POUDRE SCHOOL DISTRICT

SHEPARDSON STEM ELEMENTARY SCHOOL

AC STUDY

1501 SPRINGWOOD DR.
FORT COLLINS, CO 80525
SEPTEMBER 2023

Together, Building a Thriving Planet

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AC Study: Shepardson STEM Elementary School

PURPOSE SUMMARY

The primary function of this Air Conditioning (AC) study is to “refresh” the original 2015 study performed by Horsetooth Engineering for Poudre School District (PSD). In addition to a summary, examination, and validation of the items in the original study, this report includes an analysis of the existing building conditions, an updated historical synopsis of the building’s construction projects if applicable, and a high-level exploration of possible solutions to provide Air Conditioning to each building. McKinstry’s team has performed a site investigation, has interviewed the facility operators and other relevant parties, and has reviewed available existing documentation in order to provide this analysis.

The goal of this study is to aid PSD in planning the implementation of AC in the various schools which do not currently have cooling. The report is intended to create a basis for which to build future projects and to guide decision making as to how to accomplish this goal. The solutions explored range from budget-aware to “best case scenario” options, but ultimately it was agreed that for the purposes of this study, a single, fully functional AC system option would be presented per school. The preferred system type can be developed further once PSD decides on the direction to move forward after considering District budget, building/system urgency, and overall feasibility. Equipment sizes, cooling tonnages, structural capacities, and other similar values have been estimated using industry best practices and will be confirmed/adjusted via load calculations during the design phase.

This report is intended to be read in tandem with the other McKinstry offerings for this building (RCx, FCA) to provide an integrated and holistic understanding of the building portfolio. While the other reports will focus on the existing systems and conditions in more detail, this report will focus on future implementation of AC in the building and their impacts to electrical, structural, and architectural systems.

AC Study: Shepardson STEM Elementary School

BUILDING SUMMARY

General:

Shepardson STEM Elementary School is a single-story 50,516 square foot school located at 1501 Springwood Drive, in Fort Collins, Colorado. Originally built in 1956, the building has seen with multiple expansions and renovations in the last 50 years; these renovations are summarized in more detail in the history section below. A deeper dive on the conditions of the existing equipment, and estimated costs of replacement, can be found in McKinstry's FCA workbook and report.

Existing Mechanical Systems:

Cooling: The building is served by a "tempered air" system, utilizing DOAS units on the roof with indirect evaporative cooling and energy wheels delivering 100% outside air to all classrooms. This system is not a formal cooling system. One Rooftop Unit (RTU) serving the IT Room has DX cooling – RTU-4.

Heating: Heating is served by a central hot water plant with a gas-fired boiler, piped throughout the building to all heating equipment, including perimeter baseboard heating, Fan Coil Units (FCUs), AHUs, and DOAS units.

Ventilation: Ventilation for the building is provided by the DOAS units serving the classrooms via displacement ventilation diffusers and other interior spaces by FCUs, and AHUs serving the Gymnasium and Media Center.

Existing Electrical Systems:

The building has an existing 1600 amp, 208Y/120V 3-phase, 4-wire electrical service.

Existing Structural Systems:

The initial building was constructed in 1977 with additions in 1995 and 2007 and a renovation completed in 2012. The building consists of HSS columns supported by concrete piers or spread footings, concrete-masonry unit bearing and shear walls that are supported by mild reinforced concrete spread footing, strip footings and grade beams. The main floor is supported by a nominal concrete slab-on-grade. The roof framing consists of mostly open web steel trusses supporting corrugated metal deck, there are a few locations where the open web steel trusses frame into wide flange beams.

BUILDING HISTORY

Building Updates since 2015 Study

There have been no major additions or renovations since the 2015 study was conducted.

Historical Summary (Excerpt From the 2015 Study)

A description of the existing infrastructure and past remodels from the study performed in 2015 by Horsetooth Engineering is excerpted below:

- *In 2012 HVAC updates installed a "tempered air" system utilizing indirect evaporative cooling Dedicated Outside Air Systems (DOAS)*
    - *This strategy is to deliver outside air into the classrooms that is approximately 14 degrees cooler than the outside air temperature during the warmer parts of the year. For instance – at 85 degrees outside, the air delivered to the classroom is 71 degrees.*
    - *Air quantities and fan speed are varied depending on the mode that the air handler is in.*
        - *In heating mode the goal is to deliver 300 cfm per classroom, slightly over Code required ventilation air*
        - *In tempering mode the goal is to deliver 600 cfm per classroom*

  - *Air is delivered into the classrooms via floor displacement ventilation diffusers. The strategy is to deliver the air down in the occupant zone in lieu of overhead at the ceiling.*
  - *No zoning for individual classrooms is provided. They all receive the same quantity and temperature of air.*
  - *Fan coil units that provide heating and ventilation only were installed in corridor, work areas and office areas. PSD staff has added economizers to the fan coils in the administration area to increase outside air quantities for warmer times of the year.*
  - *Heating water piping installed in 1977 was reused in the 2012 HVAC updates.*
  - *The 1977 boiler was replaced in 2012. However, this building only has 1 boiler, there is no redundancy for heating.*
  - *Baseboard radiation installed during 2012 project provides heat for the classrooms.*
- *The 2001 cafeteria addition is served by a heating and ventilation only ERV.*
- *The 1995 classroom addition is served by a heating and ventilation only RTU.*
- *A packaged DX unit serves the computer lab. It was installed in the mid-1990s and should be replaced within the next 3-5 years.*
- *The gym and media center indoor AHUs provide heating and ventilation only. They are original to the 1977 building construction.*
- *Kitchen has no make-up air unit, air is transferred from adjacent spaces to make-up for exhaust.*

AC Study: Shepardson STEM Elementary School

AIR CONDITIONING STRATEGIES

Contextual Narrative

The existing DOAS “tempered air” system is unfortunately not compatible with a simple solution for implementing AC. The existing DOAS units have space for future cooling coils, but they are not sized adequately to provide full cooling to the building – only lowering the supply air to approximately 65 degrees. The DOAS displacement ventilation strategy is incompatible with discharge air temperatures lower than 65 degrees, which creates a further barrier to AC implementation using primarily the DOAS system. While the additional cooling would not be enough to fully cool the spaces, it would make the spaces more comfortable – however, an electric upgrade would be required to install the additional cooling coils, which would be a significant cost. Because this upgrade would be expensive, and would not achieve full air conditioning, this option has not been recommended.

The original 2015 study recommended a VAV reheat system as a possible strategy. We do not agree with this recommendation. VAV reheat systems, while popular in the past, are not particularly efficient when compared to newer systems. Energy is spent both in cooling down the main supply air, and then spent again to reheat the air in zones that are not in cooling mode. Our proposed option is a more efficient system, as each zone is able to condition independently without reheating.

In our recommended system, a new DOAS system is still utilized, with new VUV equipment replacing the displacement ventilators. Tonnage estimation was done using industry best practices, but it is likely that tonnage will decrease during the design phase when full load calculations are performed.

AC Study: Shepardson STEM Elementary School

Pricing Chart

POUDRE SCHOOL DISTRICT - AC STUDY COST SUMMARY CHART						
School Name	Square Footage	Electrical Service Upgrade	Estimated Cost Range ($)		Estimated Cost Range ($/SF)	
			Low	High	Low	High
Shepardson STEM ES	50,516	Yes	$ 4,628,800	$ 6,248,880	$ 91.63	$ 123.70

Pricing Narrative

The cost estimation for this project was developed using industry best practices. Estimations have been prepared in June 2023 dollars. These prices are an opinion of probable cost for implementing AC, including Mechanical, Electrical, Structural, Plumbing, and Architectural costs. Pricing includes replacement of associated MEP systems that may not directly be related to AC such as boilers, ductwork, and heating water piping, when identified as necessary by the district. Pricing also includes a full controls overhaul at all schools. Note that these prices do not include abatement of asbestos outside of the scope of boiler replacements.

It is important to consider that prices for equipment, materials, and labor are still fluctuating heavily since the COVID-19 pandemic. In addition, lead times for equipment continue to be longer than pre-pandemic. These estimates are intended for use as a tool for PSD to facilitate conversations and for developing capital planning; they are not intended to be used as a quoted price to build these solutions. Instead, they should be interpreted as rough orders of magnitude required to accomplish the proposed AC solutions. As the formal design process has not yet been initiated, assumptions were made concerning the scale of renovations required, as well as building-specific details, including but not limited to: total pipe lengths, structural reinforcements, architectural amendments, and electrical system modifications.

AC Recommendation

In the process of determining the system to propose, some of the explored options included: 2-pipe Changeover, 4-pipe HW/CW, VAV Reheat, DX Unit Ventilators, HW/DX RTUs, Variable Refrigerant Flow (VRF), and Chilled Beams.

- **Heat Pump system**
  Heat pump systems are one of the most efficient systems available. These systems operate on a single condenser water loop, with each individual heat pump either rejecting or absorbing heat from the condenser water. These systems are particularly efficient during the shoulder seasons (Spring and Fall) when some spaces require cooling and others require heating, as the system allows that heat to be moved from one space to another. It is likely this system could utilize much of the existing piping, however it requires all the HVAC equipment to be replaced simultaneously to heat pump equipment to implement. This system also would also move towards the District goals of electrification, as it can be more easily converted to an electric-only solution via eventual implementation of ground-sourced heat pump or electric boilers.
    - Pros:
        - Highly efficient
        - Resilient, comfortable
        - Allows for central heat pump to provide heat most of the year, lowering carbon emissions and providing fuel flexibility to react to changing utility costs
        - Likely can re-use some of the existing heating water piping for condenser water
        - Condenser water lines do not require insulation

        - System can very effectively provide heating and cooling simultaneously
        - This system can also be used with a ground-sourced heat pump loop instead of an air-sourced heat pump for additional efficiency if there is opportunity or funding. The system can also be converted to ground-source at the end of life of the air-sourced heat pump
    - Cons:
        - High capital cost for new mechanical system retrofit
        - Heat pump equipment have compressors, which can sometimes require additional maintenance
        - Heat pump units may be louder than other HW/CW hydronic systems
        - Requires an upgrade to the building electrical service, details provided below.
        - Will most likely trigger structural upgrades, details provided below.
    - Implementation:
        - Install a new 100-ton air-to-water heat pump system and connect to existing heating water piping. Provide new circulation pumps. Provide screening/sound barrier.
        - Demolish existing baseboard heaters, cabinet unit heaters, and other radiant heaters
        - Provide new condenser water piping system loop. Utilize/reconfigure existing HW piping as possible for new condenser water system
        - Boiler plant is currently under a remodel, adding a second boiler for redundancy.
        - Replace all existing equipment with water-sourced heat pump equipment
            - Replace existing DOAS units with heat pump units.
            - Replace existing RTUs with new heat pump RTUs
            - Replace existing FCUs with new horizontal heat pumps
            - Replace existing heating-only AHUs with new heat pump AHUs
        - Install new kitchen MAU with evaporative cooling
        - For areas intended to be used year-round, such as the admin areas, provide a new ASHP RTU dedicated to those spaces (such as Admin and IT spaces).
- **Electrical Implications of AC Addition:**
    - Based on utility Peak Demand data and NEC required safety factors, the existing peak demand on the 1600A service is 411 Amps. There is capacity to add cooling loads to the existing service but adding 125 tons of cooling would require a service upgrade to 2500 Amps.
    - When a heating only RTU is replaced with a Heat Pump unit, the existing electrical feeders & circuit breakers will need to be upsized to support the additional electrical load.
    - Costs for these upgrades are included in the pricing above.
- **Structural Implications:**
    - Rooftop equipment: The existing bar joist, LH, K and H truss support framing will likely trigger reinforcing.
        - Truss reinforcing to consist of welded compression strut angle members coordinated with mech unit curb location and truss panel points. Truss chord and web reinforcing will also be required.
        - Deck reinforcing will be required if new openings are larger than 16” x 16” square.
    - Air-Source Heat Pump Pad
        - The new ground mounted equipment will be supported by a down-turned thickened lip concrete footing.

        - Thickened lip = 12"tall x 10" deep perimeter footing with minimum size equal to the footprint of the equipment + 6" all-around.
        - Reinforcing = (2) #4's top and bottom.
        - 6" slab-on-grade to span between thickened lip and configured with #4 at 16" OC each way centered
    - Costs for these upgrades are included in the pricing above.
- **Architectural Implications:**
    - For installation of new mechanical equipment provide a new rooftop curb (w/appropriate structural reinforcement). Existing Roofing at new curb location to be removed. Then repair, replace, and patch roofing as required around new curb (min. 4'-0") with like material and installation techniques.
    - Where installation of new mechanical equipment is within 10' of parapet wall or edge of roof provide permanent fall protection and associated structural reinforcement railing per OSHA requirements.
    - Where existing structural members are protected with Fire-Resistive-Rated (FRR) assemblies, all new structural members must be protected with a FRR assembly of equal or greater protection.
    - All new pipe penetrations and roof mounted pipe equipment shall be flashed in a manner appropriate to the existing roofing.
    - Where new penetrations are designed through Fire-Resistive-Rated Assemblies (Roof, Wall, and Floor) appropriate Fire/Smoke Dampers, FRR sleeves, and/or Fire Caulking shall be provided.
    - All new wall penetrations for pipe, louvers, or equipment installation shall be flashed and caulked in a manner appropriate for the exterior material.
    - All new wall penetrations for louvers or equipment shall be braced with new structural headers appropriate for the existing structural system. Header sizing by a Licensed Structural Engineer

Recommendations from 2015 Study

Below are excerpts of recommendations from the 2015 study. Recommendations that are no longer applicable, or that have already been implemented, have been removed. Recommendations related to the condition of existing equipment and systems are covered in the FCA report and have been removed.

- *Remove RTUs installed in 2012, 2001, and 1995.*
    - McKinstry Comment: We have recommended a solution to replace the existing DOAS units in order to minimize changes to the existing system where possible. Our solution utilizes the existing ductwork to provide outside air to the classrooms, but relies on a different system for space conditioning.
- *Remove media center AHU*.
    - McKinstry Comment: Installing new AHU for the Media Center is included.
- *Install new RTUs capable of delivering 1,000 to 1,500 cfm per classroom.*
    - McKinstry Comment: We have recommended new heat pump RTUs.
- *Reuse supply duct installed in 2012 to the greatest extent possible and install VAV boxes to provide airflow zone control at each classroom, corridor and work areas.*
    - McKinstry Comment: We have recommended to reuse as much existing duct work as possible.
- *Install new return air duct main at new RTUs*
    - McKinstry Comment: Pricing includes some ductwork replacement
- *Install chiller and route chilled water piping to new RTUs and AHUs.*
    - McKinstry Comment: We have proposed a heat pump solution in lieu of CHW.

- *Install new AHUs for the cafeteria and media center. Route chilled water to the new AHUs.*
    - McKinstry Comment: These AHUs are to be replaced with heat pump options. We have proposed a heat pump solution in lieu of CHW
- *Install new packaged DX RTUs for the computer lab and administration areas.*
    - McKinstry Comment: Included, with ASHP RTUs in lieu of DX.
- *Install new make-up air unit with evaporative cooling for the kitchen.*
    - McKinstry Comment: Included.

POUDRE SCHOOL DISTRICT

TAVELLI ELEMENTARY SCHOOL

AC STUDY

1118 MIRAMONT DR.

FORT COLLINS, CO 80525

SEPTEMBER 2023

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Tavelli Elementary School AC Study

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AC Study: Tavelli Elementary School

PURPOSE SUMMARY

The primary function of this Air Conditioning (AC) study is to “refresh” the original 2015 study performed by Horsetooth Engineering for Poudre School District (PSD). In addition to a summary, examination, and validation of the items in the original study, this report includes an analysis of the existing building conditions, an updated historical synopsis of the building’s construction projects if applicable, and a high-level exploration of possible solutions to provide Air Conditioning to each building. McKinstry’s team has performed a site investigation, has interviewed the facility operators and other relevant parties, and has reviewed available existing documentation in order to provide this analysis.

The goal of this study is to aid PSD in planning the implementation of AC in the various schools which do not currently have cooling. The report is intended to create a basis for which to build future projects and to guide decision making as to how to accomplish this goal. The solutions explored range from budget-aware to “best case scenario” options, but ultimately it was agreed that for the purposes of this study, a single, fully functional AC system option would be presented per school. The preferred system type can be developed further once PSD decides on the direction to move forward after considering District budget, building/system urgency, and overall feasibility. Equipment sizes, cooling tonnages, structural capacities, and other similar values have been estimated using industry best practices and will be confirmed/adjusted via load calculations during the design phase.

This report is intended to be read in tandem with the other McKinstry offerings for this building (RCx, FCA) to provide an integrated and holistic understanding of the building portfolio. While the other reports will focus on the existing systems and conditions in more detail, this report will focus on future implementation of AC in the building and their impacts to electrical, structural, and architectural systems.

AC Study: Tavelli Elementary School

BUILDING SUMMARY

General:

Tavelli Elementary School is a single-story 62,537 square foot school located at 1118 Miramont Drive, in Fort Collins, Colorado. Originally built in 1956, the building has seen with multiple expansions and renovations in the last 50 years; these renovations are summarized in more detail in the history section below.

Existing Mechanical Systems:

Cooling: The building is served by a "tempered air" system, utilizing DOAS units on the roof with indirect evaporative cooling and energy wheels delivering 100% outside air to all classrooms. This system is not a formal cooling system. One Rooftop Unit (RTU) serving the IT Room has DX cooling.

Heating: Heating is served by a central hot water plant with gas-fired boilers, piped throughout the building to all heating equipment, including perimeter baseboard heating, Fan Coil Units (FCUs), AHUs, and DOAS units.

Ventilation: Ventilation for the building is provided by the DOAS units serving the classrooms via displacement ventilation diffusers and other interior spaces by FCUs, and AHUs serving the Gymnasium and Media Center.

Existing Electrical Systems:

The building has an existing 1600 amp, 208Y/120V 3-phase, 4-wire electrical service.

Existing Structural Systems:

The initial building was constructed in 1967 with additions in 1970, 1989 and 1993 with renovations in 2012. The building consists of reinforced CMU bearing and shear walls supported by reinforced concrete stem walls and concrete piers. The main floor is supported by a nominal concrete slab on grade. The roof framing consists mostly of "H" or "LH" series open web steel joists supporting a built-up roof system. The roof trusses are designed for a 30 psf nominal roof live load.

BUILDING HISTORY

Building Updates since 2015 Study

There have been no major additions or renovations since the 2015 study was conducted.

Historical Summary (Excerpt From the 2015 Study)

A description of the existing infrastructure and past remodels from the study performed in 2015 by Horsetooth Engineering is excerpted below:

- *2012 HVAC updates installed a "tempered air" system utilizing indirect evaporative cooling Dedicated Outside Air Systems (DOAS)*
    - *This strategy is to deliver outside air into the classrooms that is approximately 14 degrees cooler than the outside air temperature during the warmer parts of the year. For instance – at 85 degrees outside, the air delivered to the classroom is 71 degrees.*
    - *Air quantities and fan speed are varied depending on the mode that the air handler is in.*
        - *In heating mode the goal is to deliver 300 cfm per classroom, slightly over Code required ventilation air*
        - *In tempering mode the goal is to deliver 600 cfm per classroom*
    - *Air is delivered into the classrooms via floor displacement ventilation diffusers. The strategy is to deliver the air down in the occupant zone in lieu of overhead at the ceiling.*

- *No zoning for individual classrooms is provided. They all receive the same quantity and temperature of air.*
- *Fan coil units that provide heating and ventilation only were installed in corridor, work areas and office areas. PSD staff has added economizers to the fan coils in the administration area to increase outside air quantities for warmer times of the year.*
- *Heating water piping and boilers were installed in 1993 and were all reused in the 2012 HVAC updates.*
- *Baseboard radiation installed during 2012 project provides heat for the classrooms.*

- *In 1993 a significant remodel and addition was constructed. Classrooms were added to the north, southeast and southwest. A gym addition was constructed to the west part of the building. The gym is served by a heating and ventilation only RTU. All the classrooms are now served by the system installed in 2012. A boiler system and piping were installed throughout the building.*
- *Packaged DX RTUs serve each computer lab. One was installed in 1993, the other is not known.*
- *In 1989 a Media Center addition was constructed on the north end. This area is now served by the system installed in 2012. An addition in 1970 to the southeast was served by a MZ RTU. Also, one classroom was added in the southwest corner. These areas are now served from equipment installed in the 2012 HVAC updates project.*
- *The original construction of the building is believed to be in 1967 – the same time as Irish, Riffenburgh and Bauder. The Bauder documents show prototype floor plans of other schools, including Tavelli. The MZs serving the classrooms and office areas were removed during the 2012 HVAC project. The MZ serving the cafeteria and kitchen remains in place; this unit provides heating and ventilation only.*
- *Kitchen make-up air is provided by transfer air from the cafeteria – no dedicated make-up air unit is installed.*

AC Study: Tavelli Elementary School

AIR CONDITIONING STRATEGIES

Contextual Narrative

The existing DOAS “tempered air” system is unfortunately not compatible with a simple solution for implementing AC. The existing DOAS units have space for future cooling coils, but they are not sized adequately to provide full cooling to the building – only lowering the supply air to approximately 65 degrees. The DOAS displacement ventilation strategy is incompatible with discharge air temperatures lower than 65 degrees, which creates a further barrier to AC implementation using primarily the DOAS system. While the additional cooling would not be enough to fully cool the spaces, it would make the spaces more comfortable – however, an electric upgrade would be required to install the additional cooling coils, which would be a significant cost. Because this upgrade would be expensive, and would not achieve full air conditioning, this option has not been recommended.

The original 2015 study recommended a VAV reheat system as a possible strategy. We do not agree with this recommendation. VAV reheat systems, while popular in the past, are not particularly efficient when compared to newer systems. Energy is spent both in cooling down the main supply air, and then spent again to reheat the air in zones that are not in cooling mode. Our proposed option is a more efficient system, as each zone is able to condition independently without reheating.

In our recommended system, a new DOAS system is still utilized, with new VUV equipment replacing the displacement ventilators. Tonnage estimation was done using industry best practices, but it is likely that tonnage will decrease during the design phase when full load calculations are performed.

In Interviews with the facilities management, it was noted that there is concern the system is undersized and that ventilation is not sufficient. For the purposes of this report, we have assumed sizing would be similar to existing equipment; however, during the design phase, ventilation and load calculations will be performed to verify the sizing of new equipment. It was also noted that the admin area cooling has bee underperforming. All of our solutions therefore suggest installing a new ASHP RTU for these areas.

AC Study: Tavelli Elementary School

Pricing Chart

POUDRE SCHOOL DISTRICT - AC STUDY COST SUMMARY CHART						
			Estimated Cost Range ($)		Estimated Cost Range ($/SF)	
School Name	Square Footage	Electrical Service Upgrade	Low	High	Low	High
Tavelli ES	62,537	Yes	$ 4,945,000	$ 6,675,750	$ 79.07	$ 106.75

Pricing Narrative

The cost estimation for this project was developed using industry best practices. Estimations have been prepared in June 2023 dollars. These prices are an opinion of probable cost for implementing AC, including Mechanical, Electrical, Structural, Plumbing, and Architectural costs. Pricing includes replacement of associated MEP systems that may not directly be related to AC such as boilers, ductwork, and heating water piping, when identified as necessary by the district. Pricing also includes a full controls overhaul at all schools. Note that these prices do not include abatement of asbestos outside of the scope of boiler replacements.

It is important to consider that prices for equipment, materials, and labor are still fluctuating heavily since the COVID-19 pandemic. In addition, lead times for equipment continue to be longer than pre-pandemic. These estimates are intended for use as a tool for PSD to facilitate conversations and for developing capital planning; they are not intended to be used as a quoted price to build these solutions. Instead, they should be interpreted as rough orders of magnitude required to accomplish the proposed AC solutions. As the formal design process has not yet been initiated, assumptions were made concerning the scale of renovations required, as well as building-specific details, including but not limited to: total pipe lengths, structural reinforcements, architectural amendments, and electrical system modifications.

AC Recommendation

In the process of determining the system to propose, some of the explored options included: 2-pipe Changeover, 4-pipe HW/CW, VAV Reheat, DX Unit Ventilators, HW/DX RTUs, Variable Refrigerant Flow (VRF), and Chilled Beams

- **Heat Pump system**
  Heat pump systems are one of the most efficient systems available. These systems operate on a single condenser water loop, with each individual heat pump either rejecting or absorbing heat from the condenser water. These systems are particularly efficient during the shoulder seasons (Spring and Fall) when some spaces require cooling and others require heating, as the system allows that heat to be moved from one space to another. It is likely this system could utilize much of the existing piping, however it requires all the HVAC equipment to be replaced simultaneously to heat pump equipment to implement. This system also would also move towards the District goals of electrification, as it can be more easily converted to an electric-only solution via eventual implementation of ground-sourced heat pump or electric boilers.
    - Pros:
        - Highly efficient
        - Resilient, comfortable
        - Allows for central heat pump to provide heat most of the year, lowering carbon emissions and providing fuel flexibility to react to changing utility costs
        - Likely can re-use some of the existing heating water piping for condenser water
        - Condenser water lines do not require insulation

        - System can very effectively provide heating and cooling simultaneously
        - This system can also be used with a ground-sourced heat pump loop instead of an air-sourced heat pump for additional efficiency if there is opportunity or funding. The system can also be converted to ground-source at the end of life of the air-sourced heat pump.
    - Cons:
        - High capital cost for new mechanical system retrofit
        - Heat pump equipment has compressors, which can sometimes require additional maintenance
        - Heat pump units may be louder than other HW/CW hydronic systems
        - Requires an upgrade to the building electrical service, details provided below.
        - Will most likely trigger structural upgrades, details provided below.
        - Requires an upgrade to the building electrical service, details provided below.
        - Will most likely trigger structural upgrades, details provided below.
    - Implementation:
        - Install a new 125-ton air-to-water heat pump system and connect to existing heating water piping. Provide new circulation pumps. Provide screening/sound barrier.
        - Demolish existing baseboard heaters, cabinet unit heaters, and other radiant heaters
        - Provide new condenser water piping system loop. Utilize/reconfigure existing HW piping as possible for new condenser water system
        - Replace existing boiler plant with new high-efficiency boilers. Reconfigure piping as necessary for new CDW loop.
        - Replace all existing equipment with water-sourced heat pump equipment
            - Replace existing displacement ventilators with new heat pump VUVs.
            - Replace existing DOAS units with heat pump units. Connect existing outside air from DOAS to the new VUVs
            - Replace existing RTUs with new heat pump RTUs
            - Replace existing FCUs with new horizontal heat pumps
            - Replace existing heating-only AHUs with new heat pump AHUs
        - For areas intended to be used year-round, such as the admin areas, provide a new ASHP RTU dedicated to those spaces (such as Admin and IT spaces).
        - Install new MAU for kitchen with evaporative cooling.
- **Electrical Implications of AC Addition:**
    - Based on utility Peak Demand data and NEC required safety factors, the existing peak demand on the 1600A service is 425 Amps. There is capacity to add cooling loads to the existing service but adding 125 tons of cooling would require a service upgrade to 2000 Amps or 2500 Amps.
    - When a heating only RTU is replaced with a Heat Pump unit, the existing electrical feeders & circuit breakers will need to be upsized to support the additional electrical load.
    - Costs for these upgrades are included in the pricing above.
- **Structural Implications:**
    - Rooftop equipment: The existing steel joists, H or LH truss support framing will likely trigger reinforcing.
        - Truss reinforcing to consist of welded compression strut angle members coordinated with mech unit curb location and truss panel points. Truss chord and web reinforcing will also be required.

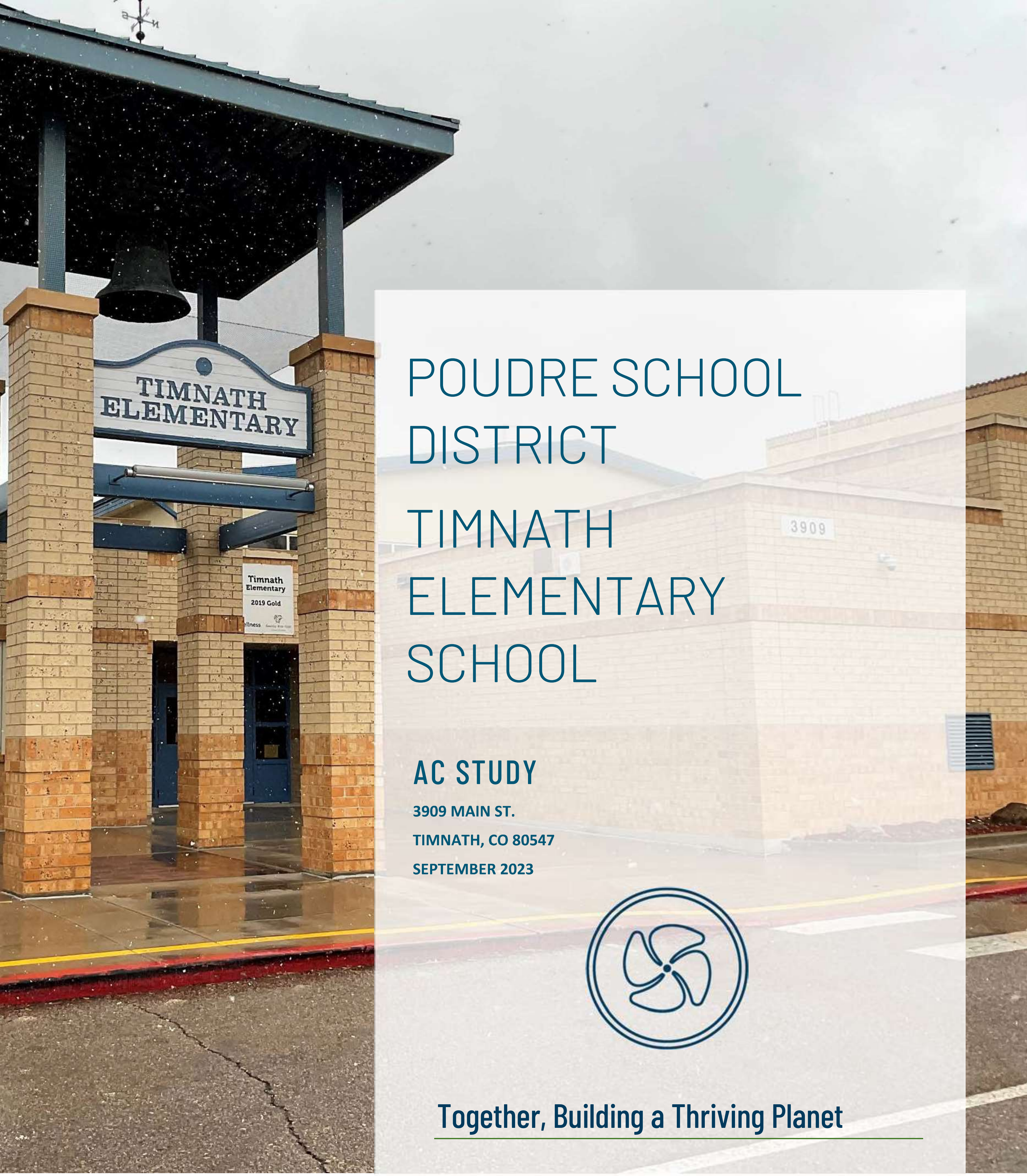
      - Deck reinforcing will be required if new openings are larger than 16" x 16" square.
  - Air-Source Heat Pump Pad
      - The new ground mounted equipment will be supported by a down-turned thickened lip concrete footing.
          - Thickened lip = 12" tall x 10" deep perimeter footing with minimum size equal to the footprint of the equipment + 6" all-around.
          - Reinforcing = (2) #4's top and bottom.
          - 6" slab-on-grade to span between thickened lip and configured with #4 at 16" OC each way centered.
  - Costs for these upgrades are included in the pricing above.
- **Architectural Implications:**
  - For installation of new mechanical equipment provide a new rooftop curb (w/appropriate structural reinforcement). Existing Roofing at new curb location to be removed. Then repair, replace, and patch roofing as required around new curb (min. 4'-0") with like material and installation techniques.
  - Where installation of new mechanical equipment is within 10' of parapet wall or edge of roof provide permanent fall protection and associated structural reinforcement railing per OSHA requirements.
  - Where existing structural members are protected with Fire-Resistive-Rated (FRR) assemblies, all new structural members must be protected with a FRR assembly of equal or greater protection.
  - All new pipe penetrations and roof mounted pipe equipment shall be flashed in a manner appropriate to the existing roofing.
  - Where new penetrations are designed through Fire-Resistive-Rated Assemblies (Roof, Wall, and Floor) appropriate Fire/Smoke Dampers, FRR sleeves, and/or Fire Caulking shall be provided.
  - All new wall penetrations for pipe, louvers, or equipment installation shall be flashed and caulked in a manner appropriate for the exterior material.
  - All new wall penetrations for louvers or equipment shall be braced with new structural headers appropriate for the existing structural system. Header sizing by a Licensed Structural Engineer.

Recommendations from 2015 Study

- *Remove RTUs installed in 2012.*
  - McKinstry Comment: We have recommended a solution to reuse the existing DOAS units in order to minimize changes to the existing system where possible. Our solution utilizes the existing RTUs to provide outside air to the classrooms, but relies on a different system for space conditioning.
- *Install new RTUs capable of delivering 1,000 to 1,500 cfm per classroom.*
  - McKinstry Comment: Refer to previous comment.
- *Reuse supply duct installed in 2012 to the greatest extent possible and install VAV boxes to provide airflow zone control at each classroom, corridor and work areas.*
  - McKinstry Comment: Refer to previous comment.
- *Install ceiling diffusers in lieu of the displacement ventilation diffusers.*
  - McKinstry Comment: Refer to previous comment.
- *Install new return air duct main at new RTUs.*
  - McKinstry Comment: Refer to previous comment
- *Install chiller and route chilled water piping to new RTUs.*
  - McKinstry Comment: We have proposed a heat pump solution in lieu of CHW.

AC Study: Tavelli Elementary School

- *Install a new RTU for the cafeteria. Route chilled water to the new RTU.*
    - McKinstry Comment: New RTU is included. We have proposed a heat pump solution in lieu of CHW.
- *Install new packaged DX RTUs for the computer labs and administration areas.*
    - McKinstry Comment: Included, with ASHP RTUs in lieu of DX.
- *Install new make-up air unit with evaporative cooling for the kitchen.*
    - McKinstry Comment: Included



POUDRE SCHOOL DISTRICT

TIMNATH ELEMENTARY SCHOOL

AC STUDY

3909 MAIN ST.

TIMNATH, CO 80547

SEPTEMBER 2023

Together, Building a Thriving Planet

McKinstry
For The Life Of Your Building

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Timnath Elementary School AC Study

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AC Study: Timnath Elementary School

PURPOSE SUMMARY

The primary function of this Air Conditioning (AC) study is to "refresh" the original 2015 study performed by Horsetooth Engineering for Poudre School District (PSD). In addition to a summary, examination, and validation of the items in the original study, this report includes an analysis of the existing building conditions, an updated historical synopsis of the building's construction projects if applicable, and a high-level exploration of possible solutions to provide Air Conditioning to each building. McKinstry's team has performed a site investigation, has interviewed the facility operators and other relevant parties, and has reviewed available existing documentation in order to provide this analysis.

The goal of this study is to aid PSD in planning the implementation of AC in the various schools which do not currently have cooling. The report is intended to create a basis for which to build future projects and to guide decision making as to how to accomplish this goal. The solutions explored range from budget-aware to "best case scenario" options, but ultimately it was agreed that for the purposes of this study, a single, fully functional AC system option would be presented per school. The preferred system type can be developed further once PSD decides on the direction to move forward after considering District budget, building/system urgency, and overall feasibility. Equipment sizes, cooling tonnages, structural capacities, and other similar values have been estimated using industry best practices and will be confirmed/adjusted via load calculations during the design phase.

This report is intended to be read in tandem with the other McKinstry offerings for this building (RCx, FCA) to provide an integrated and holistic understanding of the building portfolio. While the other reports will focus on the existing systems and conditions in more detail, this report will focus on future implementation of AC in the building and their impacts to electrical, structural, and architectural systems.

AC Study: Timnath Elementary School

BUILDING SUMMARY

General:

Timnath Elementary School is a three-story 74,265 square foot school located at 3909 Main Street, in Timnath, Colorado. Originally built in 1919, the building has seen with multiple expansions and renovations in the last 100 years; these renovations are summarized in more detail in the history section below. A deeper dive on the conditions of the existing equipment, and estimated costs of replacement, can be found in McKinstry's FCA workbook and report.

Existing Mechanical Systems:

Cooling: Most of the building has no cooling system, with the exception being the DX rooftop units serving the computer lab and the IT room. The flex room AHU also has DX cooling.

Heating: Heating is served by a central hot water plant with gas-fired boilers, piped throughout the building to all heating equipment.

Ventilation: The ventilation system consists primarily of Unit Ventilators (UVs) serving the classrooms, with some spaces served by AHUs including the Music room, Gym, Locker Rooms, and Classrooms.

Existing Electrical Systems:

The building has an existing 800 amp, 208Y/120V 3-phase, 4-wire electrical service.

Existing Structural Systems:

The building was originally constructed in 1919 with additions in 1953, 1988 and 2001. The building consists of primarily HSS columns that are supported directly by spread footings, or concrete-masonry unit bearing and shear walls that are supported by mild reinforced concrete spread footings and strip footings. The main floor is supported by a nominal concrete slab on grade. The roof framing consists of open web steel trusses framing into wide flange beams or concrete-masonry unit bearing walls supporting corrugated metal deck. The roof framing was originally designed for nominal 35 psf dead load and 30 psf live load per the original structural drawings.

BUILDING HISTORY

Building Updates since 2015 Study

There have been no major additions or renovations since the 2015 study was conducted.

Historical Summary (Excerpt From the 2015 Study)

A description of the existing infrastructure and past remodels from the study performed in 2015 by Horsetooth Engineering is excerpted below:

- *In 2006 a gym addition was constructed. This area is served by a heating and ventilating only RTU.*
- *1996 a boiler was installed to convert the 1956 basement MZ from gas-fired to hot water heat.*
- *1994 consisted of multiple additions and in infill.*
    - *A portion of building was constructed to connect the original 1956 construction to the 1966 building. This infill area is served by a CV RTU with heating and ventilating only.*
    - *Two classrooms were added to the south end of the 1966 construction. This area is served by a CV RTU that is heating and ventilating only. Two classrooms were also added to the north end of the 1958 construction, these rooms are served by underground duct that was installed in the 1958 construction to allow for 2 more classrooms to be served from the basement MZ.*

AC Study: Timnath Elementary School

- *In 1991 the 1966 construction on the east part of the building was converted to hot water heat. A boiler room was added on the north side of the 1966 construction. This heating system serves the infill area and classrooms on the south added in 1994.*
- *In 1987 a media center addition was constructed on the north side, this was infilled between the 1956 and 1958 wings. It is served by two gas fired furnaces. One of the furnaces provides air conditioning to the computer lab. Supply and return duct is overhead. The east side of the media center is 1958 construction and is served from the basement MZ.*
- *In 1966 an annex was built to the west of the building. It is served by two MZ RTUs.*
- *1958 the eastern half of the building was constructed. All these spaces are served from the basement MZ installed in 1956 with underground duct.*
- *1956 was the original construction of the building. A MZ unit was installed in the basement. Supply duct was all routed underground. Return air was transferred from the classrooms into the corridor. One large central return air opening in the corridor is connected to the MZ.*
- *Cafeteria is also served by the basement MZ via underground supply duct.*
- *Kitchen has no make-up air unit. It relies only on transfer air from the gym/cafeteria. There is a small duct from the basement MZ that provides heat to the eastern part of the kitchen.*
- *It appears as though the computer lab on the west end of the building does not currently have air conditioning.*

AC Study: Timnath Elementary School

AIR CONDITIONING STRATEGIES

Contextual Narrative

In interviews with the facility management, it was noted that replacement of the kitchen basement MZU was a high priority. For all of the options listed below, the intent is to retire that unit and replace with a kitchen MAU with evaporative cooling, while also providing unit ventilators to condition and ventilate the spaces.

Pricing Chart

POUDRE SCHOOL DISTRICT - AC STUDY COST SUMMARY CHART						
School Name	Square Footage	Electrical Service Upgrade	Estimated Cost Range ($)		Estimated Cost Range ($/SF)	
			Low	High	Low	High
Timnath ES	74,265	Yes	$ 4,492,800	$ 6,065,280	$ 60.50	$ 81.67

Pricing Narrative

The cost estimation for this project was developed using industry best practices. Estimations have been prepared in June 2023 dollars. These prices are an opinion of probable cost for implementing AC, including Mechanical, Electrical, Structural, Plumbing, and Architectural costs. Pricing includes replacement of associated MEP systems that may not directly be related to AC such as boilers, ductwork, and heating water piping, when identified as necessary by the district. Pricing also includes a full controls overhaul at all schools. Note that these prices do not include abatement of asbestos outside of the scope of boiler replacements.

It is important to consider that prices for equipment, materials, and labor are still fluctuating heavily since the COVID-19 pandemic. In addition, lead times for equipment continue to be longer than pre-pandemic. These estimates are intended for use as a tool for PSD to facilitate conversations and for developing capital planning; they are not intended to be used as a quoted price to build these solutions. Instead, they should be interpreted as rough orders of magnitude required to accomplish the proposed AC solutions. As the formal design process has not yet been initiated, assumptions were made concerning the scale of renovations required, as well as building-specific details, including but not limited to: total pipe lengths, structural reinforcements, architectural amendments, and electrical system modifications.

AC Recommendation

In the process of determining the system to propose, some of the explored options included: 2-pipe Changeover, 4-pipe HW/CW, VAV Reheat, DX Unit Ventilators, HW/DX RTUs, Variable Refrigerant Flow (VRF), and Chilled Beams.

- **Heat Pump system**
- Heat pump systems are one of the most efficient systems available. These systems operate on a single condenser water loop, with each individual heat pump either rejecting or absorbing heat from the condenser water. These systems are particularly efficient during the shoulder seasons (Spring and Fall) when some spaces require cooling and others require heating, as the system allows that heat to be moved from one space to another. It is likely this system could utilize much of the existing piping, however it requires all the HVAC equipment to be replaced simultaneously to heat pump equipment to implement. This system also would also move towards the District goals of electrification, as it can be more easily converted to an electric-only solution via eventual implementation of ground-sourced heat pump or electric boilers. It was noted during interviews with District facilities staff that the boilers are at

the end of their useful life. With the heat pump system, the boiler would only need to run as emergency backup, most likely less than 1% of the year.

- Pros:
  - Highly efficient
  - Resilient, comfortable
  - Allows for central heat pump to provide heat most of the year, lowering carbon emissions and providing fuel flexibility to react to changing utility costs.
  - Likely can re-use some of the existing heating water piping for condenser water
  - Condenser water lines do not require insulation.
  - System can very effectively provide heating and cooling simultaneously
  - This system can also be used with a ground-sourced heat pump loop instead of an air-sourced heat pump for additional efficiency if there is opportunity or funding. The system can also be converted to ground-source at the end of life of the air-sourced heat pump.
- Cons:
  - High capital cost for new mechanical system retrofit.
  - Heat pump equipment have compressors, which can sometimes require additional maintenance.
  - Heat pump units may be louder than other HW/CW hydronic systems.
  - Requires an upgrade to the building electrical service, details provided below.
  - Will most likely trigger structural upgrades, details provided below.
- Implementation:
  - Install a new 50-ton air-to-water heat pump system and connect to existing heating water piping. Provide new circulation pumps. Provide screening/sound barrier.
  - Provide new condenser water piping system loop. Utilize/reconfigure existing HW piping as possible for new condenser water system.
  - Replace existing boiler plants with a single new high-efficiency boilers. Reconfigure piping as necessary to combine the two heating plants, as well as for connection to new CDW loop.
  - Install air source heat pump for heating and cooling in annex art.
  - Replace all existing equipment with water-sourced heat pump equipment.
    - Computer lab and IT room to remain on DX cooling.
  - All VUVs, AHUs and UVs in the building would require replacement with new heat pump equipment.
    - Replace all UVs with heat pump VUVs in all classrooms.
  - Install new MAU for kitchen with evaporative cooling.
  - For areas intended to be used year-round, such as the admin areas, provide a new ASHP RTU dedicated to those spaces (such as Admin and IT spaces).

- **Electrical Implications of AC Addition:**
  - Based on utility Peak Demand data and NEC required safety factors, the existing peak demand on the 800A service is 411 Amps. There is capacity to add cooling loads to the existing service but adding 50 tons of cooling would require a service upgrade to 1200 Amps.
  - When a heating only RTU is replaced with a Heat Pump unit, the existing electrical feeders & circuit breakers will need to be upsized to support the additional electrical load.
  - Costs for these upgrades are included in the pricing above.

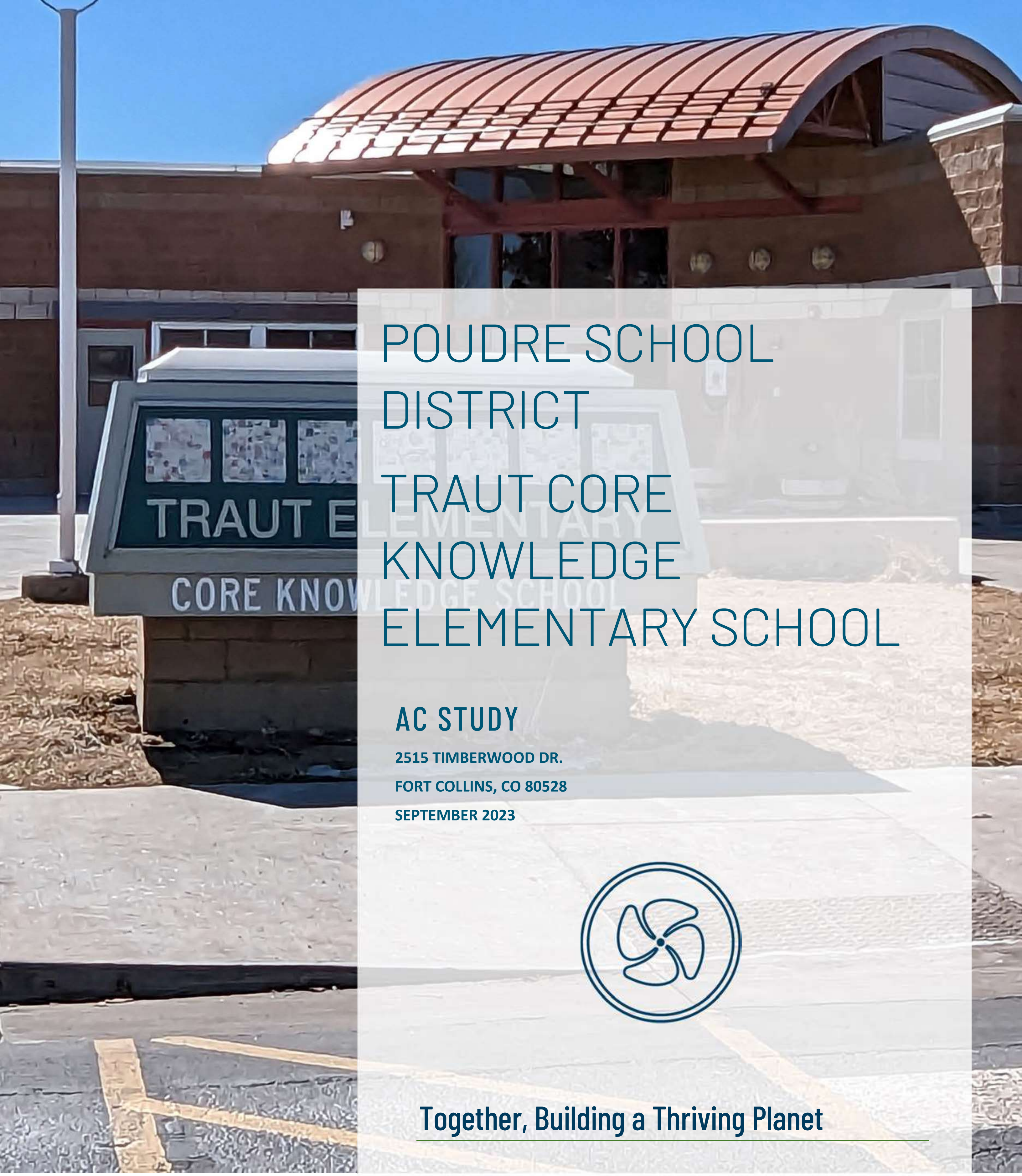
AC Study: Timnath Elementary School

- **Structural Implications:**
  - Rooftop equipment: The existing bar joist, K truss support framing will likely trigger reinforcing.
    - Truss reinforcing to consist of welded compression strut angle members coordinated with mech unit curb location and truss panel points. Truss chord and web reinforcing will also be required.
    - Deck reinforcing will be required if new openings are larger than 16” x 16” square.
  - Air-Source Heat Pump Pad
    - The new ground mounted equipment will be supported by a down-turned thickened lip concrete footing.
      - Thickened lip = 12” tall x 10” deep perimeter footing with minimum size equal to the footprint of the equipment + 6” all-around.
      - Reinforcing = (2) #4’s top and bottom.
      - 6” slab-on-grade to span between thickened lip and configured with #4 at 16” OC each way centered.
  - Costs for these upgrades are included in the pricing above.
- **Architectural Implications:**
  - For installation of new mechanical equipment provide a new rooftop curb (w/appropriate structural reinforcement). Existing Roofing at new curb location to be removed. Then repair, replace, and patch roofing as required around new curb (min. 4’-0”) with like material and installation techniques.
  - Where installation of new mechanical equipment is within 10’ of parapet wall or edge of roof provide permanent fall protection and associated structural reinforcement railing per OSHA requirements.
  - Where existing structural members are protected with Fire-Resistive-Rated (FRR) assemblies, all new structural members must be protected with a FRR assembly of equal or greater protection.
  - All new pipe penetrations and roof mounted pipe equipment shall be flashed in a manner appropriate to the existing roofing.
  - Where new penetrations are designed through Fire-Resistive-Rated Assemblies (Roof, Wall, and Floor) appropriate Fire/Smoke Dampers, FRR sleeves, and/or Fire Caulking shall be provided.
  - All new wall penetrations for pipe, louvers, or equipment installation shall be flashed and caulked in a manner appropriate for the exterior material.
  - All new wall penetrations for louvers or equipment shall be braced with new structural headers appropriate for the existing structural system. Header sizing by a Licensed Structural Engineer.

Recommendations from 2015 Study

- *Install a chiller and route piping to new equipment.*
  - McKinstry Comment: A heat pump system has been suggested in lieu of a chilled water system.
- *Install VUVs per classroom, workrooms and a RTU for the media center.*
  - McKinstry Comment: VUVs are to be installed in all classrooms for individual zone control.
- *New AHU for the 1st floor of the 1919 area.*
  - McKinstry Comment: Included.
- *Install building exhaust fans for pressure relief in economizer mode. Duct from fans to relief grilles.*
  - McKinstry Comment: Installing VUVs in place of the UVs will solve the pressure relief problem.
- *Install furnaces with DX cooling coils in the art building.*
  - McKinstry Comment: We have included an air source heat pump for heating and cooling.
- *New control system for the whole school.*

- McKinstry Comment: Included.



POUDRE SCHOOL DISTRICT

TRAUT CORE KNOWLEDGE ELEMENTARY SCHOOL

AC STUDY

2515 TIMBERWOOD DR.

FORT COLLINS, CO 80528

SEPTEMBER 2023

Together, Building a Thriving Planet

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Traut Core Knowledge Elementary School AC Study

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AC Study: Traut Core Knowledge Elementary School

PURPOSE SUMMARY

The primary function of this Air Conditioning (AC) study is to "refresh" the original 2015 study performed by Horsetooth Engineering for Poudre School District (PSD). In addition to a summary, examination, and validation of the items in the original study, this report includes an analysis of the existing building conditions, an updated historical synopsis of the building's construction projects if applicable, and a high-level exploration of possible solutions to provide Air Conditioning to each building. McKinstry's team has performed a site investigation, has interviewed the facility operators and other relevant parties, and has reviewed available existing documentation in order to provide this analysis.

The goal of this study is to aid PSD in planning the implementation of AC in the various schools which do not currently have cooling. The report is intended to create a basis for which to build future projects and to guide decision making as to how to accomplish this goal. The solutions explored range from budget-aware to "best case scenario" options, but ultimately it was agreed that for the purposes of this study, a single, fully functional AC system option would be presented per school. The preferred system type can be developed further once PSD decides on the direction to move forward after considering District budget, building/system urgency, and overall feasibility. Equipment sizes, cooling tonnages, structural capacities, and other similar values have been estimated using industry best practices and will be confirmed/adjusted via load calculations during the design phase.

This report is intended to be read in tandem with the other McKinstry offerings for this building (RCx, FCA) to provide an integrated and holistic understanding of the building portfolio. While the other reports will focus on the existing systems and conditions in more detail, this report will focus on future implementation of AC in the building and their impacts to electrical, structural, and architectural systems.

AC Study: Traut Core Knowledge Elementary School

BUILDING SUMMARY

General:

Traut Core Knowledge Elementary is a single-story 50,871 square foot school located at 2515 Timberwood Dr. in Fort Collins, Colorado. Originally built in 1999, it has had one major renovation since the 2015 study to implement a 'tempered air' system. This renovation was already planned at the time of the 2015 Study, and is summarized in more detail in the history section below. A deeper dive on the conditions of the existing equipment, and estimated costs of replacement, can be found in McKinstry's FCA workbook and report.

Existing Mechanical Systems:

Cooling: The building is served by a "tempered air" system, utilizing a cooling tower connected to the existing heating water piping in a 2-pipe changeover strategy to deliver cool water to all units in the building. All parts of the building connected to the heating water system are also able to use the tempered water; however, the entire system can only be operated in either heating or cooling mode. Two Rooftop Units (RTUs) have DX cooling – RTU-1 serving the Media Center and RTU-3 serving the Data Room.

Heating: Heating is served by a central hot water plant with gas-fired boilers, piped throughout the building to all heating equipment.

Ventilation: The ventilation system consists primarily of Vertical Unit Ventilators (VUVs) serving the classrooms, with some spaces served by RTUs including the Data Room, Flex Room, and Media Center.

Existing Electrical Systems:

The building has an existing 1400 amp, 208Y/120V 3-phase, 4-wire electrical service.

Existing Structural Systems:

The initial building was constructed in 1999 with a renovation completed in 2015. The building consists of concrete-masonry unit bearing and shear walls that are supported by mild reinforced concrete spread footing, strip footings and grade beams. The main floor is supported by a nominal concrete slab-on-grade. The roof framing consists of open web steel trusses supporting corrugated metal deck. The roof framing was originally designed for nominal 15 psf dead load per the original structural drawings.

BUILDING HISTORY

Building Updates since 2015 Study

There have been no major additions or renovations since the 2015 study was conducted (the 2015 "tempered air" update was included in the original report).

Historical Summary (Excerpt From the 2015 Study)

A description of the existing infrastructure and past remodels from the study performed in 2015 by Horsetooth Engineering is excerpted below:

- *2015 HVAC updates will install a "tempered air" system utilizing a cooling tower and VUVs*
  - *This strategy is able to deliver 65 to 70 degree air into the classrooms during the hottest days of the year.*
  - *Air quantities are 1,200 to 2,000 CFM per classroom depending on number of exterior walls are orientation (east, west, north, south)*
- *Air is delivered into the classrooms via exposed spiral ductwork up high with sidewall diffusers. Air quantity varies between 50 and 100% based on how much heat or cooling the room requires.*

  - *Zoning per individual classrooms is provided.*
- *Fan coil units that also receive cool water from the tower will be installed in corridor, work areas, and office areas.*
  - *New pumps and piping to work with the 2-pipe system for heating and cooling will be installed.*
- *2015 HVAC updates also included a new packaged DX RTU for the Comm Data room.*
- *A new kitchen make-up air unit with evaporative cooling will also be installed in 2015.*
- *1999 was the original construction of the building.*

AC Study: Traut Core Knowledge Elementary School

AIR CONDITIONING STRATEGIES

Pricing Chart

POUDRE SCHOOL DISTRICT - AC STUDY COST SUMMARY CHART						
School Name	Square Footage	Electrical Service Upgrade	Estimated Cost Range ($)		Estimated Cost Range ($/SF)	
			Low	High	Low	High
Traut Core Knowledge ES	50,871	Yes	$ 4,710,900	$ 6,359,715	$ 92.60	$ 125.02

Pricing Narrative

The cost estimation for this project was developed using industry best practices. Estimations have been prepared in June 2023 dollars. These prices are an opinion of probable cost for implementing AC, including Mechanical, Electrical, Structural, Plumbing, and Architectural costs. Pricing includes replacement of associated MEP systems that may not directly be related to AC such as boilers, ductwork, and heating water piping, when identified as necessary by the district. Pricing also includes a full controls overhaul at all schools. Note that these prices do not include abatement of asbestos outside of the scope of boiler replacements.

It is important to consider that prices for equipment, materials, and labor are still fluctuating heavily since the COVID-19 pandemic. In addition, lead times for equipment continue to be longer than pre-pandemic. These estimates are intended for use as a tool for PSD to facilitate conversations and for developing capital planning; they are not intended to be used as a quoted price to build these solutions. Instead, they should be interpreted as rough orders of magnitude required to accomplish the proposed AC solutions. As the formal design process has not yet been initiated, assumptions were made concerning the scale of renovations required, as well as building-specific details, including but not limited to: total pipe lengths, structural reinforcements, architectural amendments, and electrical system modifications.

AC Recommendation

In the process of determining the system to propose, some of the explored options included: 2-pipe Changeover, 4-pipe HW/CW, VAV Reheat, DX Unit Ventilators, HW/DX RTUs, Variable Refrigerant Flow (VRF), and Chilled Beams

- **Heat Pump system**
- Heat pump systems are one of the most efficient systems available. These systems operate on a single condenser water loop, with each individual heat pump either rejecting or absorbing heat from the condenser water. These systems are particularly efficient during the shoulder seasons (Spring and Fall) when some spaces require cooling and others require heating, as the system allows that heat to be moved from one space to another. It is likely this system could utilize much of the existing piping, however it requires all the HVAC equipment to be replaced simultaneously to heat pump equipment to implement. This system also would also move towards the District goals of electrification, as it can be more easily converted to an electric-only solution via eventual implementation of ground-sourced heat pump or electric boilers.
    - Pros:
        - Highly efficient
        - Resilient, comfortable
        - Allows for central heat pump to provide heat most of the year, lowering carbon emissions and providing fuel flexibility to react to changing utility costs

- Likely can re-use some of the existing heating water piping for condenser water
- Condenser water lines do not require insulation
- System can very effectively provide heating and cooling simultaneously
- This system can also be used with a ground-sourced heat pump loop instead of an air-sourced heat pump for additional efficiency if there is opportunity or funding. The system can also be converted to ground-source at the end of life of the air-sourced heat pump.

  - Cons:
    - High capital cost for new mechanical system retrofit
    - Heat pump equipment have compressors, which can sometimes require additional maintenance
    - Heat pump units may be louder than other HW/CW hydronic systems
    - Requires an upgrade to the building electrical service, details provided below.
    - Will most likely trigger structural upgrades, details provided below.
  - Implementation:
    - Install a new 110-ton air-to-water heat pump system and connect to existing heating water piping. Provide new circulation pumps. Provide screening/sound barrier.
    - Provide new condenser water piping system loop. Utilize/reconfigure existing HW piping as possible for new condenser water system
    - Demo existing cooling tower
    - Replace all existing equipment with water-sourced heat pump equipment
      - All VUVs, RTUs, and FCUs in the building would require replacement with new heat pump equipment. All CUHs will require replacement with electrical unit heaters.
    - For areas intended to be used year-round, such as the admin areas, provide a new ASHP RTU dedicated to those spaces (such as Admin and IT spaces).

- **Electrical Implications of AC Addition:**
  - Based on utility Peak Demand data and NEC required safety factors, the existing peak demand on the 1400A service is 452 Amps. There is capacity to add cooling loads to the existing service but adding 100 tons of cooling would require a service upgrade to 2000 Amps.
  - When a heating only RTU is replaced with a Heat Pump unit, the existing electrical feeders & circuit breakers will need to be upsized to support the additional electrical load.
  - Costs for these upgrades are included in the pricing above.
- **Structural Implications:**
  - Rooftop equipment: The existing bar joist, K truss support framing will likely trigger reinforcing.
    - Truss reinforcing to consist of welded compression strut angle members coordinated with mech unit curb location and truss panel points. Truss chord and web reinforcing will also be required.
    - Deck reinforcing will be required if new openings are larger than 16” x 16” square.
  - Air-Source Heat Pump Pad
    - The new ground mounted equipment will be supported by a down-turned thickened lip concrete footing.
      - Thickened lip = 12”tall x 10” deep perimeter footing with minimum size equal to the footprint of the equipment + 6” all-around.
      - Reinforcing = (2) #4’s top and bottom.

            - 6" slab-on-grade to span between thickened lip and configured with #4 at 16" OC each way centered.
    - Costs for these upgrades are included in the pricing above.
- **Architectural Implications:**
    - For installation of new mechanical equipment provide a new rooftop curb (w/appropriate structural reinforcement). Existing Roofing at new curb location to be removed. Then repair, replace, and patch roofing as required around new curb (min. 4'-0") with like material and installation techniques.
    - Where installation of new mechanical equipment is within 10' of parapet wall or edge of roof provide permanent fall protection and associated structural reinforcement railing per OSHA requirements.
    - Where existing structural members are protected with Fire-Resistive-Rated (FRR) assemblies, all new structural members must be protected with a FRR assembly of equal or greater protection.
    - All new pipe penetrations and roof mounted pipe equipment shall be flashed in a manner appropriate to the existing roofing.
    - Where new penetrations are designed through Fire-Resistive-Rated Assemblies (Roof, Wall, and Floor) appropriate Fire/Smoke Dampers, FRR sleeves, and/or Fire Caulking shall be provided.
    - All new wall penetrations for pipe, louvers, or equipment installation shall be flashed and caulked in a manner appropriate for the exterior material.
    - All new wall penetrations for louvers or equipment shall be braced with new structural headers appropriate for the existing structural system. Header sizing by a Licensed Structural Engineer.

Recommendations from 2015 Study

Below are excerpts of recommendations from the 2015 study. Recommendations that are no longer applicable, or that have already been implemented, have been removed. Recommendations related to the condition of existing equipment and systems are covered in the FCA report and have been removed.

- *Install a chiller and connect to existing piping.*
    - McKinstry Comment: We have proposed a heat pump solution in lieu of CHW.
- *Install a cooling coil in the supply duct main for the Media Center.*
    - McKinstry Comment: We suggest replacing the main system rather than installing a cooling coil in the existing ductwork.
- *Packaged DX RTU for admin*
    - McKinstry Comment: Included, with ASHP RTU in lieu of DX.

POUDRE SCHOOL DISTRICT

WEBBER MIDDLE SCHOOL

AC STUDY

4201 SENECA ST.

FORT COLLINS, CO 80526

SEPTEMBER 2023

Together, Building a Thriving Planet

McKinstry
For The Life Of Your Building

AC Study: Webber Middle School

AC Study: Webber Middle School

Webber Middle School AC Study

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AC Study: Webber Middle School

PURPOSE SUMMARY

The primary function of this Air Conditioning (AC) study is to "refresh" the original 2015 study performed by Horsetooth Engineering for Poudre School District (PSD). In addition to a summary, examination, and validation of the items in the original study, this report includes an analysis of the existing building conditions, an updated historical synopsis of the building's construction projects if applicable, and a high-level exploration of possible solutions to provide Air Conditioning to each building. McKinstry's team has performed a site investigation, has interviewed the facility operators and other relevant parties, and has reviewed available existing documentation in order to provide this analysis.

The goal of this study is to aid PSD in planning the implementation of AC in the various schools which do not currently have cooling. The report is intended to create a basis for which to build future projects and to guide decision making as to how to accomplish this goal. The solutions explored range from budget-aware to "best case scenario" options, but ultimately it was agreed that for the purposes of this study, a single, fully functional AC system option would be presented per school. The preferred system type can be developed further once PSD decides on the direction to move forward after considering District budget, building/system urgency, and overall feasibility. Equipment sizes, cooling tonnages, structural capacities, and other similar values have been estimated using industry best practices and will be confirmed/adjusted via load calculations during the design phase.

This report is intended to be read in tandem with the other McKinstry offerings for this building (RCx, FCA) to provide an integrated and holistic understanding of the building portfolio. While the other reports will focus on the existing systems and conditions in more detail, this report will focus on future implementation of AC in the building and their impacts to electrical, structural, and architectural systems.

AC Study: Webber Middle School

BUILDING SUMMARY

General:

Webber Middle School is a single-story 122,787 square foot school located at 4201 Seneca Street, in Fort Collins, Colorado. Originally built in 1989, the building has seen with multiple expansions and renovations in the last 50 years; these renovations are summarized in more detail in the history section below. A deeper dive on the conditions of the existing equipment, and estimated costs of replacement, can be found in McKinstry's FCA workbook and report.

Existing Mechanical Systems:

Cooling: Of the 10 existing RTUs, 5 have DX cooling, including the RTUs serving the Data rooms. The kitchen is served by an indirect gas fired make up air unit with direct evaporative cooling.

Heating: Heating is served by a central hot water plant with gas-fired boilers, piped throughout the building to all heating equipment. 2 new condensing boilers are to be installed this summer. The kitchen is served by an indirect gas fired make up air unit with direct evaporative cooling.

Ventilation: The ventilation system consists primarily of Vertical Unit Ventilators (VUVs) serving the classrooms, with some spaces served by RTUs including the Data Room, Flex Room, and Media Center. The kitchen is served by an indirect gas fired make up air unit with direct evaporative cooling.

Existing Electrical Systems:

The building has an existing 1200 amp, 480Y/277V 3-phase, 4-wire service.

Existing Structural Systems:

The initial building was constructed in 1989 with additions in 1997 and 2006 and major renovations in 2012. The building consists of exterior reinforced brick bearing and shear walls with interior concrete-masonry-unit bearing walls or HSS columns that are supported by mild reinforced concrete stem walls and intermittent spread footings. The main floor is supported by a nominal concrete slab on grade. The roof framing consists mostly of open web steel trusses supporting metal deck roof. The roof framing was originally designed for a nominal roof live load of 30 psf.

BUILDING HISTORY

Building Updates since 2015 Study

There have been no major additions or renovations since the 2015 study was conducted.

Historical Summary (Excerpt From the 2015 Study)

A description of the existing infrastructure and past remodels from the study performed in 2015 by Horsetooth Engineering is excerpted below:

- *2012 HVAC updates that were installed in the classrooms, music and Tech Ed rooms are air conditioning ready. The VUVs have a 4-row heating coil that can have chilled water piping routed to it for 2-pipe system air conditioning.*
- *2012 RTUs that were installed for the administration, hearing impaired, and band room have space for a cooling coil to be installed.*
- *2006 RTU serving the cafeteria also has space for a cooling coil to be added.*
- *1997 Gym addition heating and ventilating RTU is in good condition.*

- *One computer lab is served from a packaged DX RTU installed in 2012. The other computer lab also has a packaged DX RTU that was installed in earlier years by PSD.*
- *Kitchen make-up air unit and evaporative cooler was replaced in 2012.*

AC Study: Webber Middle School

AIR CONDITIONING STRATEGIES

Contextual Narrative

During interviews with the facility management team, it was noted that the piping system at Webber MS is a heating only system and that it would not be compatible with 2-pipe changeover. Because a 2-pipe changeover system does not provide effective cooling during the shoulder seasons when both heating and cooling is required, this solution has not been proposed. For our suggested heat pump option, we are also incorporating replacing any equipment that is not compatible with the proposed solutions.

In addition to the previous concern, the facility management team communicated that the existing RTUs are past their lifetime and should not be retrofitted, but rather replaced. This has been incorporated.

Pricing Chart

POUDRE SCHOOL DISTRICT - AC STUDY COST SUMMARY CHART						
School Name	Square Footage	Electrical Service Upgrade	Estimated Cost Range ($)		Estimated Cost Range ($/SF)	
			Low	High	Low	High
Webber MS	122,787	No	$ 7,397,400	$ 9,986,490	$ 60.25	$ 81.33

Pricing Narrative

The cost estimation for this project was developed using industry best practices. Estimations have been prepared in June 2023 dollars. These prices are an opinion of probable cost for implementing AC, including Mechanical, Electrical, Structural, Plumbing, and Architectural costs. Pricing includes replacement of associated MEP systems that may not directly be related to AC such as boilers, ductwork, and heating water piping, when identified as necessary by the district. Pricing also includes a full controls overhaul at all schools. Note that these prices do not include abatement of asbestos outside of the scope of boiler replacements.

It is important to consider that prices for equipment, materials, and labor are still fluctuating heavily since the COVID-19 pandemic. In addition, lead times for equipment continue to be longer than pre-pandemic. These estimates are intended for use as a tool for PSD to facilitate conversations and for developing capital planning; they are not intended to be used as a quoted price to build these solutions. Instead, they should be interpreted as rough orders of magnitude required to accomplish the proposed AC solutions. As the formal design process has not yet been initiated, assumptions were made concerning the scale of renovations required, as well as building-specific details, including but not limited to: total pipe lengths, structural reinforcements, architectural amendments, and electrical system modifications.

AC Recommendations

In the process of determining the system to propose, some of the explored options included: 2-pipe Changeover, 4-pipe HW/CW, VAV Reheat, DX Unit Ventilators, HW/DX RTUs, Variable Refrigerant Flow (VRF), and Chilled Beams.

- **Heat Pump system**
- Heat pump systems are one of the most efficient systems available. These systems operate on a single condenser water loop, with each individual heat pump either rejecting or absorbing heat from the condenser water. These systems are particularly efficient during the shoulder seasons (Spring and Fall) when some spaces require cooling and others require heating, as the system allows that heat to be moved from one space to another. It is likely this system could utilize much of the existing piping,

however it requires all the HVAC equipment to be replaced simultaneously to heat pump equipment to implement. This system also would also move towards the District goals of electrification, as it can be more easily converted to an electric-only solution via eventual implementation of ground-sourced heat pump or electric boilers.

- Pros:
  - Highly efficient
  - Resilient, comfortable
  - Allows for central heat pump to provide heat most of the year, lowering carbon emissions and providing fuel flexibility to react to changing utility costs
  - Likely can re-use some of the existing heating water piping for condenser water
  - Condenser water lines do not require insulation
  - System can very effectively provide heating and cooling simultaneously
  - This system can also be used with a ground-sourced heat pump loop instead of an air-sourced heat pump for additional efficiency if there is opportunity or funding. The system can also be converted to ground-source at the end of life of the air-sourced heat pump.
- Cons:
  - High capital cost for new mechanical system retrofit
  - Heat pump equipment have compressors, which can sometimes require additional maintenance
  - Heat pump units may be louder than other HW/CW hydronic systems
  - Requires an upgrade to the building electrical service, details provided below.
  - Will most likely trigger structural upgrades, details provided below.
- Implementation:
  - Install a new 150-ton air-to-water heat pump system and connect to existing heating water piping. Provide new circulation pumps. Provide screening/sound barrier.
  - Provide new condenser water piping system loop. Utilize/reconfigure existing HW piping as possible for new condenser water system
  - Replace all existing equipment with water-sourced heat pump equipment
  - All VUVs, RTUs, and FCUs in the building would require replacement with new heat pump equipment. CUH-1 will require replacement with electrical unit heater.
  - For areas intended to be used year-round, such as the admin areas, provide a new ASHP RTU dedicated to those spaces (such as Admin and IT spaces).

- **Electrical Implications of AC Addition:**
  - Based on utility Peak Demand data and NEC required safety factors, the existing peak demand on the 1200A service is 372 Amps. There is capacity to add 150 tons of cooling load to the existing service.
  - When a heating only RTU is replaced with a Heat Pump unit, the existing electrical feeders & circuit breakers will need to be upsized to support the additional electrical load.
  - Costs for these upgrades are included in the pricing above.
- **Structural Implications:**
  - Rooftop equipment: The existing bar joist, K truss support framing will likely trigger reinforcing.
    - Truss reinforcing to consist of welded compression strut angle members coordinated with mech unit curb location and truss panel points. Truss chord and web reinforcing will also be required.

        - Deck reinforcing will be required if new openings are larger than 16” x 16” square.
    - Air-Source Heat Pump Pad
        - The new ground mounted equipment will be supported by a down-turned thickened lip concrete footing.
            - Thickened lip = 12” tall x 10” deep perimeter footing with minimum size equal to the footprint of the equipment + 6” all-around.
            - Reinforcing = (2) #4’s top and bottom.
            - 6” slab-on-grade to span between thickened lip and configured with #4 at 16” OC each way centered.
    - Costs for these upgrades are included in the pricing above.
- **Architectural Implications:**
    - For installation of new mechanical equipment provide a new rooftop curb (w/appropriate structural reinforcement). Existing Roofing at new curb location to be removed. Then repair, replace, and patch roofing as required around new curb (min. 4’-0”) with like material and installation techniques.
    - Where installation of new mechanical equipment is within 10’ of parapet wall or edge of roof provide permanent fall protection and associated structural reinforcement railing per OSHA requirements.
    - Where existing structural members are protected with Fire-Resistive-Rated (FRR) assemblies, all new structural members must be protected with a FRR assembly of equal or greater protection.
    - All new pipe penetrations and roof mounted pipe equipment shall be flashed in a manner appropriate to the existing roofing.
    - Where new penetrations are designed through Fire-Resistive-Rated Assemblies (Roof, Wall, and Floor) appropriate Fire/Smoke Dampers, FRR sleeves, and/or Fire Caulking shall be provided.
    - All new wall penetrations for pipe, louvers, or equipment installation shall be flashed and caulked in a manner appropriate for the exterior material.
    - All new wall penetrations for louvers or equipment shall be braced with new structural headers appropriate for the existing structural system. Header sizing by a Licensed Structural Engineer.

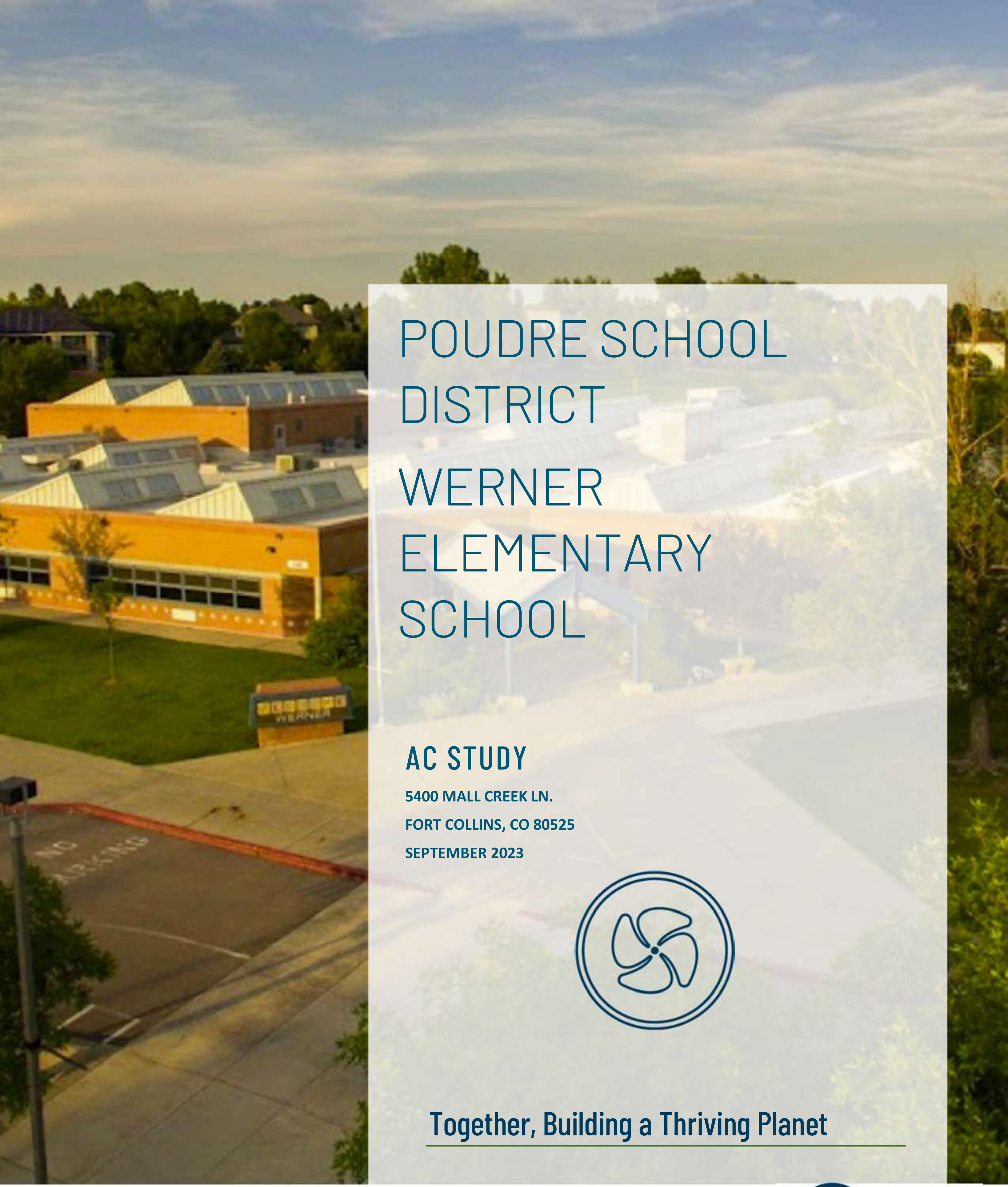
Recommendations from 2015 Study

Below are excerpts of recommendations from the 2015 study. Recommendations that are no longer applicable, or that have already been implemented, have been removed. Recommendations related to the condition of existing equipment and systems are covered in the FCA report and have been removed.

- *Install chiller and route chilled water to 2012 VUVs and RTUs. Install cooling coil in existing RTUs.*
    - McKinstry Comment: We have proposed a heat pump solution in lieu of CHW, requiring all new VUVs and RTUs.
- *Install cooling coil in 2006 cafeteria RTU and route chilled water to RTU.*
    - McKinstry Comment: We have proposed a heat pump solution in lieu of CHW, requiring a new RTU
- *Route chilled water on roof and drop into space when required.*
    - McKinstry Comment: We have proposed a heat pump solution in lieu of CHW, utilizing the heating water piping as possible.
- *Install new 4-pipe fan coils for the teacher workroom areas that did not receive any ventilation air in the 2012 HVAC updates. Currently, operable windows is how Code required ventilation air is provided. Serve adjacent corridors with these new fan coils.*

- McKinstry Comment: New heat pumps in lieu of 4-pipe fan coils will be used for these spaces.

- *Install a packaged DX RTU for the admin area.*
  - McKinstry Comment: Included, with ASHP RTU in lieu of DX.



POUDRE SCHOOL DISTRICT

WERNER ELEMENTARY SCHOOL

AC STUDY

5400 MALL CREEK LN.

FORT COLLINS, CO 80525

SEPTEMBER 2023

Together, Building a Thriving Planet

McKinstry

For The Life Of Your Building

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AC Study: Werner Elementary School

Werner Elementary School AC Study

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AC Study: Werner Elementary School

PURPOSE SUMMARY

The primary function of this Air Conditioning (AC) study is to "refresh" the original 2015 study performed by Horsetooth Engineering for Poudre School District (PSD). In addition to a summary, examination, and validation of the items in the original study, this report includes an analysis of the existing building conditions, an updated historical synopsis of the building's construction projects if applicable, and a high-level exploration of possible solutions to provide Air Conditioning to each building. McKinstry's team has performed a site investigation, has interviewed the facility operators and other relevant parties, and has reviewed available existing documentation in order to provide this analysis.

The goal of this study is to aid PSD in planning the implementation of AC in the various schools which do not currently have cooling. The report is intended to create a basis for which to build future projects and to guide decision making as to how to accomplish this goal. The solutions explored range from budget-aware to "best case scenario" options, but ultimately it was agreed that for the purposes of this study, a single, fully functional AC system option would be presented per school. The preferred system type can be developed further once PSD decides on the direction to move forward after considering District budget, building/system urgency, and overall feasibility. Equipment sizes, cooling tonnages, structural capacities, and other similar values have been estimated using industry best practices and will be confirmed/adjusted via load calculations during the design phase.

This report is intended to be read in tandem with the other McKinstry offerings for this building (RCx, FCA) to provide an integrated and holistic understanding of the building portfolio. While the other reports will focus on the existing systems and conditions in more detail, this report will focus on future implementation of AC in the building and their impacts to electrical, structural, and architectural systems.

AC Study: Werner Elementary School

BUILDING SUMMARY

General:

Werner Elementary School is a single-story 50,300 square foot school located at 5400 Mall Creek Lane, in Fort Collins, Colorado. Originally constructed in 1986, there have been no major additions since the original construction. Renovations are summarized in more detail in the history section below. In 2012, a Dedicated Outdoor Air System (DOAS) was installed to provide "tempered air" and is summarized in more detail in the history section below. A deeper dive on the conditions of the existing equipment, and estimated costs of replacement, can be found in McKinstry's FCA workbook and report.

Existing Mechanical Systems:

Cooling: The building is served by a "tempered air" system, utilizing DOAS units on the roof with indirect evaporative cooling and energy wheels delivering 100% outside air to all classrooms. This system is not a formal cooling system. 2 Rooftop Units (RTUs) have DX cooling, including the RTU serving the IT Room.

Heating: Heating is served by a central hot water plant with gas-fired boilers, piped throughout the building to all heating equipment, including perimeter baseboard heating, Fan Coil Units (FCUs), AHUs, and DOAS units. A boiler plant replacement is scheduled for the summer of 2024.

Ventilation: Ventilation for the building is provided by the DOAS units serving the classrooms via displacement ventilation diffusers and other interior spaces by FCUs, and AHUs serving the Gymnasium and Media Center.

Existing Electrical Systems:

The building has an existing 600 amp, 208Y/120V 3-phase, 4-wire electrical service.

Existing Structural Systems:

The initial building was constructed in 1986 with renovation completed in 2012. The building consists of concrete-masonry unit bearing and shear walls that are supported by mild reinforced concrete spread footing, strip footings and grade beams. The main floor is supported by a nominal concrete slab-on-grade. The roof framing consists of open web steel trusses supporting corrugated metal deck.

BUILDING HISTORY

Building Updates since 2015 Study

There have been no major additions or renovations since the 2015 study was conducted.

Historical Summary (Excerpt From the 2015 Study)

A description of the existing infrastructure and past remodels from the study performed in 2015 by Horsetooth Engineering is excerpted below:

- *2012 HVAC updates installed a "tempered air" system utilizing indirect evaporative cooling Dedicated Outside Air Systems (DOAS)*
  - *This strategy is to deliver outside air into the classrooms that is approximately 14 degrees cooler than the outside air temperature during the warmer parts of the year. For instance – at 85 degrees outside, the air delivered to the classroom is 71 degrees.*
  - *Air quantities and fan speed are varied depending on the mode that the air handler is in.*
    - *In heating mode the goal is to deliver 300 cfm per classroom, slightly over Code required ventilation air*
    - *In tempering mode the goal is to deliver 600 cfm per classroom*

  - *Air is delivered into the classrooms via floor displacement ventilation diffusers. The strategy is to deliver the air down in the occupant zone in lieu of overhead at the ceiling.*
  - *No zoning for individual classrooms is provided. They all receive the same quantity and temperature of air.*
  - *Return grilles were not observed in the classrooms. Most likely the space between the ceiling and exposed roof joists was determined to be enough free area for return air to get back to the RTU.*
  - *Fan coil units that provide heating and ventilation only were installed in corridor, work areas and office areas. PSD staff has added economizers to the fan coils in the administration area to increase outside air quantities for warmer times of the year.*
- *Heating water piping and boilers were installed in 1988 and were all reused in the 2012 HVAC updates. Heat is provided by baseboard radiation at the exterior walls, which was installed in 2012.*
- *A packaged DX RTU installed by PSD serves the computer lab. Replacement should be anticipated in the next 5-7 years.*
- *The cafeteria is heated and ventilated via 4 ceiling mounted unit ventilators installed in 1988.*
- *Media Center is provided with heating and ventilation by an indoor AHU installed in 1988.*
- *The AHU serving the gym is original from 1988. This unit should be replaced in the next 10-15 years.*
- *Kitchen make-up air unit and evaporative cooler was replaced in 2012.*

AC Study: Werner Elementary School

AIR CONDITIONING STRATEGIES

Contextual Narrative

The existing DOAS “tempered air” system is unfortunately not compatible with a simple solution for implementing AC. The existing DOAS units have space for future cooling coils, but they are not sized adequately to provide full cooling to the building – only lowering the supply air to approximately 65 degrees. The DOAS displacement ventilation strategy is incompatible with discharge air temperatures lower than 65 degrees, which creates a further barrier to AC implementation using primarily the DOAS system. While the additional cooling would not be enough to fully cool the spaces, it would make the spaces more comfortable – however, an electric upgrade would be required to install the additional cooling coils, which would be a significant cost. Because this upgrade would be expensive, and would not achieve full air conditioning, this option has not been recommended.

The original 2015 study recommended a VAV reheat system as a possible strategy. We do not agree with this recommendation. VAV reheat systems, while popular in the past, are not particularly efficient when compared to newer systems. Energy is spent both in cooling down the main supply air, and then spent again to reheat the air in zones that are not in cooling mode. Our proposed option is a more efficient system, as each zone is able to condition independently without reheating.

In our recommended system, a new DOAS system is still utilized, with new VUV equipment replacing the displacement ventilators. Tonnage estimation was done using industry best practices, but it is likely that tonnage will decrease during the design phase when full load calculations are performed.

AC Study: Werner Elementary School

Pricing Chart

POUDRE SCHOOL DISTRICT - AC STUDY COST SUMMARY CHART						
School Name	Square Footage	Electrical Service Upgrade	Estimated Cost Range ($)		Estimated Cost Range ($/SF)	
			Low	High	Low	High
Werner ES	50,300	Yes	$ 4,321,800	$ 5,834,430	$ 85.92	$ 115.99

Pricing Narrative

The cost estimation for this project was developed using industry best practices. Estimations have been prepared in June 2023 dollars. These prices are an opinion of probable cost for implementing AC, including Mechanical, Electrical, Structural, Plumbing, and Architectural costs. Pricing includes replacement of associated MEP systems that may not directly be related to AC such as boilers, ductwork, and heating water piping, when identified as necessary by the district. Pricing also includes a full controls overhaul at all schools. Note that these prices do not include abatement of asbestos outside of the scope of boiler replacements.

It is important to consider that prices for equipment, materials, and labor are still fluctuating heavily since the COVID-19 pandemic. In addition, lead times for equipment continue to be longer than pre-pandemic. These estimates are intended for use as a tool for PSD to facilitate conversations and for developing capital planning; they are not intended to be used as a quoted price to build these solutions. Instead, they should be interpreted as rough orders of magnitude required to accomplish the proposed AC solutions. As the formal design process has not yet been initiated, assumptions were made concerning the scale of renovations required, as well as building-specific details, including but not limited to: total pipe lengths, structural reinforcements, architectural amendments, and electrical system modifications.

AC Recommendation

In the process of determining the system to propose, some of the explored options included: 2-pipe Changeover, 4-pipe HW/CW, VAV Reheat, DX Unit Ventilators, HW/DX RTUs, Variable Refrigerant Flow (VRF), and Chilled Beams

- **Heat Pump system**
- Heat pump systems are one of the most efficient systems available. These systems operate on a single condenser water loop, with each individual heat pump either rejecting or absorbing heat from the condenser water. These systems are particularly efficient during the shoulder seasons (Spring and Fall) when some spaces require cooling and others require heating, as the system allows that heat to be moved from one space to another. It is likely this system could utilize much of the existing piping, however it requires all the HVAC equipment to be replaced simultaneously to heat pump equipment to implement. This system also would also move towards the District goals of electrification, as it can be more easily converted to an electric-only solution via eventual implementation of ground-sourced heat pump or electric boilers. It was noted during interviews with District facilities staff that the Aerco boiler is not reliable, and it is harder and harder to get parts. With the heat pump system, the boiler would only need to run as emergency backup, most likely less than 1% of the year.
    - Pros:
        - Highly efficient
        - Resilient, comfortable
        - Allows for central heat pump to provide heat most of the year, lowering carbon emissions and providing fuel flexibility to react to changing utility costs

        - Likely can re-use some of the existing heating water piping for condenser water
        - Condenser water lines do not require insulation
        - System can very effectively provide heating and cooling simultaneously
        - This system can also be used with a ground-sourced heat pump loop instead of an air-sourced heat pump for additional efficiency if there is opportunity or funding. The system can also be converted to ground-source at the end of life of the air-sourced heat pump.
    - Cons:
        - High capital cost for new mechanical system retrofit
        - Heat pump equipment have compressors, which can sometimes require additional maintenance
        - Heat pump units may be louder than other HW/CW hydronic systems
        - Requires an upgrade to the building electrical service, details provided below.
        - Will most likely trigger structural upgrades, details provided below.
    - Implementation:
        - Install a new 100-ton air-to-water heat pump system and connect to existing heating water piping. Provide new circulation pumps. Provide screening/sound barrier.
        - Demolish existing baseboard heaters, cabinet unit heaters, and other radiant heaters
        - Provide new condenser water piping system loop. Utilize/reconfigure existing HW piping as possible for new condenser water system
        - Replace all existing equipment with water-sourced heat pump equipment
            - Replace existing displacement ventilators with new heat pump VUVs.
            - Replace existing DOAS units with heat pump units. Connect existing outside air from DOAS to the new VUVs
            - Replace existing RTUs with new heat pump RTUs
            - Replace existing FCUs with new horizontal heat pumps
            - Replace existing heating-only AHUs with new heat pump AHUs
        - For areas intended to be used year-round, such as the admin areas, provide a new ASHP RTU dedicated to those spaces (such as Admin and IT spaces).
- **Electrical Implications of AC Addition:**
    - Based on utility Peak Demand data and NEC required safety factors, the existing peak demand on the 600A service is 339 Amps. There is capacity to add cooling loads to the existing service but adding 100 tons of cooling would require a service upgrade to 1000 Amps.
    - When a heating only RTU is replaced with a Heat Pump unit, the existing electrical feeders & circuit breakers will need to be upsized to support the additional electrical load.
    - Costs for this upgrade is included.
- **Structural Implications:**
    - Rooftop equipment: The existing bar joist, K truss support framing will likely trigger reinforcing.
        - Truss reinforcing to consist of welded compression strut angle members coordinated with mech unit curb location and truss panel points. Truss chord and web reinforcing will also be required.
        - Deck reinforcing will be required if new openings are larger than 16” x 16” square.
    - Air-Source Heat Pump
        - The new ground mounted equipment will be supported by a down-turned thickened lip concrete footing.

        - Thickened lip = 12"tall x 10" deep perimeter footing with minimum size equal to the footprint of the equipment + 6" all-around.
        - Reinforcing = (2) #4's top and bottom.
        - 6" slab-on-grade to span between thickened lip and configured with #4 at 16" OC each way centered.
    - Costs for these upgrades are included in the pricing above.
- **Architectural Implications:**
    - For installation of new mechanical equipment provide a new rooftop curb (w/appropriate structural reinforcement). Existing Roofing at new curb location to be removed. Then repair, replace, and patch roofing as required around new curb (min. 4'-0") with like material and installation techniques.
    - Where installation of new mechanical equipment is within 10' of parapet wall or edge of roof provide permanent fall protection and associated structural reinforcement railing per OSHA requirements.
    - Where existing structural members are protected with Fire-Resistive-Rated (FRR) assemblies, all new structural members must be protected with a FRR assembly of equal or greater protection.
    - All new pipe penetrations and roof mounted pipe equipment shall be flashed in a manner appropriate to the existing roofing.
    - Where new penetrations are designed through Fire-Resistive-Rated Assemblies (Roof, Wall, and Floor) appropriate Fire/Smoke Dampers, FRR sleeves, and/or Fire Caulking shall be provided.
    - All new wall penetrations for pipe, louvers, or equipment installation shall be flashed and caulked in a manner appropriate for the exterior material.
    - All new wall penetrations for louvers or equipment shall be braced with new structural headers appropriate for the existing structural system. Header sizing by a Licensed Structural Engineer.

Recommendations from 2015 Study

Below are excerpts of recommendations from the 2015 study. Recommendations that are no longer applicable, or that have already been implemented, have been removed. Recommendations related to the condition of existing equipment and systems are covered in the FCA report and have been removed.

- *Remove RTUs installed in 2012.*
    - McKinstry Comment: We have recommended a solution to replace the existing DOAS units in order to minimize changes to the existing system where possible. Our solution utilizes the existing ductwork to provide outside air to the classrooms, but relies on a different system for space conditioning.
- *Install new RTUs capable of delivering 1,000 to 1,500 cfm per classroom.*
    - McKinstry Comment: Refer to previous comment.
- *Reuse supply duct installed in 2012 to the greatest extent possible and install VAV boxes to provide airflow zone control at each classroom, corridor and work areas.*
    - McKinstry Comment: Refer to previous comment.
- *Install new return air duct main to new RTUs. Utilize plenum return from each classroom*
    - McKinstry Comment: Refer to previous comment.
- *Install chiller and route chilled water piping to new RTUs.*
    - McKinstry Comment: We have proposed a heat pump solution in lieu of CHW.
- *Install chilled water coil in existing duct main serving the media center.*

    - McKinstry Comment: We suggest replacing the main system rather than installing a cooling coil in the existing ductwork, as there are other spaces attached to the main system that would benefit from cooling.
- *Install new RTUs for the cafeteria and route chilled water to the new RTU.*
    - McKinstry Comment: We have proposed a heat pump solution in lieu of CHW
- *Install new packaged DX RTUs for the administration areas.*
    - McKinstry Comment: Included, with ASHP RTUs in lieu of DX.