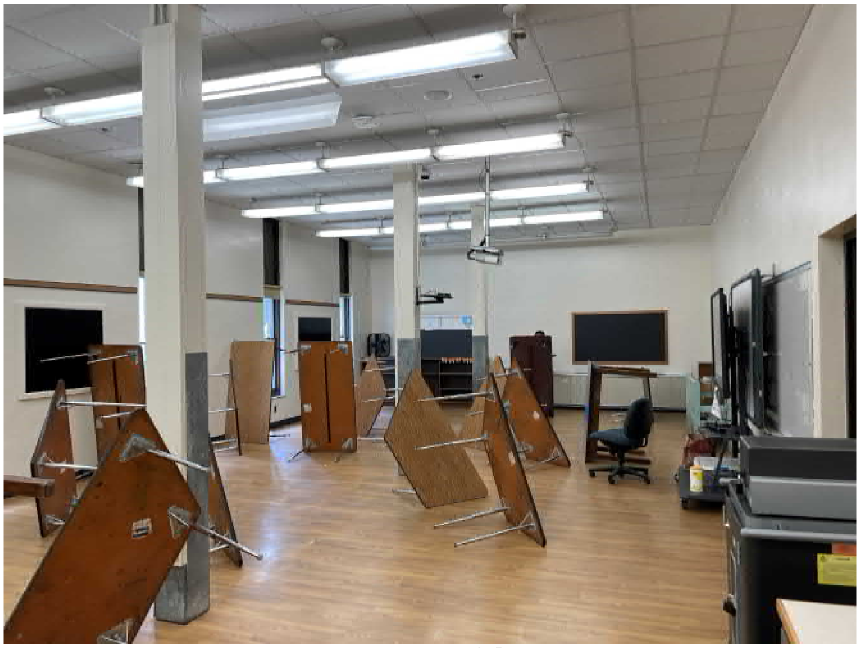
Project Risks: The following are design risks identified in implementing this project. The cost estimate includes a 15% design contingency to cover these risks. Further investigation into each of these could better define the solution and allow the design contingency to be reduced.

- Determining vertical pathways for new ductwork as necessary for the central air handling unit options. The existing structure poured concrete over clay tile. Options that require removing a concrete joist will require additional structural review.
- Determining a design solution for outside ventilation air with the central air handling unit options. The proposed location for new air handling equipment is on the ground floor adjacent to the boiler room. It is desirable to provide for the outside air intake point above grade to minimize the introduction of contaminants.
- Space heating and cooling loads are estimated based on typical loads for this type of space. Final heating and cooling loads need to be completed.
- Integrity of the existing steam and condensate systems for options that include steam heating. Piping in poor condition may necessitate additional pipe removal. The best method to mitigate this risk is to pursue the hot water heating solution as outlined in the heating section above.
- Structural capacity for options that locate new equipment on the roof. If roof options are considered, further structural evaluation will be necessary.
- Space constraints for options that include locating new central air handling units in the storage room. Final load calculations and air handling unit selections are necessary to determine the final design to fit the new equipment.

Additional Scope Considerations: The following items could be considered for inclusion in the project work scope. These items are not directly related to adding air conditioning but there would be cost efficiency by including them in the project scope and the have added value as noted.

- *Provide new ceilings and lights:* Provide new lay-in ceilings typically throughout with new LED lighting and controls. With the vertical unit ventilator options, new ceilings would allow for the air distribution above the ceiling to reduce the system noise. The ceiling condition likely will require a soffit along the exterior walls to accommodate the existing windows elevations.

Typical Photos:



Room 106

Adjacent Work Room

Building Area 3 – Auditorium / Cafeteria (7,530 Sq. Ft.): The following is a summary of the range of possible options considered.

Options Cost Summary:

Building Area	Air Delivery Method	Cooling Plant	Heating Plant	Option
3 – Auditorium / Cafeteria	C – Central CV	A – Packaged DX	B – Steam	3-CAB
			C – Hot Water	3-CAC
			D – Gas Fired	3-CAD
		B – Chilled Water	B – Steam	3-CBB
			C – Hot Water	3-CBC
			D – Gas Fired	3-CBD
	E – Retrofit CC in RTU	B - Remote DX	D – Gas Fired	3-EBD
		C – Chilled Water*	D – Gas Fired	3-ECD

Notes: * There are multiple central plant options for chilled. Refer to the Central Plant section of this report.

Air Delivery: The area is served by a gas fired constant volume single zone unit installed in the 2000 construction. The unit is a rooftop air handling unit with provisions for a future cooling coil. The following outlines possible new air delivery methods:

Central Variable Air Volume (VAV): Replace the existing rooftop air handling unit with a new rooftop variable air volume unit. the risk of contaminants. Options include constructing a new intake louver structure adjacent to the building with a ducted path into the mechanical space below.

Cooling Plant: Viable options studied include integral DX, remote DX, and construction of a new central chilled water plant. It is assumed for estimating that the required cooling capacity for this system is 30 tons. The following outlines possible cooling plant options:

Integral Direct Expansion (DX): Integral DX is an option with the rooftop unit replacement.

Remote Direct Expansion (DX): A remote DX condensing unit is an option to retrofit the existing rooftop unit or to provide cooling for a replacement rooftop unit.

Chilled Water: There are multiple options to generate chilled water to meet the cooling needs of the building. Refer to the central plant options in this report for a discussion of each.

Heating Plant: Viable options include leaving the existing steam systems in place and installing a cooling only system, connecting to the existing steam plant, installing a steam to hot water convertor, or installing a new high efficiency hot water plant. The following outlines possible heating plant options.

> *Steam:* The building is currently heated by a single large dual fuel steam fire tube boiler. The steam option includes modifying steam and condensate distribution piping to accommodate the new systems.
>
> *Hot Water HX:* Includes the installation of a new steam-to-hot water heat exchanger, pumps and distribution system to deliver hot water to the new systems. Hot water distribution piping is more flexible to route to location as necessary than steam piping. The installation of a heat exchanger will easily accommodate future conversion of the stem plant to hot water.
>
> *Hot Water Plant:* There are multiple options to generate hot water to meet the heating needs of the building. Refer to the central plant options in this report for a discussion of each.
>
> *Gas Fired: The existing unit is gas fired. Gas fire is an option with either retrofitting the existing unit or providing a new rooftop unit.*

<u>Dehumidification:</u> Active dehumidification requires a heating source that can modulate to very low load conditions. Active dehumidification is not practical with a gas-fired option. The building is heated with two large steam boilers. Reheat for dehumidification is currently not available with the existing steam plant during the summer months. Options for active dehumidification will depend on the extent of hot water that is installed with the new systems. If hot water distribution is included as the heating source, the heating coils will be located in the reheat position downstream of the cooling coils. If hot water is generated through a steam-to-hot water convertor, then reheat will only be possible when the steam boiler is in operation. An option to extend the time that hot water is available is to add a small high efficiency gas boiler. If the project include replacing the steam plant, the boiler capacity would be selected to provide adequate turn down during low load periods.

<u>Project Risks:</u> The following are design risks identified in implementing this project. The cost estimate includes a 15% design contingency to cover these risks. Further investigation into each of these could better define the solution and allow the design contingency to be reduced.

- Determining a design solution for outside ventilation air with the central air handling unit options. The proposed location for new air handling equipment is on the ground floor adjacent to the boiler room. It is desirable to provide for the outside air intake point above grade to minimize the introduction of contaminants.
- Space heating and cooling loads are estimated based on typical loads for this type of space. Final heating and cooling loads need to be completed.
- Integrity of the existing steam and condensate systems for options that include steam heating. Piping in poor condition may necessitate additional pipe removal. The best method to mitigate this risk is to pursue the hot water heating solution as outlined in the heating section above.

- Structural capacity for options that locate new equipment on the roof. If roof options are considered, further structural evaluation will be necessary.

Typical Photos:

Cafeteria / Auditorium

Building Area 4 – Gymnasium (4,690 Sq. Ft.): The following is a summary of the range of possible options considered.

Options Cost Summary:

Building Area	Air Delivery Method	Cooling Plant	Heating Plant	Option
4 – Gymnasium	C - Central CV	A - Integral DX	B - Steam	4-CAB
			C - Hot Water*	4-CAA
		B - Remote DX	B - Steam	4-CBB
			C - Hot Water*	4-CBC
		C - Chilled Water*	B - Steam	4-CCB
			C - Hot Water*	4-CCC

Notes: * There are multiple central plant options for chilled and hot water. Refer to the Central Plant section of this report.

Air Delivery: A constant volume heating only air handling unit installed in the 1975 renovation ventilates the gymnasium. The air-handling unit is located in a mechanical mezzanine adjacent to the gymnasium. The following outlines possible new air delivery methods:

Central Constant Volume (CV): Options include retrofitting a new unit into the existing mezzanine mechanical room or providing a new roof mounted unit. The mechanical mezzanine has ample height to structure allowing options to reconfigure a new air handling system; however, the space is very difficult to access for service. The distribution ductwork is located above a lay-in ceiling in the gymnasium. If the supply duct is not within the conditioned space it is recommended to insulated the duct to mitigate the risk of condensation. Further investigation is required to determine if the existing ductwork is insulated. An option would be to remove the lay-in ceiling if the existing duct is reused and not insulated.

Cooling Plant: Viable options studied include remote DX and construction of a new central chilled water plant. The tight site and proximity to the neighboring residential areas presents challenges in designing new equipment to meet the noise criteria at the property line. The following outlines possible cooling plant options:

Integral Direct Expansion (DX): Integral DX is an option with the rooftop unit replacement.

Remote Direct Expansion (DX): A remote DX condensing unit would need to be located on the roof to minimize the length of refrigerant piping.

Chilled Water: There are multiple options to generate chilled water to meet the cooling needs of the building. Refer to the central plant options in this report for a discussion of each.

Heating Plant: Viable options include leaving the existing steam systems in place and installing a cooling only system, connecting to the existing steam plant, installing a steam to hot water convertor, or installing a new high efficiency hot water plant. The following outlines possible heating plant options.

Steam: The building is currently heated by a single large dual fuel steam fire tube boiler. The steam option includes modifying steam and condensate distribution piping to accommodate the new systems.

Hot Water HX: Includes the installation of a new steam-to-hot water heat exchanger, pumps and distribution system to deliver hot water to the new systems. Hot water distribution piping is more flexible to route to location as necessary than steam piping. The installation of a heat exchanger will easily accommodate future conversion of the stem plant to hot water.

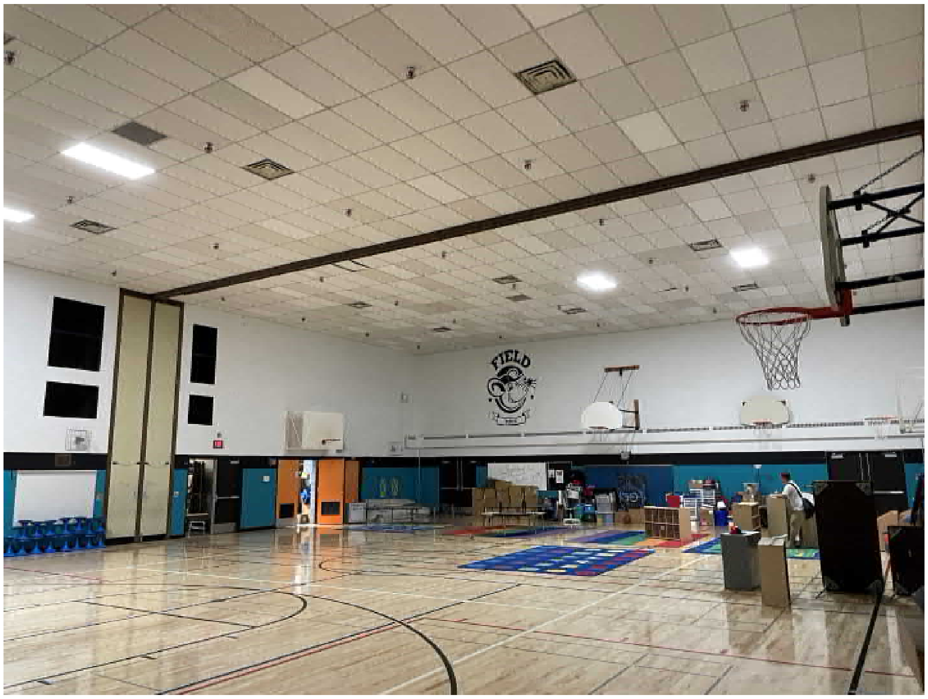
Hot Water Plant: There are multiple options to generate hot water to meet the heating needs of the building. Refer to the central plant options in this report for a discussion of each.

Dehumidification: Active dehumidification requires a heating source that is currently not available with the existing steam plant during the summer months. Options for active dehumidification will depend on the extent of hot water that is installed with the new systems. If hot water distribution is included as the heating source, the heating coils will be located in the reheat position downstream of the cooling coils. If hot water is generated through a steam-to-hot water convertor, then reheat will only be possible when the steam boiler is in operation. An option to extend the time that hot water is available is to add a small high efficiency gas boiler. If the project include replacing the steam plant, the boiler capacity would be selected to provide adequate turn down during low load periods.

Project Risks: The following are design risks identified in implementing this project. The cost estimate includes a 15% design contingency to cover these risks. Further investigation into each of these could better define the solution and allow the design contingency to be reduced.

- Determine a design solution for the option to retrofit a new unit in the existing mechanical mezzanine. Access to the space for equipment installation and future service need to be determined.
- The structural capacity of the roof for options that include roof mounted equipment need to be further investigated.
- Space heating and cooling loads are estimated based on typical loads for this type of space. Final heating and cooling loads need to be completed.
- Integrity of the existing steam and condensate systems for options that include steam heating. Piping in poor condition may necessitate additional pipe removal. The best method to mitigate this risk is to pursue the hot water heating solution as outlined in the heating section above.

Typical Photos:



Gymnasium

Gymnasium Mechanical Room

9 - Central Plant Options: Centralizing the heating and cooling plants has benefits of replacing aged infrastructure, improving the overall operating efficiency of the building and reducing on-going maintenance cost by reducing the number of failures points in the building systems. The building currently has a centralized steam plant. The building does not have a centralized cooling systems approach. The following options have been considered.

Options Cost Summary:

Building Area	Cooling Approach	Heating Approach	Option
9 - Central Plant	A - Air Cooled Chiller	A - STM Distribution	4-AA
		B - STM w/ HW HX	4-AB
		C - HW Plant	4-AC
	C - Geo Thermal	A - STM Hybrid	4-CA
		B - HW Hybrid	4-CB
		C - Full Size Heat	4-CC

Cooling Plant: Centralizing the building cooling plant will improve the overall building operating efficiency and reduce the on-going maintenance requirements. The tight urban location and proximity to residential neighbors presents a risk of noise from centralized systems having a negative impact. Any centralized solution that has outside equipment will need to be evaluated for the sound levels at the adjacent property line. A 120-ton chiller capacity is assumed for cost estimation purposes based on a square foot estimate. Final load calculations are necessary to determine the final chiller size.

Air Cooled Chiller: Because of site constraints and the proximity to the neighbors, the most likely option for locating the chiller is in the parking lot to the North. A study of the chiller sound output at the school property line needs to be completed. For the purposes of estimating, it is assumed that the chiller will have all of the available factory sound attenuation features and will be installed in a masonry enclosure with sound attenuating panels. It is possible that this option will not be viable due to excessive noise concerns.

Ground Coupled Geo-thermal: A ground coupled geothermal solution has the advantage in eliminating the risk of a sound impact to the adjacent residential neighbors. The adjacent field to the north is a possible location for the well field. Further study and a test well is necessary to determine the site specific well conditions to optimize the depth, capacity, and cost. Alternate geothermal technologies including Darcy Solutions closed loop systems should be considered to further reduce the cost and size of the well field.

Heating Plant: Two dual fuel steam fire-tube boiler currently serves the building for heating. Converting the building to hot water for heating will reduce the overall operating cost of the building, reduce the regular maintenance requirements, and allow greater flexibility in routing piping to terminal heating systems throughout the building.

Hot Water Boilers: Includes replacing the existing steam systems with a new high efficiency hot water dual fuel boiler plant. The plant will consist of multiple boilers to provide redundancy in the event of equipment failure. The existing steam and condensate piping will be removed. A variable primary hot water supply and return with multiple supply pumps will be distribute hot water throughout the building.

Ground Coupled Geo-thermal: If the ground coupled geo-thermal option is selected for cooling, the plant would also provide heating capacity for the building. Options for geo-thermal would be to increase the size of the well field and deliver all of the building heating needs from the central plant or provide a hybrid plant that includes high efficiency boiler capacity for peak heating loads. Because of the limited site available for the well field, increasing to size to match the building heating loads may not be possible. Further evaluation and a test well is necessary to determine the maximum heating capacity potential.

Typical Photo:

Possible Cooling Plant Equipment / Geo Thermal Well Field Location

Appendix A:

Existing Systems Diagram

Redacted

Appendix B:

Proposed Systems Diagrams

Redacted

Appendix C:

Dehumidification Capabilities

The recommended solution to provide air conditioning to the classrooms includes providing a high efficiency boiler for summer operation. Areas included in the scope for a new variable air volume system will be capable of active de-humidification.

Appendix D:

Cost Estimate Detail

SSD#1 Minneapolis Public Schools
Air Conditioning Cost Estimating

Cost Basis - June 2021

		Ventilation Area	Bldg Total				
BUILDING AREA 1 - 1921 / 1924 Classrooms	32,545						
Building Area #2 - RM 106	1,605			Cafeteria		Gymnasium	
Area - SQ FT	34,150	34,150	69,530	Building Area #3	7,530 SQ FT	Building Area #4	4,690 SQ FT

Specification Division		Area #1 and #2 - Central VAV, Remote DX, HW VAV's			Building Area #3 - Retrofit Ex Unit, Remote DX			Building Area #4 - Central CV, Remote DX, STM			Area #1 and #2 - Add for Ceilings and Lights			Area #4 - Add for Ceilings and Lights		
		Sq. Ft. / Qty	Unit Cost	Cost	Sq. Ft. / Qty	Unit Cost	Cost	Sq. Ft. / Qty	Unit Cost	Cost	Sq. Ft. / Qty	Unit Cost	Cost	Sq. Ft. / Qty	Unit Cost	Cost
Division 02 - Demolition (excludes Div 21, 22, 23, and 26)				**$ 34,150**			**$ -**			**$ 11,725**			**$ 17,075**			**$ 2,345**
Miscellaneous		34,150	$ 1.00	$ 34,150			$ -	4,690	$ 2.50	$ 11,725	34,150	$ 0.50	$ 17,075	4,690	$ 0.50	$ 2,345
Division 03 - Concrete				**$ 23,075**			**$ -**			**$ -**			**$ -**			**$ -**
Floor Patch and Repair		34,150	$ 0.50	$ 17,075			$ -			$ -			$ -			$ -
Cast-in-place / Misc		2	$ 3,000	$ 6,000			$ -			$ -			$ -			$ -
Division4 - Masonary				**$ 20,000**			**$ -**			**$ -**			**$ -**			**$ -**
Non-bearing Infill		1	$ 20,000	$ 20,000			$ -			$ -			$ -			$ -
Load bearing - new wall construction				$ -			$ -			$ -			$ -			$ -
Division 5 - Metals				**$ 17,075**			**$ 6,000**			**$ 6,000**			**$ -**			**$ -**
Structural Steel / Misc. Fabrications Allowance		34,150	$ 0.50	17,075	1	$ 6,000	6,000	1	$ 6,000	6,000			-			-
Division 6 - Carpentry				**$ -**			**$ -**			**$ -**			**$ -**			**$ -**
Rough Carpentry				$ -			$ -			$ -			$ -			$ -
Casework Modifications													$ -			$ -
Division 7 - Thermal / Moisture Protection				**$ -**			**$ 2,500**			**$ 10,000**			**$ -**			**$ -**
Roof Patch and Repair				$ -	1	$ 2,500	$ 2,500	1	$ 10,000	$ 10,000			$ -			$ -
Roof New Construction				$ -			$ -			$ -			$ -			$ -
Fire Stopping / Miscellaneous				$ -			$ -			$ -			$ -			$ -
Division 8 - Openings				**$ 18,000**			**$ -**			**$ -**			**$ -**			**$ -**
Access Panels				-			-			-			-			-
Doors / Hardware				-			-			-			-			-
Windows				-			-			-			-			-
Louvers		4	$ 4,500	18,000			-			-			-			-
Division - 9 Finishes				**$ 251,725**			**$ -**			**$ 14,070**			**$ 221,975**			**$ 30,485**
Soffits / Chases		34,150	$ 3.50	$ 119,525			$ -			$ -	34,150	$ 2.00	$ 68,300	4,690	$ 2.00	$ 9,380
Floor Patch and Repair		34,150	$ 2.00	$ 68,300			$ -			$ -			$ -			$ -
Acoustic Ceilings		8,500	$ 3.50	$ 29,750			$ -	4,690	$ 2.00	$ 9,380	34,150	$ 3.50	$ 119,525	4,690	$ 3.50	$ 16,415
Painting		34,150	$ 1.00	$ 34,150			$ -	4,690	$ 1.00	$ 4,690	34,150	$ 1.00	$ 34,150	4,690	$ 1.00	$ 4,690
Division 10 - Specialties				**$ -**			**$ -**			**$ -**			**$ -**			**$ -**
Miscellaneous				-			-			-			-			-
Division 11 - Equipment				**$ -**			**$ -**			**$ -**			**$ -**			**$ -**
Miscellaneous				$ -			$ -			$ -			$ -			$ -
Division 12 - Furnishings				**$ -**			**$ -**			**$ -**			**$ -**			**$ -**
Casework				$ -			$ -			$ -			$ -			$ -
Miscellaneous				$ -			$ -			$ -			$ -			$ -
Division 21 - Fire Protection				**$ 68,300**			**$ -**			**$ 11,725**			**$ 85,375**			**$ 11,725**
Demolition		-		$ -			$ -			$ -			$ -			$ -
New / Modify Existing		34,150	$ 2.00	$ 68,300			$ -	4,690	$ 2.50	$ 11,725	34,150	$ 2.50	$ 85,375	4,690	$ 2.50	$ 11,725
Division 22 - Plumbing				**$ -**			**$ -**			**$ -**			**$ -**			**$ -**
Demolition				$ -			$ -			$ -			$ -			$ -
Plumbing Fixtures				$ -			$ -			$ -			$ -			$ -
Micellaneous				$ -			$ -			$ -			$ -			$ -
Division 23 - HVAC				**$ 2,384,963**			**$ 56,200**			**$ 221,580**			**$ -**			**$ -**
Air Handling Equipment (VUV's / AHU's / RTU's)		3	$ 85,000	$ 255,000			$ -	1	$ 24,000	$ 24,000			$ -			$ -
Cooling Plant Equipment (Chiller / DX / Heat Pump)		3	$ 32,000	$ 96,000	1	$ 20,000	$ 20,000	1	$ 10,000	$ 10,000			$ -			$ -
Heating Plant Equipment (Boiler)		1	$ 35,000	$ 35,000			$ -			$ -			$ -			$ -
Demolition		34,150	$ 0.75	$ 25,613			$ -	4,690	$ 1.50	$ 7,035			$ -			$ -
AHU Equipment Installation / Start-up		3	$ 20,000	$ 60,000	1	$ 7,500	$ 7,500	1	$ 20,000	$ 20,000			$ -			$ -
Cooling Plant Equipment Installation				$ -	1	$ 24,000	$ 24,000	1	$ 15,000	$ 15,000			$ -			$ -
Heating Plant Installation		1	$ 180,000	$ 180,000			$ -			$ -			$ -			$ -
Chilled Water Distribution				$ -			$ -			$ -			$ -			$ -
Steam / Condensate Distribution		3	$ 20,000	$ 60,000			$ -			$ -			$ -			$ -
Hot Water Distribution		34,150	$ 10.00	$ 341,500			$ -			$ -			$ -			$ -
Ductwork Distribution Misc. (VAV's / Exhaust)		34,150	$ 32.00	$ 1,092,800			$ -	4,690	$ 24.00	$ 112,560			$ -			$ -
Controls		34,150	$ 6.50	$ 221,975	1	$ 2,500	$ 2,500	4,690	$ 6.50	$ 30,485			$ -			$ -
Test and Balance		34,150	$ 0.50	$ 17,075	1	$ 2,200	$ 2,200	1	$ 2,500	$ 2,500			$ -			$ -
Division 26 - Electrical				**$ 173,825**			**$ 7,500**			**$ 7,500**			**$ 204,900**			**$ 39,865**
Demolition		34,150	$ 0.50	$ 17,075			$ -			$ -	34,150	$ 0.50	$ 17,075	4,690	$ 1.00	$ 4,690
Electrical Service		1	$ 50,000	$ 50,000			$ -			$ -			$ -			$ -
Power Connections		4	$ 15,000	$ 60,000	1	$ 7,500	$ 7,500	1	$ 7,500	$ 7,500			$ -			$ -
Lighting and Controls		8,500	$ 5.50	$ 46,750			$ -			$ -	34,150	$ 5.50	$ 187,825	4,690	$ 7.50	$ 35,175
Division 27 - Technology				**$ 17,075**			**$ -**			**$ -**			**$ -**			**$ -**
Demolition Allowance				$ -			$ -			$ -			$ -			$ -
Fire / Sound / Data Allowance		34,150	$ 0.50	$ 17,075			$ -			$ -			$ -			$ -
DIVISION SUB-TOTAL				**$ 3,008,188**			**$ 72,200**			**$ 282,600**			**$ 529,325**			**$ 84,420**
Division 1 - General Conditions				**$ 526,433**			**$ 12,635**			**$ 49,455**			**$ 92,632**			**$ 14,774**
OH & P	10%			$ 300,819			$ 7,220			$ 28,260			$ 52,933			$ 8,442
Liability Insurance	1%			$ 30,082			$ 722			$ 2,826			$ 5,293			$ 844
Performance Bond	2%			$ 45,123			$ 1,083			$ 4,239			$ 7,940			$ 1,266
General Contractor Misc.	5%			$ 150,409			$ 3,610			$ 14,130			$ 26,466			$ 4,221
CONSTRUCTION SUB-TOTAL				**$ 3,534,620**			**$ 84,835**			**$ 332,055**			**$ 621,957**			**$ 99,194**
CONTINGENCY	15%			**$ 530,193**			**$ 12,725**			**$ 49,808**			**$ 93,294**			**$ 14,879**
CONSTRUCTION GRAND-TOTAL				**$ 4,064,813**			**$ 98,000**			**$ 381,863**			**$ 715,250**			**$ 114,073**
COST per SQ FT				**$ 119.03**			**$ 13.01**			**$ 81.42**			**$ 10.29**			**$ 1.64**