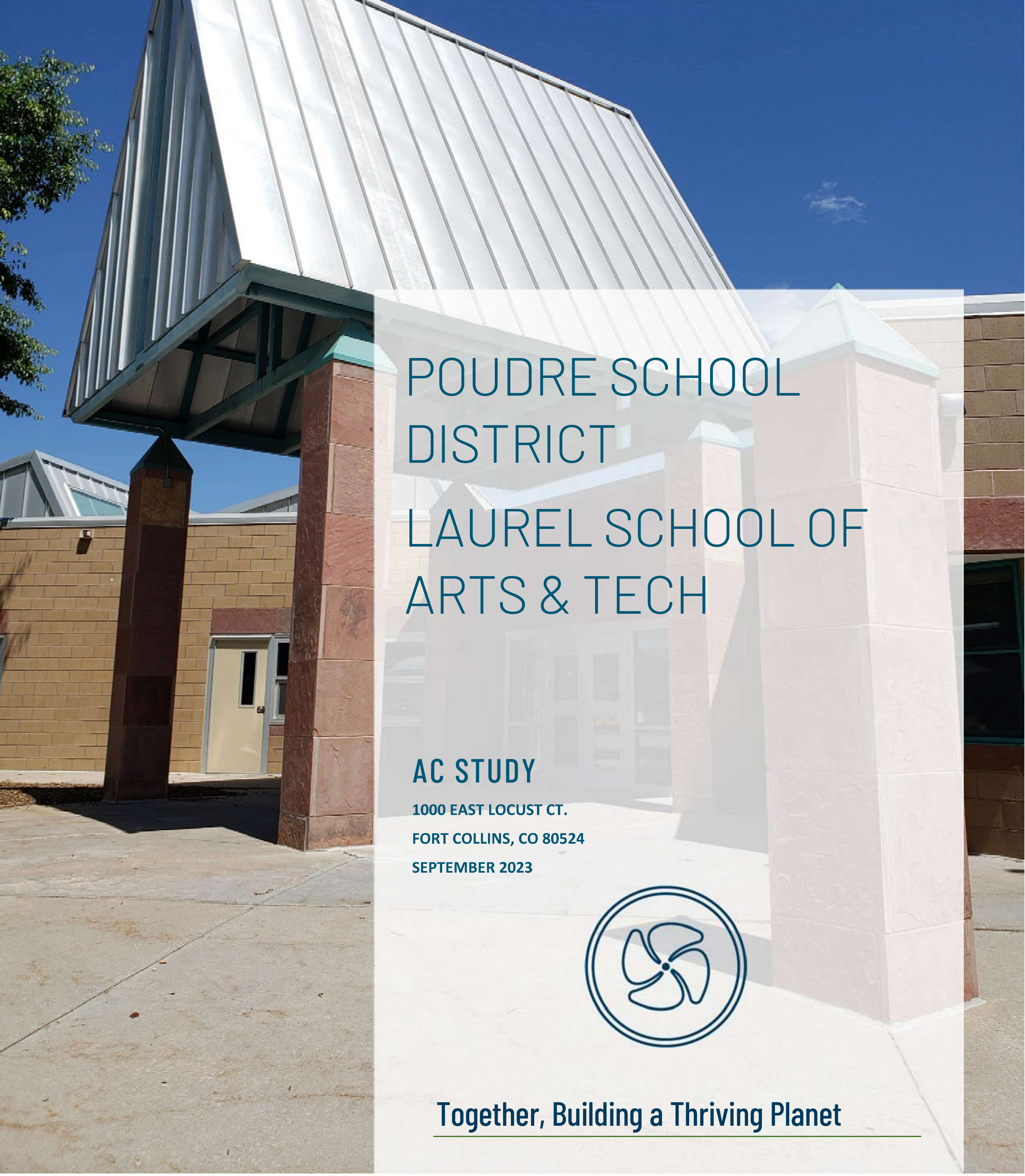

POUDRE SCHOOL DISTRICT

LAUREL SCHOOL OF ARTS & TECH

AC STUDY

1000 EAST LOCUST CT.

FORT COLLINS, CO 80524

SEPTEMBER 2023

Together, Building a Thriving Planet

McKinstry

For The Life Of Your Building

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AC Study: Laurel School of Arts & Tech

Laurel School of Arts & Tech AC Study

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AC Study: Laurel School of Arts & Tech

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: Laurel School of Arts & Tech

BUILDING SUMMARY

General:

Laurel School of Arts & Tech is a single-story 51,384 square foot school located at 1000 East Locust Court, in Fort Collins, Colorado. Originally built in 1993, it has had a major renovation in 2015 to implement a 'tempered air' system. Building history 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 IT Room and RTU-2 serving the computer lab.

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 600 amp, 208Y/120V 3-phase, 4-wire electrical service.

Existing Structural Systems:

The initial building was constructed in 1974 and 1994 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.

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:

- *In 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, cafeteria 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 new packaged DX RTUs for the computer lab and Comm Data rooms.*
- *1993 was the original construction of the building.*
   - *Media Center is provided with heating and ventilation by an indoor AHU installed in 1993. This unit should be replaced in the next 10-15 years.*
   - *The AHU serving the gym is original from 1993. This unit should be replaced in the next 10-15 years.*
   - *A residential style evaporative cooler serves the kitchen and should be replaced with a make-up air unit providing evaporative cooling in the next 0-3 years.*
   - *Boilers should be anticipated to be replaced in 15-20 years*

AC Study: Laurel School of Arts & Tech

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
Laurel School of Arts & Tech ES	51,384	Yes	$ 5,110,800	$ 6,899,580	$ 99.46	$ 134.27

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 upgrading the heating plant is the highest priority. With the heat pump system, the heating plant 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.
        - 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.
        - 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).
        - Install a new kitchen MAU with evaporative cooling.
- **Electrical Implications for AC Addition:**
    - Based on utility Peak Demand data and NEC required safety factors, the existing peak demand on the 600A service is 394 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 DX unit, the existing electrical feeders & circuit breakers will need to be upsized to support the additional electrical load.
    - Costs for this upgrade is 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: Heat Pump option proposed in lieu of chilled water
- *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.
- *Install a new make-up air unit for kitchen with evaporative cooling.*
  - McKinstry Comment: Included
- *Packaged DX RTU for admin.*
  - McKinstry Comment: Included, but with an ASHP RTU in lieu of DX.

POUDRE SCHOOL DISTRICT LESHER IB WORLD MIDDLE SCHOOL

AC STUDY

1400 STOVER ST.

FORT COLLINS, CO 80521

SEPTEMBER 2023

Together, Building a Thriving Planet

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AC Study: Lesher IB World Middle School

Lesher IB World Middle School AC Study

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AC Study: Lesher IB World 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: Lesher IB World Middle School

BUILDING SUMMARY

General:

Lesher IB World Middle School is a single-story, 93,636 square foot school located at 1400 Stover Street, in Fort Collins, Colorado. Originally built in 1959, the building has seen 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 has no central cooling system. There are 5 Rooftop Units (RTUs) which have packaged DX cooling; AC-1, RTU-4, RTU-8, RTU-9, and RTU-10.

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 at Lesher consists primarily of Unit Ventilators (UVs) serving the classrooms, with Air Handling Units (AHUs) and Rooftop Units (RTUs) serving some classrooms, as well as the assembly halls, gymnasiums, and other spaces.

Existing Electrical Systems:

The building has an existing 2000 amp, 208Y/120V, 3-phase, 4-wire electrical service.

Existing Structural Systems:

The existing building is one to two story structure with a roof primarily of fabricated deep trusses and long span steel decking, tube steel joist/beams and steel decking, or open web steel joists.

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. McKinstry believes this summary to be accurate.

- *In 2007 an addition and significant HVAC updates to the existing construction were completed.*
  - *Most of the classrooms received new, under window UVs. A few rooms received new ceiling hung UVs.*
  - *Interior classrooms with ceiling mounted UVs were refurbished*
  - *Heating and ventilating RTUs were installed for Tech Ed, Cafeteria, Media Center, Administration, Foyer, and Orchestra.*
  - *Packaged DX RTUs were installed for Vocal Music and the 2 computer labs.*
  - *Interior AHUs from 1959 serving the gym, and auditorium were refurbished and left in place. In addition, interior AHUs from 1976 serving the auxiliary gym and weight room were refurbished and left in place. Refurbishment consisted of new heating coils, cleaning of fans, replacement of motors, belts and sheaves.*
  - *The kitchen received a new make-up air unit.*

- *The majority of the heating water piping from 1959 was reused in areas where new UVs were installed. Only mains in corridor were replaced.*
- *Piping in tunnels serving UVs and the piping serving the gym/auditorium/music area where reused. the computer lab on the west end of the building does not currently have air conditioning.*
- *1993 the boilers were replaced and two science rooms were added to the south end, each received a ceiling hung UV that remains today.*
- *1980 the cafeteria was expanded further to the south and four classrooms were added to the south of the 1959 construction. These areas received HVAC updates in 2007.*
- *1976, the auxiliary gym and weight room were added, along with a few classrooms and remodel of 3 adjacent rooms. These are all served by 2 AHUs in the mezzanine mechanical room off the auxiliary gym.*
- *1972 classrooms were added to the east end of the building. These have UVs that were replaced in 2007.*
- *1959 was the original construction. Primarily consisted of under window UVs for the classrooms and mezzanine mounted air handlers serving the gym and auditorium. The air handlers were refurbished in 2007 and unit ventilators replaced as discussed above.*

AC Study: Lesher IB World Middle School

AIR CONDITIONING STRATEGIES

Contextual Narrative

During the site visit, it was noted by the PSD staff that the HVAC system at Lesher is in very poor condition. McKinstry agrees with this assessment. Because the existing system is almost entirely tied to the heating water system, McKinstry is recommending a central cooling strategy. Lesher has a unique piping configuration in that the heating water piping along the building perimeter which serves the Unit Ventilators is not insulated, functioning similarly to a baseboard radiator. This presents a challenge to retrofitting to a 2-pipe changeover system, as all this piping will need to be insulated to prevent condensation. In addition, it was mentioned that the existing UVs are not functioning well, requiring many motor replacements. As such, it is likely that a full mechanical system replacement would be a better option for this building.

During the site visit, it did not appear that routing new ductwork above the existing ceilings in the classrooms would be a viable option. As such, individual packaged RTUs as a solution have not been proposed.

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
Lesher, IB World School	93,686	Yes	$ 8,213,700	$ 11,088,495	$ 87.67	$ 118.36

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 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
- Implementation:
    - Install a new 200-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 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 UVs with new heat pump VUVs
        - Replace existing RTUs with new heat pump RTUs
        - 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).
    - Add evaporative cooling to the kitchen MAU

- **Electrical Implications of AC Addition**

- Based on utility Peak Demand data and NEC required safety factors, the existing peak demand on the 2000A service is 655 Amps. There is capacity to add cooling loads to the existing service but adding 200 tons of cooling would require a service upgrade to 3000 Amps.
- When a heating only RTU is replaced with a DX unit, the existing electrical feeders & circuit breakers will need to be upsized to support the additional electrical load. There is also potential that Panelboards P1 and P2 serving the existing RTUs would have to be upgraded as well, or additional panels served by the existing service switchboard.
- Costs for this upgrade is included.

- **Structural Implications of AC Addition**
  - Replacement of RTU's with new HW/CW, HW/DX, or Heat Pump units
    - It is likely that the existing roof system will require reinforcement to support the additional weight of a cooling section on the RTUs. Different sections of the building have different structural systems, but because of the anticipated increased weight and size of the new units, structural reinforcing should be expected.
    - If the openings need to be reconfigured, additional steel will be required to trim out the new openings
  - Air-to-water heat pump pad
    - Provide reinforced concrete pad foundation on grade
  - Costs for these upgrades are included in the pricing above.
- **Architectural Implications of AC Addition**
  - 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

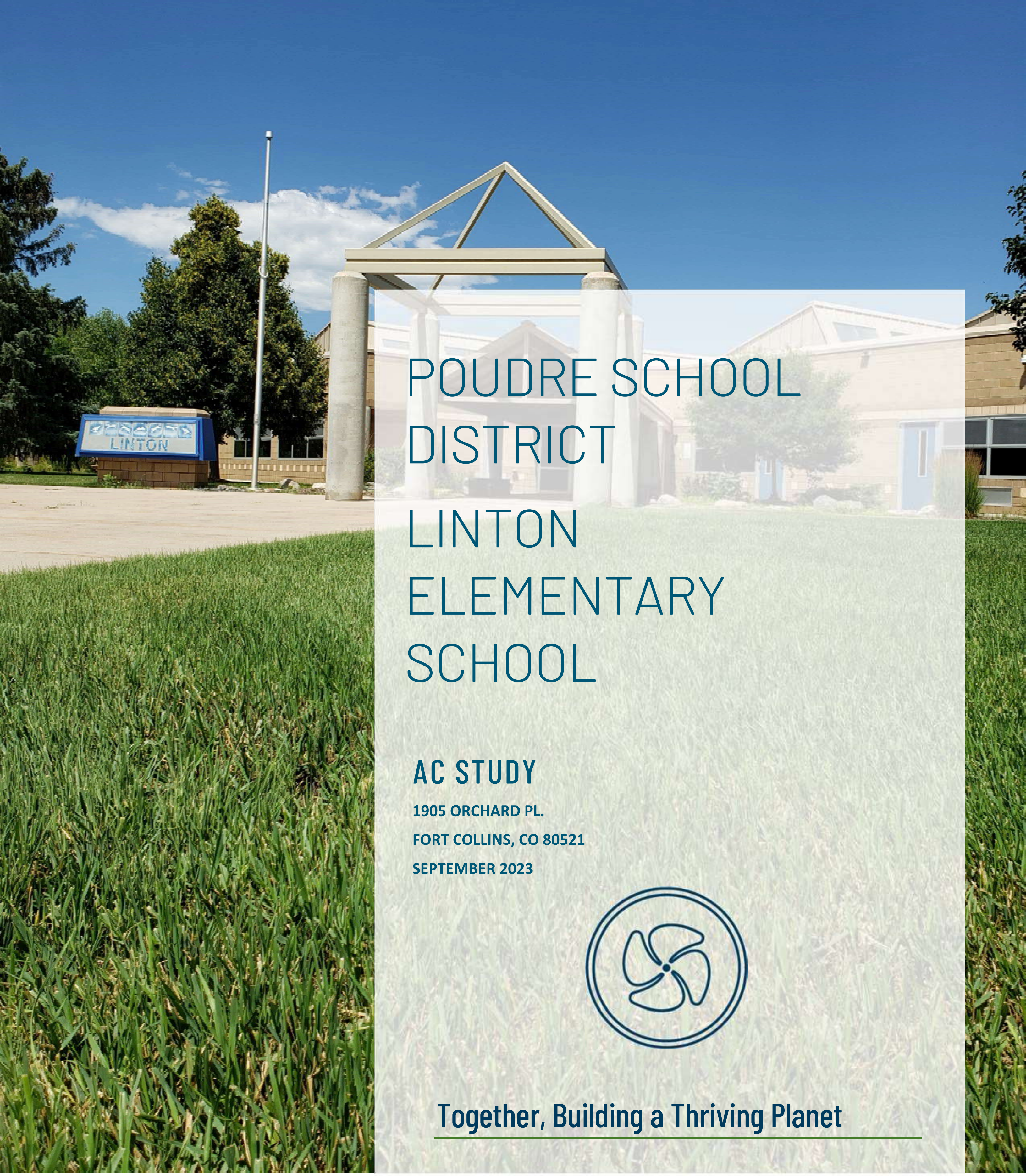
Recommendations from 2015 Study

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 VUVs for the 1959, 1972, and 1980 classrooms, replacing the under-window UVs or ceiling hung UVs that are currently installed.*
  - McKinstry Comment: Included

AC Study: Lesher IB World Middle School

- *Install RTUs and AHUs for the areas currently served by RTUs and AHUs such as the media center, auditorium, administration, weight room, cafeteria, and gyms.*
    - McKinstry Comment: Included
- *Route chilled water on roof and drop into space when required.*
    - McKinstry Comment: Existing HW lines to be reused as possible for new CDW/heat pump system.
- *Install a chiller and route chilled water to new RTUs, AHUs and VUVs.*
    - McKinstry Comment: Existing HW lines to be reused as possible for new CDW/heat pump system.
- *Packaged DX RTU for administration.*
    - McKinstry Comment: Replacement of this RTU included.
- *Add evaporative cooler section to 2007 makeup air unit.*
    - McKinstry Comment: Replacement of this unit is included
- *New Controls entire school.*
    - McKinstry Comment: Included
- *Due to the type of equipment installed in 2007 that does not have room for cooling coils, and the age of the older equipment that was not replaced in 2007, this building warrants a complete HVAC replacement if air conditioning was to be considered.*
    - McKinstry Comment: Agreed. Refer to FCA study for existing equipment condition report



POUDRE SCHOOL DISTRICT

LINTON ELEMENTARY SCHOOL

AC STUDY

1905 ORCHARD PL.

FORT COLLINS, CO 80521

SEPTEMBER 2023

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AC Study: Linton Elementary School

Linton Elementary School AC Study

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AC Study: Linton 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: Linton Elementary School

BUILDING SUMMARY

General:

Linton Elementary School is a single-story 51,384 square foot school located at 4100 Caribou Drive, in Fort Collins, Colorado. Originally constructed in 1989, there have been no major additions since the original construction. Renovations are summarized in more detail in the history section below. In 2013, 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. Two Rooftop Units (RTUs) have DX cooling, including the unit 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.

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 1989 with a renovation completed in 2013. 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:

- *In 2013 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 20 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 66 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.*
  - *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.*
  - *A packaged DX RTU was installed to cool the Comm Data rooms.*
- *Heating water piping and boilers were installed in 1989 and were all reused in the 2013 HVAC updates. Heat is provided by baseboard radiation at the exterior walls, which was installed in 2013.*
- *A packaged DX RTU serves the computer lab. The system is from 1989, replacement should be anticipated in the next 0-3 years.*
- *The cafeteria is heated and ventilated via 4 ceiling mounted unit ventilators installed in 1989.*
- *Media Center is provided with heating and ventilation by an indoor AHU installed in 1989. This unit should be replaced in the next 10-15 years.*
- *The AHU serving the gym is original from 1989. This unit should be replaced in the next 10-15 years.*

AC Study: Linton 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: Linton 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
Linton ES	51,384	Yes	$ 4,646,500	$ 6,272,775	$ 90.43	$ 122.08

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
        - 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).
- **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 347 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 DX unit, the existing electrical feeders & circuit breakers will need to be upsized to support the additional electrical load.
    - Costs for this upgrade is 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.

- *Remove RTUs installed in 2013.*
    - 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 2013 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 have proposed replacing the main unit rather than add a cooling coil in the distribution ductwork
- *Install new RTUs for the cafeteria and route chilled water to the new RTU.*
    - McKinstry Comment: All RTUs to be replaced in our solution with heat pump RTUs
- *Install new packaged DX RTUs for the administration areas.*
    - McKinstry Comment: Included, with ASHP RTUs in lieu of DX.

POUDRE SCHOOL DISTRICT

LIVERMORE ELEMENTARY SCHOOL

AC STUDY

360 RED FEATHER LAKES RD.

LIVERMORE, CO 80545

SEPTEMBER 2023

Together, Building a Thriving Planet

McKinstry
For The Life Of Your Building

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AC Study: Livermore Elementary School

Livermore Elementary School AC Study

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AC Study: Livermore 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: Livermore Elementary School

BUILDING SUMMARY

General:

Livermore Elementary School is a two-story 11,441 square foot school located at 360 Red Feather Lakes Road, in Livermore, Colorado. Originally built in 1952, the building has seen with two 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 has no central cooling system. One of the residential-style furnaces serving the media center has a DX coil.

Heating: Heating is served by a central hot water plant with propane gas-fired boilers, piped throughout the building to most heating equipment (AHUs and baseboards). There are two residential-style furnaces which have gas-fired heat.

Ventilation: The ventilation system consists of AHUs and Furnaces serving the classrooms, assembly halls, gymnasiums, and other spaces.

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 1952 with an addition and renovation in 1999. The original roof consists of open web steel trusses supporting corrugated metal deck. The added roof consists of light gage Z purlins supporting metal deck and spanning to steel wide flange girders. Both systems are supported by concrete-masonry unit bearing and shear walls with strip footings and typical slab on grade.

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:

- *2000 Addition is served by 2 residential style furnaces. The computer lab and the room adjacent to it are air conditioned. The classroom on the northwest is not air conditioned. These furnaces are fixed outside air only and do not have economizers.*
- *1993 a boiler was added to heat the original 1952 construction area on the south via baseboard radiation. At this time, an air handler was installed to provide ventilation air to the original 1952 area. Also, an air handler was installed to serve the classroom and library on the east side that were an addition in 1980.*
- *1980 a major addition to the north of the original 1952 construction was constructed. A gym/cafeteria, media center, classroom and restrooms were created. The gym is served by an air handler in the boiler room that was installed in 1980. Supply and return are provided via sidewall grilles, from the same wall in the gym. As mentioned above, the media center and classroom, received an updated AHU in 1993.*

AC Study: Livermore Elementary School

- *1952 original construction received an HVAC upgrade in 1993. Ventilation air is provided overhead, return air is underground and new baseboard was installed at the exterior walls.*

AC Study: Livermore 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 ($) Low	Estimated Cost Range ($) High	Estimated Cost Range ($/SF) Low	Estimated Cost Range ($/SF) High
Livermore ES	11,441	Yes	$ 720,700	$ 972,945	$ 62.99	$ 85.04

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

- **Air-Sourced Heat Pump Cooling**
  Due to the small size of the building, it is unlikely to be cost effective to demolish the existing system entirely and replace it with a new central system. Central systems require additional mechanical room space. On a floorplan of this size, it is difficult to reallocate enough square footage without significant alternations. For this reason, a full system replacement to a heat pump system has not been suggested.
    - Pros:
        - Low first cost
        - Does not require replacing most equipment in the school; utilizes existing infrastructure.
        - Utilizes the existing hot water and hot water piping.
        - Cooling will be provided.
    - Cons:
        - Not as energy efficient has switching to a central plant or heat pump system.
        - The existing service is small and any additional load will likely trigger an electrical service upgrade
    - Implementation:
        - Provide new heat pump coils with remote condensing units for the 2 existing AHUs and 1 existing furnace without cooling. Route condensate lines to the nearest floor drain or branch tailpiece. Provide condensate drain pumps if required.

        - Existing ductwork will require modification to accommodate new coils.
      - Install condensing units on ground outdoors
- **Electrical Implications of AC Addition:**
  - In lieu of obtaining peak utility demand data for determining service upgrades, the Main Switchboard size of 600 Amps will be used. There is capacity to add cooling loads to the existing service but adding 40 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 this upgrade is included in the pricing above.
- **Structural Implications:**
  - The addition of condensing units on grade will not require structural modifications.
- **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.
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  - 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

- *Add a DX cooling coil for the furnace installed in 2000 that does not have AC now.*
  - McKinstry Comment: Included in Option 1 (with an ASHP instead of DX)
- *Replace the air handler installed for the Media Center and classroom with a new VUV with DX cooling coil.*
  - McKinstry Comment: Included in Option 1 (with an ASHP instead of DX)
- *Replace the air handler serving the original 1952 area with a new VUV with DX cooling coil.*
  - McKinstry Comment: Included in Option 1 (with an ASHP instead of DX)
- *Replace the air handler installed for the gym/cafeteria with a new indoor air handler that has a DX cooling coil.*
  - McKinstry Comment: Included in Option 1 (with an ASHP instead of DX)
- *New control system for the whole school.*
  - McKinstry Comment: Included.

POUDRE SCHOOL DISTRICT

LOPEZ ELEMENTARY SCHOOL

AC STUDY

637 WABASH ST.

FORT COLLINS, CO 80526

SEPTEMBER 2023

Together, Building a Thriving Planet

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Lopez Elementary School AC Study

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AC Study: Lopez Elementary School

PURPOSE SUMMARY

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AC Study: Lopez Elementary School

BUILDING SUMMARY

General:

Lopez Elementary School is a single-story 57,639 square foot school located at 637 Wabash, in Fort Collins, Colorado. Originally built in 1986, the building has had 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. Two 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.

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 1200 amp, 208Y/120V 3-phase, 4-wire electrical service.

Existing Structural Systems:

The initial building was constructed in 1986 with additions completed in 1994 and 2001 and renovations completed in 1994 and 2013. 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:

- *2013 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 21 degrees cooler than the outside air temperature during the warmer parts of the year. For instance – at 90 degrees outside, the air delivered to the classroom is 69 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 400 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 1986 and were all reused in the 2013 HVAC updates.*
  - *Baseboard radiation installed during 2013 project provides heat for the classrooms.*
  - *Ductwork installed in 2013 was incorrectly installed by the contractor and is smaller than specified by the engineer due to not accounting for duct liner thickness. Due to time constraints with school opening, PSD was unable to have the contractor correct the installation.*
- *The 2001 gym addition is served by a heating and ventilation only RTU.*
- *Unit ventilators serve the Music and Art classrooms that were added in 1994.*
- *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 cafeteria and media indoor AHUs provide heating and ventilation only. They are original to the 1986 building construction.*
- *Kitchen make-up air unit is also original to the building.*

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: Lopez 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
Lopez ES	57,639	Yes	$ 4,332,000	$ 5,848,200	$ 75.16	$ 101.46

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. It was noted during interviews with District facilities staff that the baseboard heaters have had a lot of issues after the remodel. With the heat pump system, the baseboard heaters 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 135-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.
                - PSD facilities staff mentioned that the computer lab unit is at the end of its life, this option will replace the aging unit.
            - 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 kitchen MAU with evaporative cooling coil
- **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 422 Amps. There is capacity to add cooling loads to the existing service but adding 135 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 this upgrade is included
- **Structural Implications:**
    - Rooftop equipment: The existing bar joist, LH, K and H truss support framing will likely trigger reinforcing.

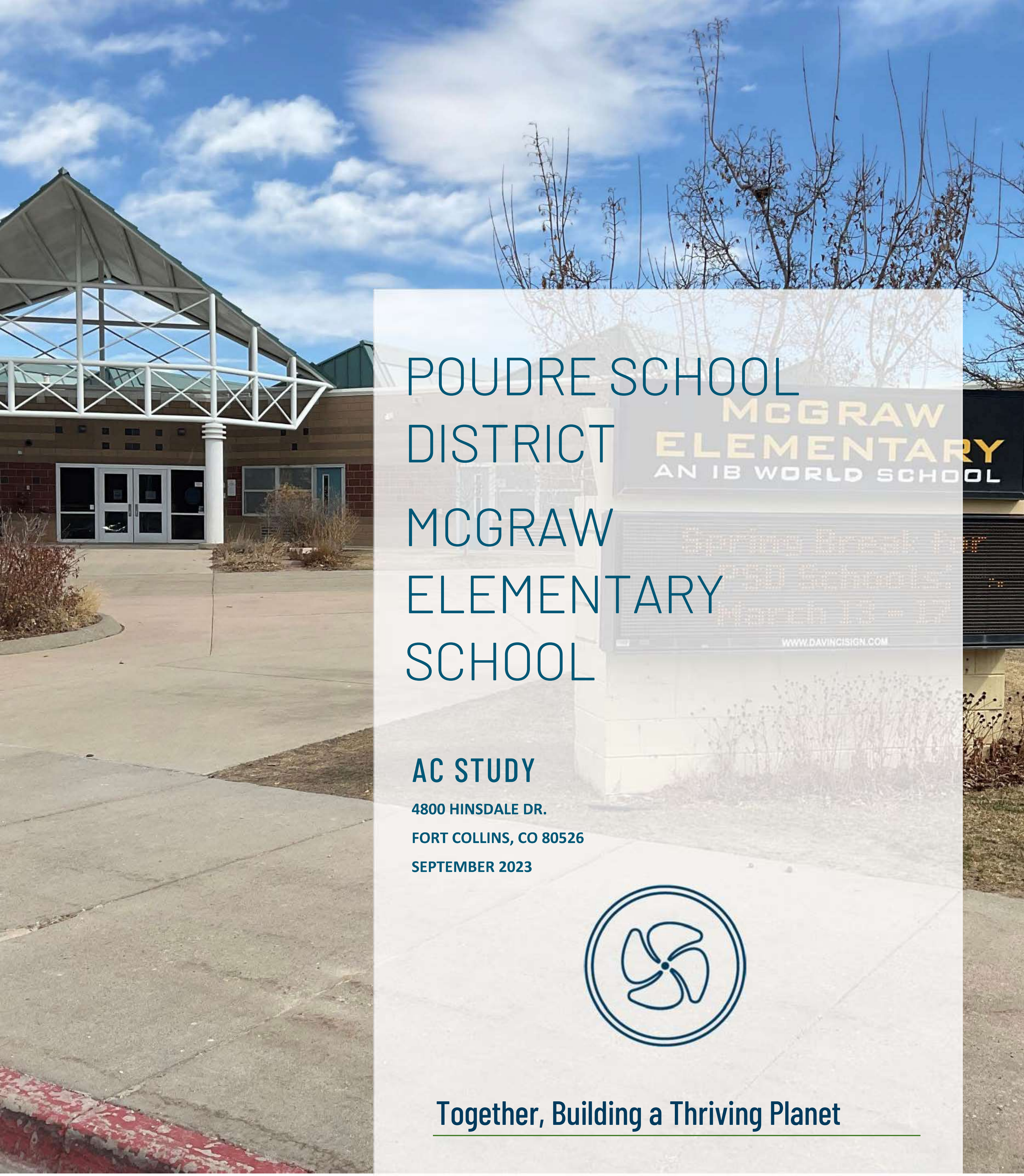
        - Truss reinforcing to consist of welded compression strut angle members coordinated with mech unit curb location and truss panel points. Truss chord and web reinforcing will also be required.
        - Deck reinforcing will be required if new openings are larger than 16” x 16” square.
    - Air-Source 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 this upgrade is 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 2013.*
    - 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 *Replace supply duct installed in 2013 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 at new RTUs*
    - McKinstry Comment: Refer to previous comment
- *Install chiller and route chilled water piping to new RTUs and AHUs. Install new AHUs for the cafeteria and media center. Route chilled water to the new AHUs.*

AC Study: Lopez Elementary School

- McKinstry Comment: 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: Our solutions suggest installing new Heat Pump systems rather than DX
- *Install new make-up air unit with evaporative cooling for the kitchen.*
    - McKinstry Comment: Included



POUDRE SCHOOL DISTRICT

MCGRAW ELEMENTARY SCHOOL

AC STUDY

4800 HINSDALE DR.

FORT COLLINS, CO 80526

SEPTEMBER 2023

Together, Building a Thriving Planet

McKinstry
For The Life Of Your Building

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McGraw Elementary School AC Study

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AC Study: McGraw 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: McGraw Elementary School

BUILDING SUMMARY

General:

McGraw Elementary School is a single-story 51,384 square foot school located at 4800 Hinsdale Drive, in Fort Collins, Colorado. Originally built in 1992, it has had a major renovation in 2014 to implement a ‘tempered air’ system. Building history 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 IT Room and RTU-2 serving the computer lab.

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.

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 1991 with a renovation completed in 2014. 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:

- *In 2014 HVAC updates installed 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 were installed in corridor, work areas, cafeteria and office areas.*
    - *New pumps and piping to work with the 2-pipe system for heating and cooling were installed.*
- *2014 HVAC updates also included new packaged DX RTUs for the computer lab and Comm Data rooms.*
- *A new kitchen make-up air unit with evaporative cooling was also installed in 2014.*
- *1992 was the original construction of the building.*
    - *Media Center is provided with heating and ventilation by an indoor AHU installed in 1992. This unit should be replaced in the next 10-15 years.*
    - *The AHU serving the gym is original from 1992. This unit should be replaced in the next 10-15 years.*
    - *Boilers should be anticipated to be replaced in 15-20 years.*

AC Study: McGraw 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 ($) Low	Estimated Cost Range ($) High	Estimated Cost Range ($/SF) Low	Estimated Cost Range ($/SF) High
McGraw, IB World School ES	51,384	Yes	$ 5,118,200	$ 6,909,570	$ 99.61	$ 134.47

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

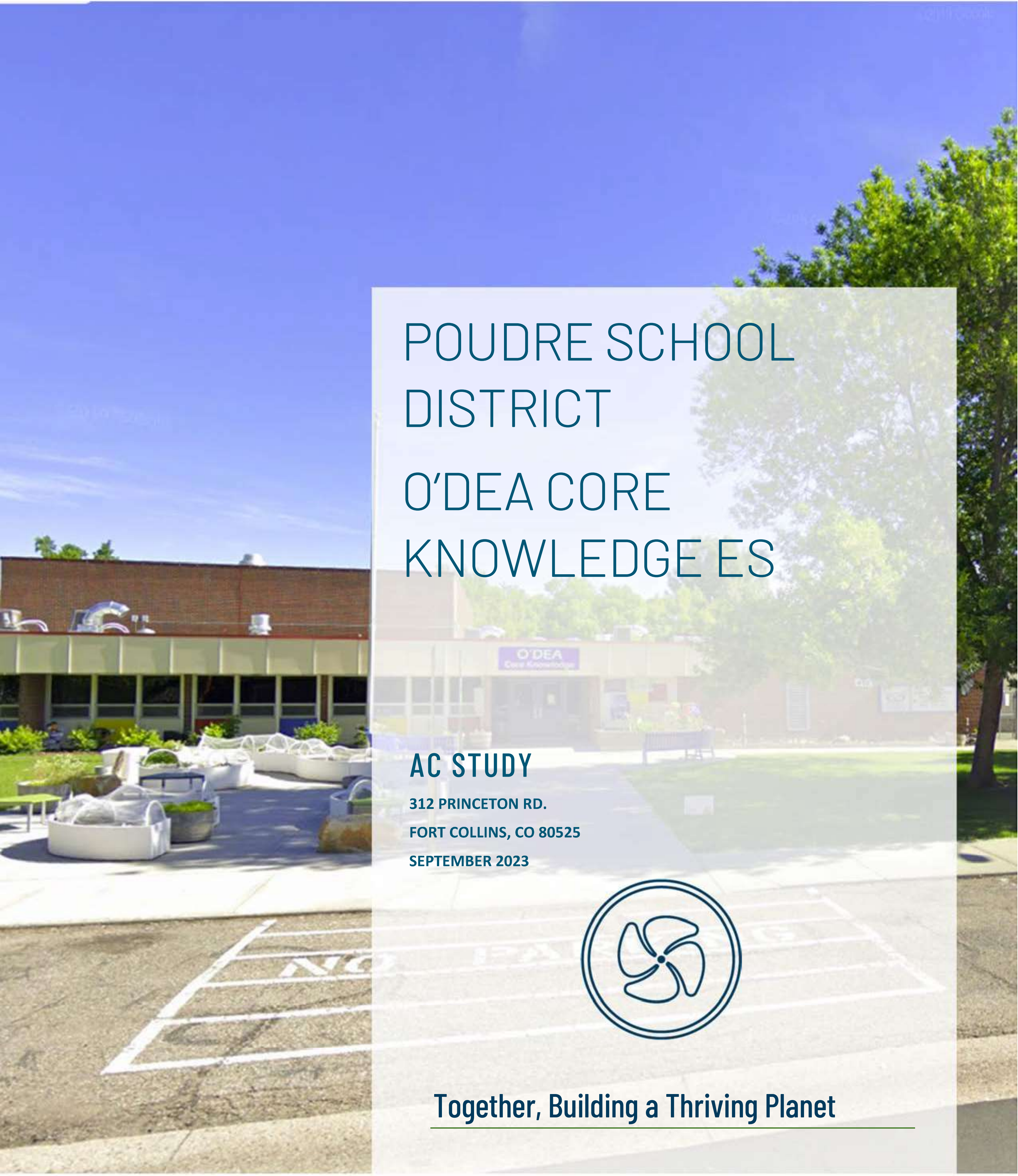
- **Heat Pump system**
  Heat pump systems are one of the most efficient systems available. These systems operate on a single condenser water loop, with each individual heat pump either rejecting or absorbing heat from the condenser water. These systems are particularly efficient during the shoulder 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 100-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 plant with new high-efficiency boilers. Reconfigure piping as necessary for new CDW loop.
    - 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 600A service is 347 Amps. There is capacity to add cooling loads to the existing service but adding 100 tons of cooling would require a service upgrade to 1600 or 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 this upgrade is 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 this upgrade is 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 connect to existing piping.*
    - McKinstry Comment: We have suggested a heat pump system in lieu of a CHW system.
- *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 RTUs in lieu of DX.



POUDRE SCHOOL DISTRICT

O'DEA CORE KNOWLEDGE ES

AC STUDY

312 PRINCETON RD.

FORT COLLINS, CO 80525

SEPTEMBER 2023

Together, Building a Thriving Planet

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O'Dea Core Knowledge ES AC Study

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AC Study: O’Dea Core Knowledge ES

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: O'Dea Core Knowledge ES

BUILDING SUMMARY

General:

O'Dea Core Knowledge ES is a single-story 45,931 square foot school located at 312 Princeton Road, in Fort Collins, Colorado. Originally built in 1962, 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 has partial air conditioning, with 1 RTU and 15 VUVs with DX cooling. The remaining RTUs, AHU, and Fan Coil Units (FCUs) do not have cooling.

Heating: Heating is served by a two hot water plants with gas-fired boilers (one for the annex and one for the rest of the building), piped throughout the building to all heating equipment, including unit ventilators, Fan Coil Units (FCUs), RTUs and an AHU.

Ventilation: Ventilation for the building is provided by the unit ventilators serving the south classrooms, RTUs serving the north classrooms and other interior spaces by CUHs, and AHUs.

Existing Electrical Systems:

The building has an existing 1200 amp, 208Y/120V 3-phase, 4-wire electrical service.

Existing Structural Systems:

The initial building was constructed in 1962 with additions in 1976, 1967, 1986, 1994 and 2004 and a renovation completed in 2004. The building consists of concrete-masonry unit bearing and shear walls that are supported by mild reinforced concrete strip footings. The main floor is supported by a nominal concrete slab-on-grade. The roof framing consists of mostly open web steel trusses supporting plywood roof.

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:

- *2004 corridors were constructed on the north and south sides of the 1966 annex so access to each room did not require walking through other classrooms. These areas are heated via cabinet unit heaters.*
- *1994 consisted of an infill.*
  - *A media center, music classroom and some offices were added.*
  - *A portion of building was constructed to connect the original 1962 construction to the 1966 building. This infill area is served by a CV RTU with heating and ventilating only. The RTU does have space for a future cooling coil.*
  - *This RTU also picks up the special needs room to the west of the media center.*
- *In 1986 a media center addition was constructed on the north side, adjacent to the kitchen. This area is served by the 1994 RTU and is now a special needs room.*

AC Study: O'Dea Core Knowledge ES

- *In 1966 an annex was built to the northeast of the building. It is served by two MZ RTUs. The drawings indicate that the eastern most 2 classrooms have underground as well as overhead supply duct.*
- *1962 was the original construction of the building.*
  - *All classrooms are served by UVs.*
  - *Some interior rooms have ceiling hung UVs.*
  - *The gym/cafeteria is served by an indoor AHU in the boiler room. It provides supply air via underground duct.*
- *A packaged DX RTU serves the computer lab in the 1962 area.*
- *Kitchen has no make-up air unit. It relies only on transfer air from the gym.*

AC Study: O'Dea Core Knowledge ES

AIR CONDITIONING STRATEGIES

Contextual Narrative

During interviews with the facility management team, it was noted the gym AHU has existing underground duct work. As district standards do not allow underground ductwork, we suggest replacing the AHU and rerouting ductwork for both of our options below.

In addition, it was noted that the district would like to combine the two heating plants into a single central plant. This will require significant re-piping, which has been included in the pricing for this 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
O'Dea Core Knowledge ES	48,018	Yes	$ 4,722,100	$ 6,374,835	$ 98.34	$ 132.76

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

- **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 at least one boiler is due for an upgrade. We have included a heating system replacement, combining the two plants

into one in this report. With the heat pump system, the boiler would only need to run as emergency backup, most likely less than 1% of the year. 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.

- 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 75-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 plants with a single new high-efficiency boiler plant. Reconfigure piping as necessary for a combined system with a new CDW loop.
  - Replace all existing equipment with water-sourced heat pump equipment
    - Replace existing unit ventilators with new heat pump VUVs and connect to the condenser water system.
    - Replace existing RTUs with new heat pump RTUs
    - All CUHs will require replacement with electrical unit heaters.
    - Replace existing heating-only AHUs with new heat pump AHUs
    - Replace existing gym AHU and abandon underground ductwork. Route new ductwork near gym ceiling.
  - Replace all ductwork in 1966 area.
  - Install kitchen MAU with evaporative cooling coil.
  - 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:**

AC Study: O'Dea Core Knowledge ES

    - Based on utility Peak Demand data and NEC required safety factors, the existing peak demand on the 1200A service is 439 Amps. There is capacity to add cooling loads to the existing service but adding 75 tons of cooling would require a service upgrade to 1600 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 in the pricing above.
- **Structural Implications:**
    - Rooftop equipment: The existing bar joist, 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 this upgrade is 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.

AC Study: O'Dea Core Knowledge ES

- *Install VUVs per classroom on the south half of the building (1962 area). Wood structure and little space to route duct does not allow for a central AHU or RTU solution.*
  - McKinstry Comment: Installing new VUVs for the classrooms is included
- *Install a cooling coil in the 1994 RTU.*
  - McKinstry Comment: Unit is planned for replacement with new heat pump rtu
- *Install VAVs in 1994 duct for zoning.*
  - McKinstry Comment: Included
- *Cap all underground ductwork for the gym/cafeteria. Install a new RTU with cooling coil. Route exposed spiral duct or Ductsox through the space.*
  - McKinstry Comment: Installing new heat pump RTU.
- *Install VUVs for all areas on the 1966 portion of the building.*
  - McKinstry Comment: Installing new VUVs for the classrooms is included.
- *Install chiller and route chilled water to new AHU, existing RTUs and new VUVs.*
  - McKinstry Comment: Included, but with CDW for the heat pump system
- *Replace all ductwork in the 1966 construction area.*
  - McKinstry Comment: Included
- *Install a make-up air unit with evaporative cooling for the kitchen.*
  - McKinstry Comment: Included.
- *Install a packaged DX RTU for the admin area*
  - McKinstry Comment: Installing heat pump RTU instead of DX
- *New control system for whole school.*
  - McKinstry Comment: Included.

POUDRE SCHOOL DISTRICT

OLANDER SCHOOL FOR PROJECT BASED LEARNING

AC STUDY

3401 AUNTIE STONE ST.

FORT COLLINS, CO 80526

SEPTEMBER 2023

Together, Building a Thriving Planet

McKinstry
For The Life Of Your Building

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AC Study: Olander School for Project Based Learning

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: Olander School for Project Based Learning

BUILDING SUMMARY

General:

Olander School for Project Based Learning is a single-story 51,384 square foot school located at 3401 Auntie Stone Street, in Fort Collins, Colorado. Originally constructed in 1989, there have been no major additions since the original construction. Renovations are summarized in more detail in the history section below. In 2013, 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. 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 600 amp, 208Y/120V 3-phase, 4-wire electrical service.

Existing Structural Systems:

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:

- *In 2013 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 20 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 66 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.*

- *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.*
- *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 1989 and were all reused in the 2013 HVAC updates. Heat is provided by baseboard radiation at the exterior walls, which was installed in 2013.*
- *A DX split system tied to a ceiling mounted unit ventilator serves the computer lab. This area is already air conditioned. The system is from 1989, replacement should be anticipated in the next 0-2 years.*
- *The cafeteria is heated and ventilated via 4 ceiling mounted unit ventilators installed in 1989.*
- *Media Center is provided with heating and ventilation by an indoor AHU installed in 1989.*
- *The AHU serving the gym is original from 1989. This unit should be replaced in the next 10-15 years.*
- *Kitchen make-up air unit and evaporative cooler was replaced in 2013.*

AC Study: Olander School for Project Based Learning

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: Olander School for Project Based Learning

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
Olander School for Project Based Learning ES	51,384	Yes	$ 4,857,300	$ 6,557,355	$ 94.53	$ 127.61

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

- **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. 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.
  - 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 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).
- **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 333 Amps. There is capacity to add cooling loads to the existing service but adding 100 tons of cooling would require a service upgrade to 1600 Amps or 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 this upgrade is 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 this upgrade is 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 2013.*
    - 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 2013 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.

AC Study: Olander School for Project Based Learning

- *Install chilled water coil in existing supply 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 RTU 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 computer lab and administration areas.*
    - McKinstry Comment: Included, with ASHP RTUs in lieu of DX.