PHASE I

APPENDIX 1

Building HVAC Summary

HORSETOOTH ENGINEERING, LLC

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NO TEMPERING OR AC

BARTON ELEMENTARY SCHOOL – PSD GLOBAL ACADEMY

Existing Infrastructure

- In 2014 the boiler installed in 1999 was replaced.
- In 2005, PSD installed a packaged DX RTU for the offices spaces on the southeast side. This also cools the kitchen.
- 1999 a boiler was installed and the original basement MZ was converted from gas-fired heat to hot water heat.
- 1975 a media center and offices were added to the northeast corner. These were served from underground supply stubouts from the basement MZ installed in 1956
- 1958 the eastern half of the building was constructed. All these spaces are served from the MZ installed in 1956.
- 1956 was the original construction of the building. A MZ unit was installed in the basement. Supply duct was all routed underground. Return air was transferred from the classrooms into the corridor. One large central return air opening in the corridor is connected to the MZ.
- Gym/cafeteria is also served by the basement MZ via underground supply duct.
- Kitchen has no make-up air unit. It relies only on transfer air from the gym/cafeteria.

Air Conditioning Strategies

- Cap all underground ductwork. Seal all transfer air into the corridor from the classrooms. Remove the basement MZ unit, this will require cutting up and disassembling the unit to get it out of the basement.
- Install VUVs per classroom and office areas. Wood structure and little space to route duct does not allow for a central AHU or RTU solution.
- Install an RTU for the gym/cafeteria. Route DuctSox or spiral duct through the space.
- Install chiller and route chilled water to new RTU and VUVs.
- Reuse 2014 boiler to route heating water to the new VUVs and RTU.
- Install a packaged DX RTU for the administration area.
- New controls system for the whole school

Life Cycle Needs Due to Aging Equipment

- Cap all underground ductwork. Seal all transfer air into the corridor from the classrooms. Remove the basement MZ unit, this will require cutting up and disassembling the unit to get it out of the basement.
- Install VUVs per classroom and office areas. Wood structure and little space to route duct does not allow for a central AHU or RTU solution.
- Install an RTU for the gym/cafeteria. Route DuctSox or spiral duct through the space.
- Install a packaged DX RTU for the administration area.
- New controls system for the whole school

Recommendations for 2010 Bond project

- The monies slated for the 2017 HVAC updates from the 2010 Bond will not be enough to upgrade the HVAC system appropriately. With the exception of the boiler, this building needs an entire HVAC system replacement that has significant architectural and structural impacts.
- The PSD administration has to determine how those monies will best be spent.
    - If doing something to improve comfort now is the number one priority, then Horsetooth Engineering recommends the following:
        - Install VUVs in as many of the classrooms as is possible within the budget. These should have a cooling coil installed.
        - Install a relief hood through the roof at each classroom that a VUV is installed.
        - Cap holes in floor, transfer openings to corridor and underground ductwork in all rooms that VUVs are installed.
        - Size piping to new VUVs for future 2-pipe changeover.
        - Rebalance the existing MZ unit to account for removed zones if the budget does not allow all underground duct zones to be replaced with new VUVs. Note: this is not recommended.
        - Upgrade the temperature controls system and components in the existing MZ unit, if it must remain – note that this is not recommended.
    - If the administration feels that an air conditioning Bond is to pass in the near term or that a total replacement of the HVAC at this school with or without air conditioning is imminent, then Horsetooth Engineering recommends the following:
        - Upgrade the controls on the existing MZ.

BENNETT ELEMENTARY SCHOOL

Existing Infrastructure

- In 2002 a classroom addition was constructed on the south side. This area is served by a CV RTU providing heating and ventilating only. An adjacent existing classroom is also served by this unit. The administration area was also remodeled, a packaged DX RTU now serves this space.
- 1994 consisted of a small addition and an infill.
    - 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 flex room, which was the library constructed in 1984, was expanded slightly to the south. It now serves as the cafeteria.
- In 1984 a media center addition was constructed on the south side, adjacent to the kitchen. This area is served by two unit ventilators that were relocated in the 1994 expansion of this space. UVs are from 1984.
- In 1966 an annex was built to the west of the building. It is served by two MZ RTUs.
- 1962 was the original construction of the building.
    - All classrooms are served by UVs.
    - Some interior rooms have ceiling hung UVs.
    - The gym is served by an indoor AHU in the boiler room. It provides supply air via underground duct.
- PSD has installed a split system DX fan coil for the computer lab in the 1962 area.
- Kitchen has no make-up air unit. It relies only on transfer air from the gym.

Air Conditioning Strategies

- Install VUVs per classroom on the east half of the building (1962 area). Wood structure and little space to route duct does not allow for a central AHU or RTU solution.
- Install new VUVs for the south classrooms installed in 2002.
- Install a new RTU to serve the cafeteria.
- Install VUVs for all areas on the western portion of the building (1994 and 1966 construction). Except the media center, install a new RTU for the media center.
- Install chiller and route chilled water to new RTU and VUVs.
- Replace all ductwork in the 1966 construction area. If possible reuse the 1994 duct.
- Replace boilers and heating water piping (installed in 1962 and 1966). Route heating water to the new VUVs and RTUs.

- Install a make-up air unit with evaporative cooling for the kitchen.
- New controls system for the whole school

Life Cycle Needs Due to Aging Equipment

- Install VUVs per classroom on the east half of the building (1962 area). Wood structure and little space to route duct does not allow for a central AHU or RTU solution.
- Install a new RTU to serve the cafeteria.
- Install VUVs for all areas on the western portion of the building (1994 and 1966 construction). Except the media center, install a new RTU for the media center.
- Replace all ductwork in the 1966 construction area. If possible reuse the 1994 duct.
- Replace boilers and heating water piping (installed in 1962 and 1966). Route heating water to the new VUVs and RTUs.
- Install a make-up air unit with evaporative cooling for the kitchen.
- New controls system for the whole school
- Cap all underground ductwork for the gym. Install a new AHU with exposed spiral duct or DuctSox.

This building is due for a complete HVAC replacement, regardless if air conditioning is desired to be installed. Duct and RTUs from 1994 and 2002 are the only items that should remain. However, if tempering is desired, these RTUs must be replaced also.

Recommendations for 2010 Bond project

- The monies slated for the 2016 HVAC updates from the 2010 Bond will not be able to replace all of the aging equipment that is on the Bond list.
- The PSD administration has to determine how those monies will best be spent.
    - If doing something to improve comfort now is the number one priority, then Horsetooth Engineering recommends the following:
        - Install VUVs for each classroom in 1962 and 1966 areas. A cooling coil should be installed in each VUV. Remove ductwork in 1962 and 1966 areas.
        - Install a cooling tower similar to what has been done at Irish, Riffenburgh and Beattie.
        - Route chilled water pipe from the tower across the roof to a few specific areas and then drop down into the ceiling and distribute to the VUVs. Install branch valves for future expansion of the pipe network.

        - Upgrade the temperature controls system and components in any remaining equipment.
        - Replace boilers if budget allows.
        - Replace heating water piping in 1962 and 1966 areas if budget allows.
        - Leave all other equipment as is. If budget allows for more work to be done, the following is recommended, in order of priority due to age of equipment.
            - Replace the gym AHU with a new RTU. Route Ductsox through the space for supply air.
            - Flex room UVs should be replaced with a RTU. Space for a future cooling coil should be provided for future.
            - Next would be replacement of the RTUs installed in 1994 and 2002 serving the classrooms and media center. Provide VUVs for the classrooms and a dedicated RTU for the media center, all with space for a future cooling coil.
    - If the administration feels that an air conditioning Bond is to pass in the near term and that a total replacement of the HVAC at this school, including air conditioning is imminent, then Horsetooth Engineering recommends the following:
        - Replace the gym AHU with a new RTU, since this space will not be receiving air conditioning in the future anyway (as long as PSD policy does not change from its current stance)
        - Install new RTU with space for future cooling coil for the flex space.
        - Replace the boilers with high efficiency boilers that can be optimized once the total HVAC replacement project is undertaken.
        - Upgrade controls for the heating plant, gym RTU and flex RTU.

CLP ELEMENTARY SCHOOL

Existing Infrastructure

- 2015 HVAC updates that were installed in the 1972 part of the building are air conditioning ready. Some of the original ductwork from 1972 was reused, if air

conditioning is to be installed, it would be prudent to replace the ductwork that is reaching the end of its service life at that time.

- In 2007 an expansion of the cafeteria to the west was constructed. New and relocated UVs were part of the project.
- Equipment installed in the 1992 addition and renovation to the north part of the building, with the exception of the office area, is not air conditioning ready. All equipment will need to be replaced if air conditioning is to be installed. With the exception of the Gym RTU, all other equipment will reach the end of its service life in the next 5-7 years.
    - Office area is served by a packaged DX RTU provided air conditioning. Zone control is via reheat coils. At an age of 22 years, and to reduce energy consumption, it would be prudent to replace this unit in the next 3-5 years, regardless if air conditioning is installed in the rest of the building. Packaged VAV DX RTU should be installed and VAV boxes installed for zone control to meet current Energy Code.
- 1972 was a significant addition to the south of the building served by CV MZ units. These units are being replaced in 2015 under the 2010 Bond. Some ductwork from 1972 is being reused in the 2015 project.
- 1962 was the original construction of the building. All equipment in this area has been replaced due to HVAC projects in 1992, 2007 and 2015.

Kitchen make-up air unit and evaporative cooler should be replaced.

Air Conditioning Strategies

- Install chiller and route chilled water to 2015 RTUs and VUVs
- Replace ductwork in the 1972 area that the 2010 Bond project budget was unable to address
- Route chilled water on roof and drop into space when required.
- Install new RTU, with VAV zoning and remove existing UVs for the NE corner 4 classrooms
- Install new RTU and remove existing UVs for the cafeteria
- Replace office area packaged DX RTU with a new VAV packaged DX RTU for operation during afternoon and summer times when no students are there to avoid running the chiller for only a portion of the school
- Kitchen makeup air unit with evap cooling

Life Cycle Needs Due to Aging Equipment

- Replace ductwork in the 1972 area that the 2010 Bond project budget was unable to address
- Install new RTU and remove existing UVs for the cafeteria
- Replace office area packaged DX RTU with a new VAV packaged DX RTU for operation during afternoon and summer times when no students are there to avoid running the chiller for only a portion of the school
- Install new RTU and remove existing VAVs for the NE classrooms
- Kitchen makeup air unit with evap cooling

All areas of the building not receiving upgrades in 2015 are due for HVAC replacement in the next 5-7 years regardless if air conditioning is desired to be installed. RTUs from 1992 are nearing their life expectancy. Duct from 1972 that was reused in the 2015 project should be replaced.

DUNN ELEMENTARY SCHOOL

Existing Infrastructure

- 2006 classroom addition was constructed on the northwest corner. These areas are served by a CV RTU providing heating and ventilation only. This RTU also serves the adjacent classroom that was added in 1992
- 1992 consisted of a major remodel and additions.
    - Three classrooms were added to the north end. These are served by unit ventilators, with the exception of one classroom which now borders the above mentioned 2006 addition.
    - The addition to the east side of the building consisted of classrooms and administration area. This area is served by a CV RTU. Zoning is via reheat coils in the ductwork. The adjacent area to the west of the addition is also served from this RTU.
    - 1948 steam boilers and UVs were removed. New hot water boilers were installed.
    - New UVs, baseboard and convectors were installed throughout the original 1948 areas (including classrooms, gym/cafeteria and entry ways)
    - Tunnels along the exterior walls used in the 1948 construction for steam piping were reused for heating water pipe.
    - A packaged DX RTU was installed for the computer lab and resource room.
- In 1987 a media center addition was constructed on the north side. This area is served by a heating and ventilating AHU in the ceiling space.

- 1948 was the original construction of the building. All HVAC systems were replaced in 1992.
- Kitchen has recently had new make-up air units and exhaust installed.

Air Conditioning Strategies

- Install VUVs per classroom in the original construction (1948 area). Little space to route duct does not allow for a central AHU or RTU solution.
- Install a new RTU and spiral ductwork or DuctSox for the gym/cafeteria.
- Install a new RTU for the media center.
- Install VUVs for the 1992 and 2006 addition classrooms
- Install a packaged DX RTU for the administration area.
- Install chiller and route chilled water to new RTUs and VUVs.
- Install an evaporative cooling section in the recently installed make-up air unit for the kitchen.
- New controls system for the whole school

Life Cycle Needs Due to Aging Equipment

- Install VUVs per classroom in the original construction (1948 area). Little space to route duct does not allow for a central AHU or RTU solution.
- Install a new RTU and spiral ductwork or DuctSox for the gym/cafeteria.
- Install a new RTU for the media center.
- Install a packaged DX RTU for the administration area.
- New controls system for the whole school

Recommendations for 2010 Bond project

- The monies slated for the 2016 HVAC updates from the 2010 Bond will not likely be able to replace all of the aging equipment that is on the Bond list.
- The PSD administration has to determine how those monies will best be spent.
    - If doing something to improve comfort now is the number one priority, then Horsetooth Engineering recommends the following:
        - Install VUVs for each classroom in 1948 areas. A cooling coil should be installed in each VUV.
        - Install a cooling tower similar to what has been done at Irish, Riffenburgh, Beattie, Kruse and McGraw..
        - Route chilled water pipe from the tower across the roof to a few specific areas and then drop down below the ceiling and

distribute to the VUVs. Install branch valves for future expansion of the pipe network.

- Upgrade the temperature controls system and components in any remaining equipment.
- Leave all other equipment as is. If budget allows for more work to be done, the following is recommended, in order of priority due to age of equipment.
    - Replace the gym UVs with a new RTU. Route Ductsox through the space for supply air. These units are 1992, however, UVs is a very poor concept for a large volume space such as a gym and should be changed.
    - Replace the 1987 media AHU with a new RTU. Space for a future cooling coil should be installed.
    - 1992 UVs for northeast classrooms removed and VUVs with a cooling coil should be installed.
    - 1992 admin RTU removed and new DX RTU installed. Install retrofit VAV boxes for zone control in the existing ductwork.
    - 2006 RTU removed and VUVs with a cooling coil should be installed.

- If the administration feels that an air conditioning Bond is to pass in the near term and that a total replacement of the HVAC at this school, including air conditioning is imminent, then Horsetooth Engineering recommends the following:
    - Replace the gym UVs with a new RTU. Route Ductsox through the space for supply air.
    - Replace the 1987 media AHU with a new RTU. Space for a future cooling coil should be installed.
    - Upgrade controls for the remaining RTUs and the heating plant.

HARRIS ELEMENTARY SCHOOL

Existing Infrastructure

- In 2002 a significant building addition was done. Areas of the original construction were also remodeled.
    - A packaged DX RTU provides cooling to the office lobby and the Learning Lab.

    - The ductwork from an existing packaged DX RTU installed in 1998 was reworked to serve Early Childhood, Principal and conference room.
    - A DX fan coil with a condensing unit was installed to serve the computer lab on the northeast corner of the lower level.
    - The addition is served by two air handlers. One is an ERV serving the classrooms, the other is a heating and ventilating only RTU serving the gym/cafeteria.
    - A make-up air unit and exhaust fan serves the kitchen.
- Drawing sets go back as far as 1962. Based on construction of the building, it is estimated that this building is much older. Data available from PSD indicates that 1919 is the original construction and additions were done in 1958, 1987 and the above noted 2002. 1919, 1958 and 1987 drawings are not available.
    - Original construction part of the building on both levels is heated via baseboard radiation and ventilated via operable windows.
    - A whole house fan type of fan is in the corridor of the main level for exhaust of hot air during warmer months and induction of fresh air through open windows
    - The flex room on the interior of the original part of the building on the main level has no ventilation air.
    - As mentioned above, a few spaces in this original construction part of the building, did receive AC units in 1998 and 2002.

Air Conditioning Strategies

- Remove RTUs installed in 2002 for addition and replace with chilled water VUVs for classrooms and RTU for cafeteria/gymnasium.
- Install VUVs in each room in the original construction part of the building.
- Install a chiller and route chilled water to the new VUVs and RTUs.
- Add an evaporative cooling section on to the intake of the make-up air/exhaust RTU installed for the kitchen in 2002.
- New controls system for the whole school

Due to the age of the building, variable refrigerant volume (VRV) technology should be considered to reduce pipe routing and the number of outdoor condensing units.

Life Cycle Needs Due to Aging Equipment

- Install VUVs per classroom in the original construction (1948 area). Little space to route duct does not allow for a central AHU or RTU solution.
- Install a packaged DX RTU for the administration area.

- New controls system for the whole school

LAB/POLARIS SCHOOL @ MOORE

Existing Infrastructure

- In 2006 a gym addition was constructed. This area is served by a heating and ventilating only RTU.
- 1996 a boiler was installed to convert the 1956 basement MZ from gas-fired to hot water heat.
- 1994 consisted of multiple additions and in infill.
    - A portion of building was constructed to connect the original 1956 construction to the 1966 building. This infill area is served by a CV RTU with heating and ventilating only.
    - Two classrooms were added to the south end of the 1966 construction. This area is served by a CV RTU that is heating and ventilating only. Two classrooms were also added to the north end of the 1958 construction, these rooms are served by underground duct that was installed in the 1958 construction to allow for 2 more classrooms to be served from the basement MZ.
- In 1991 the 1966 construction on the east part of the building was converted to hot water heat. A boiler room was added on the north side of the 1966 construction. This heating system serves the infill area and classrooms on the south added in 1994.
- In 1987 a media center addition was constructed on the north side, this was infilled between the 1956 and 1958 wings. It is served by two gas fired furnaces. One of the furnaces provides air conditioning to the computer lab. Supply and return duct is overhead. The east side of the media center is 1958 construction and is served from the basement MZ.
- In 1966 an annex was built to the west of the building. It is served by two MZ RTUs.
- 1958 the eastern half of the building was constructed. All these spaces are served from the basement MZ installed in 1956 with underground duct.
- 1956 was the original construction of the building. A MZ unit was installed in the basement. Supply duct was all routed underground. Return air was transferred from the classrooms into the corridor. One large central return air opening in the corridor is connected to the MZ.
- Cafeteria is also served by the basement MZ via underground supply duct.

- Kitchen has no make-up air unit. It relies only on transfer air from the gym/cafeteria. There is a small duct from the basement MZ that provides heat to the eastern part of the kitchen.
- It appears as though the computer lab on the west end of the building does not currently have air conditioning.

Air Conditioning Strategies

- Cap all underground ductwork. Seal all transfer air into the corridor from the classrooms. Remove the basement MZ unit, this will require cutting up and disassembling the unit to get it out of the basement.
- Install VUVs per classroom on the east half of the building (from the entry way east). Wood structure and little space to route duct does not allow for a central AHU or RTU solution.
- Install an RTU for the cafeteria. Route spiral supply duct or DuctSox through the space.
- Install VUVs for all areas on the western portion of the building (from the entry way west). Ceiling space available will make duct routing challenging for central VAV RTUs. Space for VUVs is limited due to extensive existing casework.
- Install chiller and route chilled water to new RTU and VUVs.
- Install an RTU for the Media Center
- Replace all ductwork in the 1966 construction area.
- Reuse 1991 and 1996 boilers to route heating water to the new VUVs and RTU.
- Install a packaged DX RTU for the administration area.
- Install a make-up air unit with evaporative cooling for the kitchen.
- New control system for the whole school

Life Cycle Needs Due to Aging Equipment

- Cap all underground ductwork. Seal all transfer air into the corridor from the classrooms. Remove the basement MZ unit, this will require cutting up and disassembling the unit to get it out of the basement.
- Install VUVs per classroom on the east half of the building (from the entry way east). Wood structure and little space to route duct does not allow for a central AHU or RTU solution.
- Install an RTU for the cafeteria. Route spiral supply duct or DuctSox through the space.

- Install VUVs for all areas on the western portion of the building (from the entry way west). Ceiling space available will make duct routing challenging for central VAV RTUs. Space for VUVs is limited due to extensive existing casework.
- Install an RTU for the Media Center
- Replace all ductwork in the 1966 construction area.
- Install a packaged DX RTU for the administration area.
- Install a make-up air unit with evaporative cooling for the kitchen.
- New control system for the whole school

This building is due for a complete HVAC replacement, regardless if air conditioning is desired to be installed.

Recommendations for 2010 Bond project

- The monies slated for the 2016 HVAC updates from the 2010 Bond will only be able to address a portion of what is needed at this school. With the exception of the boiler, this building needs an entire HVAC system replacement that has significant architectural and structural impacts.
- The PSD administration has to determine how those monies will best be spent.
    - If doing something to improve comfort now is the number one priority, then Horsetooth Engineering recommends the following, in order of priority:
        - Install VUVs in as many of the classrooms in the area served by the basement MZ as is possible within the budget. These should have a cooling coil installed.
        - Install relief hood through roof at each classroom that a VUV is installed for the 1956/1958 area.
        - Cap holes in floor, transfer openings to corridor and underground ductwork in all rooms that VUVs are installed in the area currently served by the basement MZ.
        - Install a new RTU for the cafeteria that is served by the underground duct from the basement MZ. Route Ductsox through the space for air distribution. Install on 2006 gym roof.
        - Install RTU or VUVs for the media center currently served by a combination of underground duct from the basement MZ and 2 furnaces. Install a cooling coil for future.
        - Size piping to new VUVs for future 2-pipe changeover.

        - Rebalance the existing MZ unit to account for removed zones if the budget does not allow all underground duct zones to be replaced with new VUVs. Note: this is not recommended.
        - Upgrade the temperature controls system and components in the existing MZ unit, if it must remain – note that this is not recommended.
        - Upgrade controls on all existing equipment to remain.
        - Remove 1966 MZs and ductwork, install new VUVs with a cooling coil. Existing casework makes VUVs challenging.
        - Install a central ducted relief via exhaust fan on a VFD for the 1966 area.
        - Size piping to new VUVs for future 2-pipe changeover.
    - If the administration feels that an air conditioning Bond is to pass in the near term or that a total replacement of the HVAC at this school with or without air conditioning is imminent, then Horsetooth Engineering recommends the following:
        - Upgrade the controls on the existing MZ and the heating plants.

LIVERMORE ELEMENTARY SCHOOL

Existing Infrastructure

- 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.
- 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.

Air Conditioning Strategies

- Add a DX cooling coil for the furnace installed in 2000 that does not have AC now.
- Replace the air handler installed for the Media Center and classroom with a new VUV with DX cooling coil.
- Replace the air handler serving the original 1952 area with a new VUV with DX cooling coil.
- Replace the air handler installed for the gym/cafeteria with a new indoor air handler that has a DX cooling coil.
- New control system for the whole school.

Life Cycle Needs Due to Aging Equipment

- Replace the air handler installed for the gym/cafeteria with a new indoor air handler that has a DX cooling coil.
- New control system for the whole school.

DuctSox or exposed spiral duct should be installed to better distribute the supply air in the gym/cafeteria.

Due to the elevation and cooler climate of this school, consideration should be given to installing economizers on all furnaces to bring in more fresh air during warmer times of the year. Code will require this to be done if air conditioning is added.

O'DEA ELEMENTARY SCHOOL

Existing Infrastructure

- 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.
- 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.

Air Conditioning Strategies

- 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.
- Install a cooling coil in the 1994 RTU.
- Install VAVs in 1994 duct for zoning.
- Cap all underground ductwork for the gym/cafeteria. Install a new RTU with cooling coil. Route exposed spiral duct or Ductsox through the space.
- Install VUVs for all areas on the 1966 portion of the building.
- Install chiller and route chilled water to new AHU, existing RTUs and new VUVs.
- Replace all ductwork in the 1966 construction area.
- Install a make-up air unit with evaporative cooling for the kitchen.
- Install a packaged DX RTU for the admin area
- New control system for whole school.

Life Cycle Needs Due to Aging Equipment

- 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.
- Cap all underground ductwork for the gym/cafeteria. Install a new AHU. Route exposed spiral duct or Ductsox through the space.
- Install VUVs for all areas on the 1966 portion of the building.
- Replace all ductwork in the 1966 construction area.

- Replace boilers and heating water piping (installed in 1962 and 1966). Route heating water to the new VUVs, VAVs, AHUs and RTUs.
- Install a make-up air unit with evaporative cooling for the kitchen.
- Install a packaged DX RTU for the admin area
- New control system for whole school.

Recommendations for 2010 Bond project

- The monies slated for the 2016 HVAC updates from the 2010 Bond will not be able to replace all of the aging equipment that is on the Bond list.
- The PSD administration has to determine how those monies will best be spent.
    - If doing something to improve comfort now is the number one priority, then Horsetooth Engineering recommends the following:
        - Install VUVs for each classroom in 1962 and 1966 areas. A cooling coil should be installed in each VUV. Remove ductwork in 1962 and 1966 areas.
        - Install a cooling tower similar to what has been done at Irish, Riffenburgh and Beattie.
        - Route chilled water pipe from the tower across the roof to a few specific areas and then drop down into the ceiling and distribute to the VUVs. Install branch valves for future expansion of the pipe network.
        - Replace the gym/cafeteria AHU with a new AHU. Route Ductsox through the space for supply air.
        - Install a cooling coil in the RTU installed in 1994 and route chilled water piping from the cooling tower to this RTU.
        - Upgrade the temperature controls system and components in any remaining equipment.
        - Leave all other equipment as is. If budget allows for more work to be done, the following is recommended, in order of priority due to age of equipment.
            - Replace boilers
            - Replace heating water piping in 1962 and 1966 areas

    - If the administration feels that an air conditioning Bond is to pass in the near term and that a total replacement of the HVAC at this school, including air conditioning is imminent, then Horsetooth Engineering recommends the following:

- Replace the gym/cafeteria AHU with a new AHU that has a cooling coil for future connection.
- Replace the boilers with high efficiency boilers that can be optimized once the total HVAC replacement project is undertaken.
- Upgrade controls for the heating plant, gym RTU and 1994 RTU.

PUTNAM ELEMENTARY SCHOOL

Existing Infrastructure

- The 2014 project related to the 2010 Bond consisted mainly of adding variable frequency drives to the existing AHU fan motors to improve energy efficiency. Budget constraints limited the work for this school.
- 1997 consisted of multiple additions and in infill.
    - A portion of building was constructed to connect the original 1955 construction to the 1966 building. This infill area is served by CV packaged DX RTUs.
    - The original 1955 entry way was removed and an addition was constructed to the south. This area and the rooms adjacent to it are served by CV packaged DX RTUs.
    - The classrooms in between the infill and the entry way are also served by CV packaged DX RTUs.
    - A gym and cafeteria addition was installed on the north side. Each area is served by a dedicated indoor heating and ventilating only AHU.
    - The media center is served by an indoor AHU installed in the same mechanical mezzanine as the gym AHU. This unit provides heating and ventilation only. A cooling coil is installed in the unit and could be connected to a condensing unit in the future.
    - New boilers were installed in the 1955 basement mechanical room. These serve the 1955 MZ and the zone reheat coils installed in 1999.
- In 1991 the 1966 construction on the west part of the building was converted to hot water heat. A boiler room was added on the south side of the 1966 construction. This heating system still serves the west end MZs.
- In 1986 a media center addition was constructed on the west side. This was removed in the 1997 remodel and addition.
- In 1966 an annex was built to the west of the building. It is served by three MZ RTUs.

- 1955 was the original construction of the building. A MZ unit was installed in the basement. Supply duct was all routed underground. Return air was transferred from the classrooms into the corridor. One large central return air opening in the corridor is connected to the MZ.
- Kitchen has no make-up air unit. It relies only on transfer air from the gym/cafeteria. There is a small duct from the basement MZ that provides heat to the eastern part of the kitchen, from below.

Air Conditioning Strategies

- Cap all underground ductwork. Seal all transfer air into the corridor from the classrooms. Remove the basement MZ unit, this will require cutting up and disassembling the unit to get it out of the basement.
- Install VUVs per classroom on the east half of the building (from the entry way east). Wood structure and little space to route duct does not allow for a central AHU or RTU solution.
- Install a cooling coil in AHU supply main for the cafeteria.
- Remove the media center DX cooling coil and install a chilled water coil.
- Remove the DX RTUs on the infill and install VUVs in place.
- Install VUVs for on the western portion of the building (1966 and 1994 classrooms.
- Install chiller and route chilled water to existing AHUs and new VUVs.
- Replace all ductwork in the 1966 construction area.
- Reuse 1991 and 1999 boilers to route heating water to the new VUVs.
- Install a make-up air unit with evaporative cooling for the kitchen.
- Packaged DX administration RTU to remain.
- New control system for whole school.

Life Cycle Needs Due to Aging Equipment

- Cap all underground ductwork. Seal all transfer air into the corridor from the classrooms. Remove the basement MZ unit, this will require cutting up and disassembling the unit to get it out of the basement.
- Install VUVs per classroom on the east half of the building (from the entry way east). Wood structure and little space to route duct does not allow for a central AHU or RTU solution.
- Install VUVs for on the western portion of the building (1966 classrooms).
- Replace all ductwork in the 1966 construction area.
- Install a make-up air unit with evaporative cooling for the kitchen.

- New control system for whole school.

RED FEATHER ELEMENTARY SCHOOL

Existing Infrastructure

- 1997 modular was built as an addition to the west of the original 1986 construction. The furnace serving this area was recently replaced in 2013. This unit does not have an economizer. Supply and return air are overhead.
- 1984 was the original construction of the school. Three residential furnaces serve this area. One furnace serves the classrooms on the north and east. Another furnace serves the 2 south facing classrooms. The third furnace serves the gym/cafeteria. All areas received new furnaces in 2013.
- Gym supply and return air is delivered via sidewall, from the same wall.
- Kitchen currently has no exhaust and has supply and return air from the furnace serving the gym/cafeteria

Air Conditioning Strategies

- Add a DX cooling coil to the furnaces installed in 2013. Ductwork revisions would be required to install a new cooling coil.

Exhaust fans should be installed for the kitchen and return air removed.

Exposed spiral duct or DuctSox should be installed for the gym/cafeteria to better distribute the supply air.

Due to the elevation and cooler climate of this school, consideration should be given to installing economizers on all furnaces to bring in more fresh air during warmer times of the year. If this were to be implemented, it is unlikely that AC is necessary unless year round school schedule was adopted.

STOVE PRAIRIE ELEMENTARY SCHOOL

Existing Infrastructure

- In 2005 an addition was built that joined the 1896, 1960, 1972 and 1988 areas together. At this time, new furnaces were installed in all the existing areas, as well as the new construction.
- 1988 modular was built as an addition to the north of the 1972 construction. The furnace serving this area was recently replaced in 2005. This unit does not have an economizer.

- 1972 the southeast classroom and multi-purpose room was built. Two new furnaces serving this area were installed in 2005. These units do not have an economizer.
- 1960 east classroom is served by a furnace installed in 2005. It also serves the east classroom built in 2005.
- 1896 classroom is also served from the furnace serving the other 2 east classrooms that was installed in 2005. Last summer, this area also received new windows and doors.
- Kitchen currently has no exhaust, supply or return air.

Air Conditioning Strategies

- Add a DX cooling coil to the furnaces installed in 2005. Ductwork revisions would be required to install a new cooling coil.

Exhaust fans should be installed for the kitchen.

Exposed spiral duct or DuctSox should be installed for the multipurpose to better distribute the supply air.

Due to the elevation and cooler climate of this school, consideration should be given to installing economizers on all furnaces to bring in more fresh air during warmer times of the year. If this were to be implemented, it is unlikely that AC is necessary unless year round school schedule was adopted.

It should also be noted that staff requested humidification to help improve staff and student health during the winter months. For this location, this may achieve better comfort improvement than air conditioning.

TIMNATH ELEMENTARY SCHOOL

Existing Infrastructure

- Sometime between 2001 and 2015 the administration area floor plan was altered and a DX RTU was installed. Drawings were not available.
- In 2001 a cafeteria and kitchen addition was constructed on the south end of the building.
    - The cafeteria is served by a packaged DX cooling RTU.
    - The kitchen had a make-up air unit with evaporative cooling installed.
    - A classroom directly to the north of the cafeteria addition had a packaged DX cooling RTU installed.

- 1992 consisted of multiple replacements for the mechanical system.
    - New unit ventilators were installed for the majority of the 1919 portion of the building.
    - An air handler was installed for the eastern half of the lower floor of the 1919 portion of the building.
    - The western half of the lower floor in the 1919 portion of the building appeared to receive unit heaters only. Ventilation is assumed to have been intended via operable windows.
    - Site visit observations noted newer windows in the 1919 portion of the building. These were included in the 1992 project.
    - A new gym AHU was installed in the 1953 portion of the building.
    - New boilers and heating water piping were installed to serve the 1953 and 1919 areas of the building. It appears as though this new boiler plant was tied into the 1988 boiler plant to allow for redundancy.
- In 1988 a classroom addition was constructed on the south end of the building, adjacent to the gym constructed in 1953. This area is served by unit ventilators and its own boiler system. Ceiling unit ventilators serve the media center that was also built at this time.
- 1953 a gym addition was constructed to the south of the original 1919 construction. The HVAC system in this part of the building was updated in 1992.
- 1919 was the original construction of the building. Consisting of 3 stories. The lowest story is partially below grade. The HVAC systems in this part of the building were updated in 1992.
- A separate structure to the north of the 1919 building is used for art classrooms. It is served by two furnaces installed in the crawl space.

Air Conditioning Strategies

- Install a chiller and route piping to new equipment.
- Install VUVs per classroom, workrooms and a RTU for the media center.
- Media Center RTU
- New AHU for the 1st floor of the 1919 area.
- Install building exhaust fans for pressure relief in economizer mode. Duct from fans to relief grilles.
- Install furnaces with DX cooling coils in the art building.
- New control system for the whole school.

Life Cycle Needs Due to Aging Equipment

- Install VUVs per classroom, workrooms and a RTU for the media center.
- Media Center RTU
- New AHU for the 1st floor of the 1919 area.
- Install building exhaust fans for pressure relief in economizer mode. Duct from fans to relief grilles.
- New control system for the whole school.

Recommendations for 2010 Bond project

- The monies slated for the 2016 HVAC updates from the 2010 Bond are only directed toward controls upgrades and the art building furnaces.
- The PSD administration has to determine how those monies will best be spent.
    - If doing something to improve comfort now is the number one priority, then Horsetooth Engineering recommends the following:
        - Upgrade controls
        - Utilize the corridor of the 1919 building second and third floors to connect the relief air grilles in each classroom to duct and route duct to the exhaust fans. This will create a better negative pressure to pull heat out of the building.
        - Route duct from each relief air grille in the 1988 portion of the building to the plenum exhaust fans. This will create a better negative pressure to pull heat out of the building.
        - Connect an inline fan to the existing louver on the south wall of the music room in the lower floor of the 1919 part of the building.
        - Install new furnaces with DX cooling for the art building.
    - If the administration feels that an air conditioning Bond is to pass in the near term and that a total replacement of the HVAC at this school, including air conditioning is imminent, then Horsetooth Engineering recommends the following:
        - Install new furnaces with DX cooling for the art building.

BLEVINS MIDDLE SCHOOL

Existing Infrastructure

- 2012 HVAC updates were installed in portions of the building. Primarily the classrooms.
    - High efficiency boilers replaced the 1967 boilers.

    - All classrooms in the original 1967 area, 1983 addition and 1993 addition are now served by heating and ventilating RTUs with VAV zoning. Coils were sized to provide future cooling in a 2-pipe changeover strategy.
    - The existing ductwork and piping in all areas were reused to the greatest extent possible.
    - A kitchen make-up air unit with evaporative cooling was installed
    - The Tech Ed areas received fan coils that are heating and ventilating only with economizers.
    - All controls were replaced with new DDC controls, including on HVAC equipment that remained in place.
    - Indoor AHUs for areas such as administration, music, cafeteria, gyms, etc were left in place. See the discussion below on the 1967 construction for more information.
- 1997 gym that was added to the north end of the school is provided with heating and ventilation only via a constant volume RTU.
- 1993 science room addition to the south end is served by heating and ventilating RTUs installed in 2012. Zoning is provided for each room by VAV boxes.
- 1983 classroom addition to the southwest corner is served by heating and ventilating RTUs installed in 2012. Zoning is provided for each room by VAV boxes.
- The 1967 original construction is served by a variety of HVAC equipment
    - An indoor air handler located in a mezzanine to the west of the stage serves the cafeteria. This unit provides heating and ventilation only and is original equipment. It is not air conditioning ready and should be replaced, as it is past its useful service life.
    - An indoor air handler located in a mezzanine to the east of the stage serves the administration area. Supply duct is delivered underground to convectors with fintube radiation for zone control. Return air is transferred back to the corridor, which does not comply with current Code. This unit provides heating and ventilation only and is original equipment. It is not air conditioning ready and should be replaced, as it is past its useful service life. Solutions for this area are very difficult due to limited ceiling space and existing construction.
    - The stage and music areas to the north of the stage are served by an indoor AHU located in a mezzanine above the gym bleachers. This unit was retrofitted with new controls and VAV boxes were installed for zone control of the 3 rooms served by this AHU in 2012

- The gym and auxiliary gyms are served by heating and ventilating AHUs hung below the ceiling. These are original to the building and should be replaced with RTUs for better maintenance access.
- Locker rooms have exhaust only, make-up air is transferred from the gym.
- Tech Ed areas received new heating and ventilating fan coil units in 2012. Space for a cooling coil to be installed is available.
- All classrooms in the 1967 area are served by heating and ventilating RTUs with VAV zoning. These were installed in 2012. The heating coil provided in the unit is oversized to allow for future 2-pipe air conditioning strategy via chilled water. Ductwork and piping in the 1967 area should all be replaced.
- Computer labs are served by a packaged DX cooling RTU.
- The kitchen received a new make-up air unit with evaporative cooling in 2012.

Air Conditioning Strategies

- Install chiller and route chilled water to 2012 RTUs and all other new equipment that will be required to air condition the building.
- Remove indoor air handlers for cafeteria, admin and music. Install new RTUs with chilled water. Provide VAV zoning. Reuse VAV boxes installed in 2012.
- Install new ductwork and piping in the 1967 area. Reuse VAV boxes installed in 2012. Exposed duct will likely be required in the admin area.
- Route chilled water on roof and drop into space when required.
- Install new cooling coils in the 2012 fan coils for Tech Ed.

Life Cycle Needs Due to Aging Equipment

- Remove indoor air handlers for cafeteria, admin and music. Provide VAV zoning. Reuse VAV boxes installed in 2012.
- Provide Packaged DX RTU for the administration area.
- Install new ductwork and piping in the 1967 area. Reuse VAV boxes installed in 2012. Exposed duct will likely be required in the admin area.
- Install new heating and ventilating only rooftop unit for the 1967 gyms that are currently served by the ceiling hung units.
- Install a new ERV for the locker rooms.

CLP MIDDLE SCHOOL

Existing Infrastructure

- 2015 HVAC updates that were installed in the five southeast classrooms of the 1988 addition and are air conditioning ready.
- 1997 the computer lab 128 and classrooms 109 through 111C were air conditioned with packaged DX units.
- 1992 addition and remodel equipment is not air conditioning ready and should be replaced.
- 1988 RTU has had a significant load removed from it during the 2015 HVAC updates. This unit should be removed and sized appropriately for the load that it now serves. Ductwork is fiber board and has been repaired many times. Duct should be removed and replaced.
- Indoor air handler serving the 1984 addition that functions as the cafeteria is not air conditioning ready and should be replaced. UVs serving the industrial science are also not air conditioning ready and should be replaced.
- North portion of the building was initially built in 1947 and is served by an air handling unit in the basement. It serves the gym as well as most of the classrooms in the original north part of the building.
    - The HVAC in this portion of the building needs to be completely removed and replaced. All ceiling systems, lights, and cabling above the ceiling should be removed. Asbestos abatement should be anticipated due to the age of the building and ceiling systems observed.
    - The extent of work required in this area will be so extensive that the work will not be able to be completed during a typical summer break. Moving of students and staff should be included in any plan to improve/update the HVAC system in this portion of the building.
- Kitchen make-up air unit and evaporative cooler should be replaced.

Air Conditioning Strategies

- Install chiller and route chilled water to 2015 VUVs and all other new equipment that will be required to air condition the building.
- Install VUVs in the 1947/1962 areas of the building. Structure and space does not allow for other systems to be cost effectively installed. All other classrooms should also be served by VUVs.
- Route chilled water on roof and drop into space when required.
- Install new RTUs, for media center, music room, and cafeteria.
- Provide Packaged DX RTU for the administration area.
- New kitchen makeup air unit with evaporative cooling.

- New control system for the whole school.

Life Cycle Needs Due to Aging Equipment

- Install VUVs in the 1947/1962 areas of the building. Structure and space does not allow for other systems to be cost effectively installed. All other classrooms should also be served by VUVs.
- Install new RTUs, for media center, music room, and cafeteria.
- Provide Packaged DX RTU for the administration area.
- New kitchen makeup air unit with evaporative cooling.
- New control system for the whole school.
- Install new heating and ventilating only rooftop unit for the Gym that is currently served by the basement unit AHU in the 1947 section of the building.

This entire school is in need of a complete HVAC replacement. VUVs installed in 2015 are the only parts that should be salvaged.

LESHER MIDDLE SCHOOL

Existing Infrastructure

- 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.

- 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.

Air Conditioning Strategies

- Install VUVs for the 1959, 1972, and 1980 classrooms, replacing the under window UVs or ceiling hung UVs that are currently installed.
- 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.
- Route chilled water on roof and drop into space when required.
- Install new heating water piping in all of the building except the 2007 additions.
- Replace all ductwork installed in the 1959 and 1976 areas.
- Install a chiller and route chilled water to new RTUs, AHUs and VUVs.
- Packaged DX RTU for administration
- Add evaporative cooler section to 2007 makeup air unit.
- New Controls entire school.
- 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.

Life Cycle Needs Due to Aging Equipment

- 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.
- Install new heating water piping in all of the building except the 2007 additions.
- Replace all ductwork installed in the 1959 and 1976 areas.

- Packaged DX RTU for administration
- New Controls entire school.

Even if air conditioning is not to be installed; the 1959, 1976, and 1980 spaces that did not receive an update in 2007 are due for an equipment, ductwork, and piping replacement.

LINCOLN MIDDLE SCHOOL

Existing Infrastructure

- 1995 Addition consists of constant volume reheat RTUs. 1 of them, in the northeast corner, has packaged DX cooling. Some air from this unit has also been distributed to one of the adjacent classrooms in the 1974 portion of the building.
- The boilers are original to the building in 1974. They work well still and could be considered as perhaps an item to leave alone in the scheduled 2016 HVAC updates.
- Piping and ductwork is all original to the building in 1974. Replacement of the systems should be within 0-5 years.
- The classroom and office spaces are served from MZ RTUs installed in 1974
- The gyms are served from indoor air handlers hung beneath ceiling. Maintenance access to these units is very challenging.
- Locker rooms do not have direct fresh air supply, only exhaust.

Air Conditioning Strategies

- Install chiller and chilled water piping and route to new RTUs
- Replace all existing RTUs, piping and ductwork from the 1974 area. Energy Code and best practice will require zoning control in these areas to be VAV.
- Install a packaged DX RTU for the admin area.
- Install kitchen makeup air unit with evaporative cooling.
- The extent of work required in this building will be so extensive that the work will not be able to be completed during a typical summer break. Moving of students and staff should be included in any plan to improve/update the HVAC system in this building.

Life Cycle Needs Due to Aging Equipment

- Replace all existing RTUs, piping and ductwork from the 1974 area. Energy Code and best practice will require zoning control in these areas to be VAV.

- Install new heating and ventilation only RTUs for the 3 AHUs serving the gyms. Route supply air and exhaust to the weight room which currently has no supply air.
- Install new heating and ventilation only ERVs for the boys and girls locker rooms.
- Install a packaged DX RTU for the admin area.
- Install kitchen makeup air unit with evaporative cooling.

Recommendations for 2010 Bond project

- The monies slated for the 2016 HVAC updates from the 2010 Bond will only be able to address a portion of what is needed at this school.
- The PSD administration has to determine how those monies will best be spent.
    - If doing something to improve comfort now is the number one priority, then Horsetooth Engineering recommends the following:
        - Install a cooling coil in all the existing MZ RTUs.
        - Install a cooling tower similar to what has been done at Irish, Riffenburgh and Beattie.
        - Route chilled water pipe on the roof to the new cooling coil in the existing RTUs
        - Upgrade the temperature controls system and components in the existing RTUs.
        - Leave all other equipment, heating water piping, and duct as is.
    - If the administration feels that an air conditioning Bond is to pass in the near term and that a total replacement of the HVAC at this school, including air conditioning is imminent, then Horsetooth Engineering recommends the following:
        - Replace the gym AHUs with new RTUs, since this space will not be receiving air conditioning in the future anyway (as long as PSD policy does not change from its current stance)
        - Install new ERVs for fresh air and exhaust to the boys and girls locker room
        - Replace the boilers with high efficiency boilers that can be optimized once the total HVAC replacement project is undertaken.

WEBBER MIDDLE SCHOOL

Existing Infrastructure

- 2012 HVAC updates that were installed in the classrooms, music and Tech Ed rooms are air conditioning ready. The VUVs have a 4-row heating coil that can have chilled water piping routed to it for 2-pipe system air conditioning.
- 2012 RTUs that were installed for the administration, hearing impaired, and band room have space for a cooling coil to be installed.
- 2006 RTU serving the cafeteria also has space for a cooling coil to be added.
- 1997 Gym addition heating and ventilating RTU is in good condition.
- One computer lab is served from a packaged DX RTU installed in 2012. The other computer lab also has a packaged DX RTU that was installed in earlier years by PSD.
- Kitchen make-up air unit and evaporative cooler was replaced in 2012.

Air Conditioning Strategies

- Install chiller and route chilled water to 2012 VUVs and RTUs. Install cooling coil in existing RTUs.
- Install cooling coil in 2006 cafeteria RTU and route chilled water to RTU.
- Route chilled water on roof and drop into space when required.
- Install new 4-pipe fan coils for the teacher workroom areas that did not receive any ventilation air in the 2012 HVAC updates. Currently, operable windows is how Code required ventilation air is provided. Serve adjacent corridors with these new fan coils.
- Install a packaged DX RTU for the admin area.

Regardless of air conditioning decisions, PSD should extend Gym RTU ductwork into interior locker rooms and offices to provide direct supply air into these rooms in lieu of transfer air only as is currently installed.

CENTENNIAL HIGH SCHOOL

Existing Infrastructure

- In 2004 a significant building addition was done. Some parts of this project were connected to the original 1906 structure. The remainder of the project was an activities building that was a separate structure.
    - New heating and ventilating only RTUs were installed on all of the 2004 construction.
    - New boilers and heating plant components were also installed. It is unclear if the piping in the 1906 portion of the building was also replaced at that time.

- 1906 portion of the building is heated via baseboard radiation. Ventilation is from operable windows.

Air Conditioning Strategies

- Remove RTUs installed in 2004 and replace with VAV RTUs with a cooling coil.
- Install VAV boxes in ductwork installed in 2004 for zoning and to meet current Energy Code.
- Install VUVS in each room in the 1906 area. Economizers will be difficult due to the historical status of this building. New penetrations in the façade should be carefully located.
- Install chiller and route piping to RTUs and VUVs
- Packaged DX for administration
- New control system for the whole school

Life Cycle Needs Due to Aging Equipment

- Install VUVS in each room in the 1906 area. Economizers will be difficult due to the historical status of this building. New penetrations in the façade should be carefully located.
- New control system for the whole school

Variable refrigerant volume systems should be considered as an alternative to the 1906 area solution.

MOUNTAIN VIEW

Existing Infrastructure

- In 2003 a project that consisted of connecting the 3 buildings on the site was undertaken.
    - Hallways, restrooms and offices were constructed that allowed connection of the 4 west classrooms, the 2 south facing eastern most classrooms and the cafeteria/gym structure.
    - The west classrooms did not appear to receive any HVAC updates at this time.
    - The furnace serving the 2 southeast classrooms was left in place.
    - A RTU providing heating and ventilation only was installed for the 2003 administration area.
    - 2 furnaces were installed to heat and ventilate the gym/cafeteria. Supply and return air is delivered via sidewall diffusers – on the same wall.

    - 1 furnace was installed to heat the kitchen/restrooms/corridor adjacent to the gym/cafeteria.
    - Another furnace was installed to heat the corridor/lobby/offices created in 2003.
- Gym construction date is believed to be 1968.
- The 2 southeast classrooms appear to be built quite some time ago. Perhaps the 1940s or 1950s
- The 4 west classrooms were likely the original construction. This appears to be around the turn of the 20th century. These spaces are heated by baseboard heat. Ventilation is only provided via operable windows. One classroom that is now adjacent to the 2003 corridor no longer has operable windows to the outside.

Air Conditioning Strategies

- Install new furnaces and condensing units for all the areas currently served by furnaces.
- Install new packaged DX RTU for the administration area.
- Install VUVs in each of the 4 classrooms in the original building. Each VUV shall have a corresponding DX condensing unit.
- Route DuctSox through the gym for improved air distribution.
- New control system for the whole school

Life Cycle Needs Due to Aging Equipment

- Install VUVs in each of the 4 classrooms in the original building. Each VUV shall have a corresponding DX condensing unit.
- Route DuctSox through the gym for improved air distribution.
- New control system for the whole school

VRV could also be considered for all areas other than the gym.

TEMPERED – MORE THAN 30 YEARS OLD – RELATIVELY ADAPTABLE

BEATTIE ELEMENTARY SCHOOL

Existing Infrastructure

- 2014 HVAC updates installed a “tempered air” system utilizing a cooling tower to create cool water that was routed via roof mounted piping to a number of rooftop units.

    - This strategy is able to deliver 65 to 70 degree air into the classrooms during the hottest days of the year.
    - Heating water piping and boilers were installed in 1995 and were all reused in the 2014 HVAC updates.
    - The existing RTU serving the 1979 area of the building was replaced with a new RTU because it was not able to be retrofitted with a cooling coil. The area served by this unit now has VAV zoning and some new ductwork. Existing ductwork downstream of the new VAVs was reused. Sections of duct in this area that remain from 1979 are nearing the age were they should be replaced. The RTU and zoning scheme is air conditioning ready.
    - Existing MZ RTUs from 1971 were retrofitted with cooling coils and all ductwork was reused. These units and the associated ductwork should be replaced. Budget constraints and prioritization of improved comfort resulted in these RTUs remaining in place during the 2014 HVAC updates project.
    - Kitchen make-up air unit was installed in 2014.
- A packaged DX RTU serves the Music and Art classrooms that were added in 1995. This area is already air conditioned. Unit replacement should be anticipated in the next 3-5 years.
- The RTU serving the gym is original from 1971. The gym is also used as the cafeteria. This unit should be replaced and piping extended to this area to provide air conditioning.

Air Conditioning Strategies

- Install chiller and reuse chilled water piping installed in 2014 that is currently connected to the cooling tower.
- Rebalance chilled water flows at new RTU installed in 2014.
- Install new RTUs for the 3 RTUs serving the 1971 area. Energy Code and best practice will require zoning control in these areas to be revised to VAV. All ductwork in these areas to be removed and replaced.
- Install new RTU on gym/cafeteria and install a new branch from the existing roof mounted chilled water piping to the gym roof. Remove and replace existing duct in gym/cafeteria.
- Replace 1995 DX RTU with chilled water RTU.
- Packaged DX RTU for admin
- Install evaporative cooling on kitchen MAU installed in 2014.

Life Cycle Needs Due to Aging Equipment

- Install new RTUs for the 3 RTUs serving the 1971 area. Energy Code and best practice will require zoning control in these areas to be revised to VAV. All ductwork in these areas to be removed and replaced.
- Install new RTU on gym/cafeteria.
- Replace gym/cafeteria ductwork and all ductwork from 1971 that was reused in 2014.

IRISH ELEMENTARY SCHOOL

Existing Infrastructure

- 2014 HVAC updates installed a "tempered air" system utilizing a cooling tower to create cool water that was routed via roof mounted piping to a number of rooftop units.
    - This strategy is able to deliver 65 to 70 degree air into the classrooms during the hottest days of the year.
    - A new RTU serving the 2006 southeast addition is air conditioning ready.
    - Heating water piping and boilers were installed in 1993 and were all reused in the 2014 HVAC updates.
    - A new RTU serves the media center area that was added in 1989. This unit is air conditioning ready.
    - The existing RTU serving the 1970 area of the building was replaced with a new RTU because it was not able to be retrofitted with a cooling coil. The area served by this unit now has VAV zoning and some new ductwork. Existing ductwork downstream of the new VAVs was reused. Sections of duct in this area that remain from 1970 should be replaced. The RTU and zoning scheme is air conditioning ready.
    - The two classrooms north of the gym are served by a new RTU installed in 2014 and is air conditioning ready.
    - Existing MZ RTUs from 1967 were retrofitted with cooling coils and all ductwork was reused. These units and the associated ductwork should be replaced. Budget constraints and prioritization of improved comfort resulted in these RTUs remaining in place during the 2014 HVAC updates project.
- The RTU serving the gym is original from 1967. The gym is also used as the cafeteria. This unit should be replaced and piping extended to this area to provide air conditioning.

- Kitchen has no makeup air. It relies only on transfer air from the gym/cafeteria.

Air Conditioning Strategies

- Install chiller and reuse chilled water piping installed in 2014 that is currently connected to the cooling tower.
- Rebalance chilled water flows at new RTUs installed in 2014.
- Install new RTUs for the 3 RTUs serving the 1967 area. Energy Code and best practice will require zoning control in these areas to be revised to VAV. All ductwork in these areas to be removed and replaced.
- Install new RTU on gym/cafeteria and install a new branch from the existing roof mounted chilled water piping to the gym roof. Remove and replace existing duct in gym/cafeteria.
- Packaged DX RTU for admin
- Kitchen makeup air unit with evaporative cooling

Life Cycle Needs Due to Aging Equipment

- Install new RTUs for the 3 RTUs serving the 1967 area. Energy Code and best practice will require zoning control in these areas to be revised to VAV. All ductwork in these areas to be removed and replaced.
- Install new RTU on gym/cafeteria.
- Replace gym/cafeteria ductwork and all ductwork from 1967 that was reused in 2014.

RIFFENBURGH ELEMENTARY SCHOOL

Existing Infrastructure

- 2014 HVAC updates installed a “tempered air” system utilizing a cooling tower to create cool water that was routed via roof mounted piping to a number of rooftop units.
    - This strategy is able to deliver 65 to 70 degree air into the classrooms during the hottest days of the year.
    - Heating water piping and boilers were installed in 1994 and were all reused in the 2014 HVAC updates.
    - A new RTU serves the media center area that was added in 1988. This unit is air conditioning ready.
    - The existing RTU serving the 1970 area of the building was replaced with a new RTU because it was not able to be retrofitted with a cooling coil.

The area served by this unit now has VAV zoning and some new ductwork. Existing ductwork downstream of the new VAVs was reused. Sections of duct in this area that remain from 1970 should be replaced. The RTU and zoning scheme is air conditioning ready.

- The two classrooms north of the cafeteria are served by a new RTU installed in 2014 and is air conditioning ready.
- Existing MZ RTUs from 1967 were retrofitted with cooling coils and all ductwork was reused. These units and the associated ductwork should be replaced. Budget constraints and prioritization of improved comfort resulted in these RTUs remaining in place during the 2014 HVAC updates project.

- In 2002 a gym addition was constructed. Equipment is relatively new and gyms are not to be air conditioned. Air handling equipment should be replaced in 15-20 years.
- The RTU serving the cafeteria is original from 1967. This unit should be replaced and piping extended to this area to provide air conditioning.
- Kitchen has no makeup air. It relies only on transfer air from the cafeteria.

Air Conditioning Strategies

- Install chiller and reuse chilled water piping installed in 2014 that is currently connected to the cooling tower.
- Rebalance chilled water flows at new RTUs installed in 2014.
- Install new RTUs for the 3 RTUs serving the 1967 area. Energy Code and best practice will require zoning control in these areas to be revised to VAV. All ductwork in these areas to be removed and replaced.
- Install new RTU on cafeteria and install a new branch from the existing roof mounted chilled water piping to the cafeteria roof. Remove and replace existing duct in cafeteria.
- Packaged DX RTU for admin
- Kitchen makeup air unit with evaporative cooling

Life Cycle Needs Due to Aging Equipment

- Install new RTUs for the 3 RTUs serving the 1967 area. Energy Code and best practice will require zoning control in these areas to be revised to VAV. All ductwork in these areas to be removed and replaced.
- Install new RTU on cafeteria.
- Replace cafeteria ductwork and all ductwork from 1967 that was reused in 2014.

TEMPERED – LESS THAN 30 YEARS – RELATIVELY ADAPTABLE

Kruse Elementary School

Existing Infrastructure

- 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 and 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

Air Conditioning Strategies

- Install a chiller and connect to existing piping.
- Install a cooling coil in the supply duct main for the Media Center.
- Packaged DX RTU for admin

Laurel Elementary School

Existing Infrastructure

- 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

Air Conditioning Strategies

- Install a chiller and connect to existing piping.
- Install a cooling coil in the supply duct main for the Media Center.
- Install a new make-up air unit for kitchen with evaporative cooling.
- Packaged DX RTU for admin

Life Cycle Needs Due to Aging Equipment

- Install a new make-up air unit for kitchen with evaporative cooling.

McGraw Elementary School

Existing Infrastructure

- 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

Air Conditioning Strategies

- Install a chiller and connect to existing piping.
- Install a cooling coil in the supply duct main for the Media Center.
- Packaged DX RTU for admin

Traut Elementary School

Existing Infrastructure

- 2015 HVAC updates will install a “tempered air” system utilizing a cooling tower and VUVs
    - This strategy is able to deliver 65 to 70 degree air into the classrooms during the hottest days of the year.

    - Air quantities are 1,200 to 2,000 CFM per classroom depending on number of exterior walls are orientation (east, west, north, south)
    - Air is delivered into the classrooms via exposed spiral ductwork up high with sidewall diffusers. Air quantity varies between 50 and 100% based on how much heat or cooling the room requires.
    - Zoning per individual classrooms is provided.
    - Fan coil units that also receive cool water from the tower will be installed in corridor, work areas, and office areas.
    - New pumps and piping to work with the 2-pipe system for heating and cooling will be installed.
- 2015 HVAC updates also included a new packaged DX RTU for the Comm Data room.
- A new kitchen make-up air unit with evaporative cooling will also be installed in 2015.
- 1999 was the original construction of the building.
    - Media Center is provided with heating and ventilation by an indoor AHU installed in 1999. This unit should be replaced in the next 15-20 years.
    - The AHU serving the gym is original from 1999. This unit should be replaced in the next 15-20 years.
    - Computer lab adjacent to the Media Center is cooled via a 5 ton packaged DX RTU. Replacement should be anticipated in the next 3-5 years.
    - Cafeteria (flex room) is cooled from a 10 ton packaged DX RTU. Replacement should be anticipated in the next 3-5 years.
    - Boiler replacement should be anticipated to be replaced in 20-25 years

Air Conditioning Strategies

- Install a chiller and connect to existing piping.
- Install a cooling coil in the supply duct main for the Media Center.
- Packaged DX RTU for admin

Preston Middle School

Existing Infrastructure

- 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 ceiling diffusers. Air quantity varies between 50 and 100% based on how much heat or cooling the room requires.
    - Zoning per individual classrooms is provided.
    - New pumps and piping to work with the 2-pipe system for heating and cooling were installed.
- 2015 HVAC updates also included new packaged DX RTUs for the media center, admin area, and music department.
- 1993 was the original construction of the building.
    - Cafeteria is provided with heating and ventilation by a RTU installed in 1993. This unit should be replaced in the next 10-15 years.
    - Heating and ventilating RTUs serve the gyms. These units should be replaced in the next 10-15 years.
    - The locker rooms are only exhausted and heated, no direct makeup air is provided. Makeup air is transferred from the gym.
    - An evaporative cooler serves the kitchen and should be replaced with a make-up air unit providing evaporative cooling in the next 3-5 years.
    - Packaged DX RTUs serve the computer labs and should be replaced in the next 0-5 years.
    - Boilers should be anticipated to be replaced in 15-20 years.

Air Conditioning Strategies

- Install a chiller and connect to existing piping.
- Install new RTUs with a cooling coil for the cafeteria and route chilled water piping to these RTUs.
- Install a new make-up air unit for kitchen with evaporative cooling.

The locker rooms should have an ERV installed to serve them for exhaust and makeup air. Gym and cafeteria RTUs should be replaced within the next 7-10 years.

TEMPERED – 2012/2013 DOAS INSTALLATIONS

BAUDER ELEMENTARY SCHOOL

Existing Infrastructure

- 2012 HVAC updates installed a “tempered air” system utilizing indirect evaporative cooling Dedicated Outside Air Systems (DOAS)
    - This strategy is to deliver outside air into the classrooms that is approximately 15 degrees cooler than the outside air temperature during the warmer parts of the year. For instance – at 88 degrees outside, the air delivered to the classroom is 73 degrees.
    - VAV boxes regulate air flow quantity into each zone/classroom. Maximum air quantity for each classroom is between 1,200 and 2,000 cfm.
    - Air is supplied via ceiling diffusers.
    - Return air is at the ceiling.
    - Packaged DX RTUs were installed for each computer lab.
    - Heating water piping and boilers were installed in 1993 and were all reused in the 2012 HVAC updates.
- In 1992 a significant remodel and addition was constructed. Classrooms were added to the northwest, southeast and southwest. All the classrooms are now served by the system installed in 2012. A gym addition was constructed to the east part of the building. The gym is served by a heating and ventilation only RTU.
- In 1988 a Media Center addition was constructed on the north end. This area is now served by the system installed in 2012.
- An addition in 1970 to the northeast was served by a MZ RTU. Also, one classroom was added east of the cafeteria. These areas are now served from equipment installed in the 2012 HVAC updates project.
- The original construction of the building is believed to be in 1967 – the same time as Irish, Riffenburgh and Tavelli. The MZs serving the classrooms and office areas were removed during the 2012 HVAC project. The MZ serving the cafeteria and kitchen remains in place; this unit provides heating and ventilation only.
- Kitchen make-up air is provided by transfer air from the cafeteria – no dedicated make-up air unit is installed.

Air Conditioning Strategies

- Install cooling coils in 2012 RTUs.
- Install chiller and route chilled water piping to new RTUs.
- Install a new RTU for the cafeteria. Route chilled water to the new RTU.
- Install new make-up air unit with evaporative cooling for the kitchen

Life Cycle Needs Due to Aging Equipment

- Replace duct from 1967 that was reused in the 2012 project due to budget constraints.

Improvement Strategies for DOAS

- Install a cooling coil in RTUs installed in 2012.
- Install a DX split condensing unit for each of the 2012 RTUs.
- Deliver 55 degree air to the classroom.

Eyestone Elementary School

Existing Infrastructure

- 2012 HVAC updates installed a "tempered air" system utilizing indirect evaporative cooling Dedicated Outside Air Systems (DOAS) for portions of the building.
    - This strategy is to deliver outside air into the classrooms that is approximately 24 degrees cooler than the outside air temperature during the warmer parts of the year. For instance – at 95 degrees outside, the air delivered to the classroom is 71 degrees.
    - A future cooling coil could be installed in these units, downstream of the heating coil.
    - Exterior classrooms on the north and south side of the 1972/1988 construction and exterior classrooms in the 1992 addition are served by these units.
    - VAV boxes regulate air flow quantity into each zone/classroom. Maximum air quantity for each classroom is between 800 and 1,000 cfm.
    - Air is supplied via ceiling diffusers.
    - Return air is pulled from down low. An exposed spiral duct is installed in each classroom that goes to the floor. A return grille is installed near floor level in the spiral duct. Many of these were observed to be blocked, by furniture, etc.
    - A packaged DX RTU was installed for the Comm Data room.
    - A boiler was installed to supplement the boiler from 1972. The 1972 boiler still remains in service.
- An addition was installed in 2002. No drawings were available.

    - 6 classrooms were added to the east end. Two RTUs serve this area. Both provide heating and ventilation only. One contains an energy recovery heat wheel.
    - Also a gym was added to the northwest corner. The RTU serving this space provides heating and ventilation only. Supply duct is distributed via a DuctSox. Air movement is noticeably better in this gym than in many other gyms in PSD.
- 1992 classrooms were added to the east of the 1988 construction. This is still served by the RTU installed in 1992.
- 1988 classrooms were added to the east and south of the 1972 construction. This area is now served by the HVAC update installed in 2012.
- 1972 was the original construction of the building. 3 MZ RTUs from this construction remain in place.
    - 1 MZ serves the interior spaces such as the media center and surrounding rooms. These spaces are adjacent to the exterior classrooms served by the 2012 DOAS system.
    - Another MZ RTU serves the kitchen and office areas.
    - The 3rd MZ serves the cafeteria.
- Kitchen does not have a dedicated make-up air unit.
- A packaged DX RTU serves the computer lab.

Air Conditioning Strategies

- Install chiller and chilled water piping and route to new RTUs
- Replace all existing RTUs in the building, except RTUs installed in 2012.
- Reuse RTUs, ductwork, and VAVs installed in 2012. Install chilled water coils in the existing RTUs.
- Reuse ductwork installed in the east addition, and add VAV zone control for each classroom.
- Remove all ductwork and piping in the 1972 area that remain from original construction. Install new VAV zoning for each classroom.
- Install a new RTU for the cafeteria and route chilled water to it.
- Install a dedicated make-up air unit for the kitchen with evaporative cooling.
- Packaged DX RTU for admin

Life Cycle Needs Due to Aging Equipment

- Remove all RTUs, ductwork and piping in the 1972 area that remain from original construction. Install new VAV zoning for each classroom.

- Install a new RTU for the cafeteria
- Replace the 1972 boiler still in service.
- Install a dedicated make-up air unit for the kitchen with evaporative cooling.
- Replace 1972 boiler

Improvement Strategies for DOAS

- Determine how the sequence of operation currently functions.
- Review sequence and determine changes that can optimize the current installation.
- Activate a night cooling cycle that gets the building as cool as possible prior to occupancy.
- Change return air to be installed at the ceiling in lieu of the floor. With many of the returns being blocked, it would be better to have them unrestricted at the ceiling. Also, with the return at the ceiling, warmer air that stratifies to the top of the room will be pulled into the return plenum in lieu of being mixed into the occupied space of the room.
- Install a cooling coil in RTUs installed in 2012.
- Install a DX split condensing unit for each of the 2012 RTUs.
- Deliver 55 degree air to the classroom.

Johnson Elementary School

Existing Infrastructure

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

    - No zoning for individual classrooms is provided. They all receive the same quantity and temperature of air.
    - Return grilles were not observed in the classrooms. Most likely the space between the ceiling and exposed roof joists was determined to be enough free area for return air to get back to the RTU.
    - Fan coil units that provide heating and ventilation only were installed in corridor, work areas and office areas. PSD staff has added economizers to the fan coils in the administration area to increase outside air quantities for warmer times of the year.
- Four classrooms were added to the west part of the building in 1994. These are now served by the 2012 DOAS system.
- Heating water piping and boilers were installed in 1988 and were all reused in the 2012 HVAC updates. Heat is provided by baseboard radiation at the exterior walls, which was installed in 2012.
- A packaged DX RTU installed by PSD serves the computer lab. Replacement should be anticipated in the next 5-7 years.
- The cafeteria is heated and ventilated via 4 ceiling mounted unit ventilators installed in 1988.
- Media Center is provided with heating and ventilation by an indoor AHU installed in 1988.
- The AHU serving the gym is original from 1988. This unit should be replaced in the next 10-15 years.
- Kitchen make-up air unit and evaporative cooler was replaced in 2012.

Air Conditioning Strategies

- Remove RTUs installed in 2012.
- Install new RTUs capable of delivering 1,000 to 1,500 cfm per classroom.
- Reuse supply duct installed in 2012 to the greatest extent possible and install VAV boxes to provide airflow zone control at each classroom, corridor and work areas.
- Install new return air duct main to new RTUs. Utilize plenum return from each classroom.
- Install chiller and route chilled water piping to new RTUs.
- Install chilled water coil in existing duct main serving the media center.
- Install new RTUs for the cafeteria and route chilled water to the new RTU.
- Install new packaged DX RTUs for the administration areas.

Life Cycle Needs Due to Aging Equipment

- Install a new RTU for the cafeteria to replace ceiling mounted UVs

Improvement Strategies for DOAS

- Install return air grilles at the ceiling, opposite the displacement diffuser. Install 2 small grilles in opposite corners.
- Install a cooling coil in RTUs installed in 2012.
- Install a DX split condensing unit for each of the 2) 2012 RTUs.
- Deliver 55° air to the classroom. 600 CFM of 55 degree air will be able to compensate for the heat gain from the lights and people. As the day warms up the room temperature may creep up, however, if the room is precooled overnight with the 55° air from the RTU, the room will stay comfortable for most of the day.
- Reuse supply duct installed in 2012 and install VAV boxes to provide airflow zone control at each classroom. Rework supply mains to install 2 or 3 ceiling diffusers in the middle of each classroom in lieu of the displacement ventilation diffusers.
    - Displacement ventilation diffusers are not designed for temperatures below 63° F. Discomfort will likely result if occupants feet are in contact with 55° F air.
    - Due to the air volume available to be delivered to each classroom, supplying 63° air via displacement ventilation is not anticipated to improve the cooling effect of these rooms as much as supplying 55° air via the ceiling.

Linton Elementary School

Existing Infrastructure

- 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.

Air Conditioning Strategies

- Remove RTUs installed in 2013.
- Install new RTUs capable of delivering 1,000 to 1,500 cfm per classroom.
- 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.
- Install new return air duct main to new RTUs. Utilize plenum return from each classroom.
- Install return grilles in each classroom.
- Install chiller and route chilled water piping to new RTUs.
- Install chilled water coil in existing supply duct main serving the media center.
- Install new RTU for the cafeteria and route chilled water to the new RTU.

- Install new packaged DX RTUs for the computer lab and administration areas.
- Install a new make-up air unit with evaporative cooling for the kitchen.

Life Cycle Needs Due to Aging Equipment

- Install a new RTU for the cafeteria to replace ceiling mounted UVs

Improvement Strategies for DOAS

- Install return air grilles at the ceiling, opposite the displacement diffuser. Install 2 small grilles in opposite corners.
- Install a cooling coil in RTUs installed in 2013.
- Install a DX split condensing unit for each of the 2) 2013 RTUs.
- Deliver 55° air to the classroom. 600 CFM of 55 degree air will be able to compensate for the heat gain from the lights and people. As the day warms up the room temperature may creep up, however, if the room is precooled overnight with the 55° air from the RTU, the room will stay comfortable for most of the day.
- Reuse supply duct installed in 2013 and install VAV boxes to provide airflow zone control at each classroom. Rework supply mains to install 2 or 3 ceiling diffusers in the middle of each classroom in lieu of the displacement ventilation diffusers.
    - Displacement ventilation diffusers are not designed for temperatures below 63° F. Discomfort will likely result if occupants feet are in contact with 55° F air.
    - Due to the air volume available to be delivered to each classroom, supplying 63° air via displacement ventilation is not anticipated to improve the cooling effect of these rooms as much as supplying 55° air via the ceiling.

LOPEZ ELEMENTARY SCHOOL

Existing Infrastructure

- 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

- Remove RTUs installed in 2013.
- Install new RTUs capable of delivering 1,000 to 1,500 cfm per classroom.
- Replace supply duct installed in 2013 and install VAV boxes to provide airflow zone control at each classroom, corridor and work areas.
- Install new return air duct main at new RTUs
- 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.
- Install new packaged DX RTUs for the computer lab and administration areas.
- Install new make-up air unit with evaporative cooling for the kitchen

Life Cycle Needs Due to Aging Equipment

- Install new AHUs for the cafeteria and media center.
- Install new packaged DX RTUs for the computer lab and administration areas.
- Install new make-up air unit with evaporative cooling for the kitchen
- Install a boiler to provide redundancy for the boiler plant

Improvement Strategies for DOAS

- Install additional return air grilles at the ceiling, opposite the displacement diffuser. Install 2 small grilles in opposite corners.
- Install a cooling coil in RTUs installed in 2013.
- Install a DX split condensing unit for each of the 2) 2013 RTUs.
- Deliver 55° air to the classroom. 600 CFM of 55 degree air will be able to compensate for the heat gain from the lights and people. As the day warms up the room temperature may creep up, however, if the room is precooled overnight with the 55° air from the RTU, the room will stay comfortable for most of the day.
- Reuse supply duct installed in 2013 and install VAV boxes to provide airflow zone control at each classroom. Rework supply mains to install 2 or 3 ceiling diffusers in the middle of each classroom in lieu of the displacement ventilation diffusers.
    - Displacement ventilation diffusers are not designed for temperatures below 63° F. Discomfort will likely result if occupants feet are in contact with 55° F air.
    - Due to the air volume available to be delivered to each classroom, supplying 63° air via displacement ventilation is not anticipated to improve the cooling effect of these rooms as much as supplying 55° air via the ceiling.

Olander Elementary School

Existing Infrastructure

- 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.

Air Conditioning Strategies

- Remove RTUs installed in 2013.
- Install new RTUs capable of delivering 1,000 to 1,500 cfm per classroom.

- 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.
- Install new return air duct main to new RTUs. Utilize plenum return from each classroom.
- Install chiller and route chilled water piping to new RTUs.
- Install chilled water coil in existing supply duct main serving the media center.
- Install new RTU for the cafeteria and route chilled water to the new RTU.
- Install new packaged DX RTUs for the computer lab and administration areas.

Life Cycle Needs Due to Aging Equipment

- Install a new RTU for the cafeteria to replace ceiling mounted UVs

Improvement Strategies for DOAS

- Install return air grilles at the ceiling, opposite the displacement diffuser. Install 2 small grilles in opposite corners.
- Install a cooling coil in RTUs installed in 2013.
- Install a DX split condensing unit for each of the 2) 2013 RTUs.
- Deliver 55° air to the classroom. 600 CFM of 55 degree air will be able to compensate for the heat gain from the lights and people. As the day warms up the room temperature may creep up, however, if the room is precooled overnight with the 55° air from the RTU, the room will stay comfortable for most of the day.
- Reuse supply duct installed in 2013 and install VAV boxes to provide airflow zone control at each classroom. Rework supply mains to install 2 or 3 ceiling diffusers in the middle of each classroom in lieu of the displacement ventilation diffusers.
    - Displacement ventilation diffusers are not designed for temperatures below 63° F. Discomfort will likely result if occupants feet are in contact with 55° F air.
    - Due to the air volume available to be delivered to each classroom, supplying 63° air via displacement ventilation is not anticipated to improve the cooling effect of these rooms as much as supplying 55° air via the ceiling.

SHEPARDSON ELEMENTARY SCHOOL

Existing Infrastructure

- 2012 HVAC updates installed a “tempered air” system utilizing indirect evaporative cooling Dedicated Outside Air Systems (DOAS)
    - This strategy is to deliver outside air into the classrooms that is approximately 14 degrees cooler than the outside air temperature during the warmer parts of the year. For instance – at 85 degrees outside, the air delivered to the classroom is 71 degrees.
    - Air quantities and fan speed are varied depending on the mode that the air handler is in.
        - In heating mode the goal is to deliver 300 cfm per classroom, slightly over Code required ventilation air
        - In tempering mode the goal is to deliver 600 cfm per classroom
    - Air is delivered into the classrooms via floor displacement ventilation diffusers. The strategy is to deliver the air down in the occupant zone in lieu of overhead at the ceiling.
    - No zoning for individual classrooms is provided. They all receive the same quantity and temperature of air.
    - Fan coil units that provide heating and ventilation only were installed in corridor, work areas and office areas. PSD staff has added economizers to the fan coils in the administration area to increase outside air quantities for warmer times of the year.
    - Heating water piping installed in 1977 was reused in the 2012 HVAC updates.
    - The 1977 boiler was replaced in 2012. However, this building only has 1 boiler, there is no redundancy for heating.
    - Baseboard radiation installed during 2012 project provides heat for the classrooms.
- The 2001 cafeteria addition is served by a heating and ventilation only ERV.
- The 1995 classroom addition is served by a heating and ventilation only RTU.
- A packaged DX unit serves the computer lab. It was installed in the mid-1990s and should be replaced within the next 3-5 years.
- The gym and media center indoor AHUs provide heating and ventilation only. They are original to the 1977 building construction.
- Kitchen has no make-up air unit, air is transferred from adjacent spaces to make-up for exhaust.

Air Conditioning Strategies

- Remove RTUs installed in 2012, 2001, and 1995.
- Remove media center AHU.

- Install new RTUs capable of delivering 1,000 to 1,500 cfm per classroom.
- Reuse supply duct installed in 2012 to the greatest extent possible and install VAV boxes to provide airflow zone control at each classroom, corridor and work areas.
- Install new return air duct main at new RTUs
- 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.
- Install new packaged DX RTUs for the computer lab and administration areas.
- Install new make-up air unit with evaporative cooling for the kitchen

Life Cycle Needs Due to Aging Equipment

- Install new RTUs for the gym and media center.
- Install new packaged DX RTU for administration.
- Install new make-up air unit with evaporative cooling for the kitchen
- Install a boiler to provide redundancy for the boiler plant
- Replace heating water piping in the entire school.

Improvement Strategies for DOAS

- Install a cooling coil in RTUs installed in 2012.
- Install a DX split condensing unit for each of the 2) 2012 RTUs.
- Deliver 55° air to the classroom. 600 CFM of 55 degree air will be able to compensate for the heat gain from the lights and people. As the day warms up the room temperature may creep up, however, if the room is precooled overnight with the 55° air from the RTU, the room will stay comfortable for most of the day.
- Reuse supply duct installed in 2012 and install VAV boxes to provide airflow zone control at each classroom. Rework supply mains to install 2 or 3 ceiling diffusers in the middle of each classroom in lieu of the displacement ventilation diffusers.
    - Displacement ventilation diffusers are not designed for temperatures below 63° F. Discomfort will likely result if occupants feet are in contact with 55° F air.
    - Due to the air volume available to be delivered to each classroom, supplying 63° air via displacement ventilation is not anticipated to improve the cooling effect of these rooms as much as supplying 55° air via the ceiling.

TAVELLI ELEMENTARY SCHOOL

Existing Infrastructure

- 2012 HVAC updates installed a "tempered air" system utilizing indirect evaporative cooling Dedicated Outside Air Systems (DOAS)
    - This strategy is to deliver outside air into the classrooms that is approximately 14 degrees cooler than the outside air temperature during the warmer parts of the year. For instance – at 85 degrees outside, the air delivered to the classroom is 71 degrees.
    - Air quantities and fan speed are varied depending on the mode that the air handler is in.
        - In heating mode the goal is to deliver 300 cfm per classroom, slightly over Code required ventilation air
        - In tempering mode the goal is to deliver 600 cfm per classroom
    - Air is delivered into the classrooms via floor displacement ventilation diffusers. The strategy is to deliver the air down in the occupant zone in lieu of overhead at the ceiling.
    - No zoning for individual classrooms is provided. They all receive the same quantity and temperature of air.
    - Fan coil units that provide heating and ventilation only were installed in corridor, work areas and office areas. PSD staff has added economizers to the fan coils in the administration area to increase outside air quantities for warmer times of the year.
    - Heating water piping and boilers were installed in 1993 and were all reused in the 2012 HVAC updates.
    - Baseboard radiation installed during 2012 project provides heat for the classrooms.
- In 1993 a significant remodel and addition was constructed. Classrooms were added to the north, southeast and southwest. A gym addition was constructed to the west part of the building. The gym is served by a heating and ventilation only RTU. All the classrooms are now served by the system installed in 2012. A boiler system and piping were installed throughout the building.
- Packaged DX RTUs serve each computer lab. One was installed in 1993, the other is not known.
- In 1989 a Media Center addition was constructed on the north end. This area is now served by the system installed in 2012.

- An addition in 1970 to the southeast was served by a MZ RTU. Also, one classroom was added in the southwest corner. These areas are now served from equipment installed in the 2012 HVAC updates project.
- The original construction of the building is believed to be in 1967 – the same time as Irish, Riffenburgh and Bauder. The Bauder documents show prototype floor plans of other schools, including Tavelli. The MZs serving the classrooms and office areas were removed during the 2012 HVAC project. The MZ serving the cafeteria and kitchen remains in place; this unit provides heating and ventilation only.
- Kitchen make-up air is provided by transfer air from the cafeteria – no dedicated make-up air unit is installed.

Air Conditioning Strategies

- Remove RTUs installed in 2012.
- Install new RTUs capable of delivering 1,000 to 1,500 cfm per classroom.
- Reuse supply duct installed in 2012 to the greatest extent possible and install VAV boxes to provide airflow zone control at each classroom, corridor and work areas.
- Install ceiling diffusers in lieu of the displacement ventilation diffusers.
- Install new return air duct main at new RTUs.
- Install chiller and route chilled water piping to new RTUs.
- Install a new RTU for the cafeteria. Route chilled water to the new RTU.
- Install new packaged DX RTUs for the computer labs and administration areas.
- Install new make-up air unit with evaporative cooling for the kitchen

Life Cycle Needs Due to Aging Equipment

- Install new RTU for the cafeteria.
- Install new packaged DX RTU for administration.
- Install new make-up air unit with evaporative cooling for the kitchen

Improvement Strategies for DOAS

- Install a cooling coil in RTUs installed in 2012.
- Install a DX split condensing unit for each of the 2) 2012 RTUs.
- Deliver 55° air to the classroom. 600 CFM of 55 degree air will be able to compensate for the heat gain from the lights and people. As the day warms up the room temperature may creep up, however, if the room is precooled

overnight with the 55° air from the RTU, the room will stay comfortable for most of the day.

- Reuse supply duct installed in 2012 and install VAV boxes to provide airflow zone control at each classroom. Rework supply mains to install 2 or 3 ceiling diffusers in the middle of each classroom in lieu of the displacement ventilation diffusers.
    - Displacement ventilation diffusers are not designed for temperatures below 63° F. Discomfort will likely result if occupants feet are in contact with 55° F air.
    - Due to the air volume available to be delivered to each classroom, supplying 63° air via displacement ventilation is not anticipated to improve the cooling effect of these rooms as much as supplying 55° air via the ceiling.

Werner Elementary School

Existing Infrastructure

- 2012 HVAC updates installed a "tempered air" system utilizing indirect evaporative cooling Dedicated Outside Air Systems (DOAS)
    - This strategy is to deliver outside air into the classrooms that is approximately 14 degrees cooler than the outside air temperature during the warmer parts of the year. For instance – at 85 degrees outside, the air delivered to the classroom is 71 degrees.
    - Air quantities and fan speed are varied depending on the mode that the air handler is in.
        - In heating mode the goal is to deliver 300 cfm per classroom, slightly over Code required ventilation air
        - In tempering mode the goal is to deliver 600 cfm per classroom
    - Air is delivered into the classrooms via floor displacement ventilation diffusers. The strategy is to deliver the air down in the occupant zone in lieu of overhead at the ceiling.
    - No zoning for individual classrooms is provided. They all receive the same quantity and temperature of air.
    - Return grilles were not observed in the classrooms. Most likely the space between the ceiling and exposed roof joists was determined to be enough free area for return air to get back to the RTU.
    - Fan coil units that provide heating and ventilation only were installed in corridor, work areas and office areas. PSD staff has added economizers

to the fan coils in the administration area to increase outside air quantities for warmer times of the year.

- Heating water piping and boilers were installed in 1988 and were all reused in the 2012 HVAC updates. Heat is provided by baseboard radiation at the exterior walls, which was installed in 2012.
- A packaged DX RTU installed by PSD serves the computer lab. Replacement should be anticipated in the next 5-7 years.
- The cafeteria is heated and ventilated via 4 ceiling mounted unit ventilators installed in 1988.
- Media Center is provided with heating and ventilation by an indoor AHU installed in 1988.
- The AHU serving the gym is original from 1988. This unit should be replaced in the next 10-15 years.
- Kitchen make-up air unit and evaporative cooler was replaced in 2012.

Air Conditioning Strategies

- Remove RTUs installed in 2012.
- Install new RTUs capable of delivering 1,000 to 1,500 cfm per classroom.
- Reuse supply duct installed in 2012 to the greatest extent possible and install VAV boxes to provide airflow zone control at each classroom, corridor and work areas.
- Install new return air duct main to new RTUs. Utilize plenum return from each classroom.
- Install return grilles for each classroom.
- Install chiller and route chilled water piping to new RTUs.
- Install chilled water coil in existing duct main serving the media center.
- Install new RTUs for the cafeteria and route chilled water to the new RTU.
- Install new packaged DX RTUs for the computer lab and administration areas.

Life Cycle Needs Due to Aging Equipment

- Install a new RTU for the cafeteria to replace ceiling mounted UVs

Improvement Strategies for DOAS

- Install return air grilles at the ceiling, opposite the displacement diffuser. Install 2 small grilles in opposite corners.
- Install a cooling coil in RTUs installed in 2012.
- Install a DX split condensing unit for each of the 2) 2012 RTUs.

- Deliver 55° air to the classroom. 600 CFM of 55 degree air will be able to compensate for the heat gain from the lights and people. As the day warms up the room temperature may creep up, however, if the room is precooled overnight with the 55° air from the RTU, the room will stay comfortable for most of the day.
- Reuse supply duct installed in 2012 and install VAV boxes to provide airflow zone control at each classroom. Rework supply mains to install 2 or 3 ceiling diffusers in the middle of each classroom in lieu of the displacement ventilation diffusers.
    - Displacement ventilation diffusers are not designed for temperatures below 63° F. Discomfort will likely result if occupants feet are in contact with 55° F air.
    - Due to the air volume available to be delivered to each classroom, supplying 63° air via displacement ventilation is not anticipated to improve the cooling effect of these rooms as much as supplying 55° air via the ceiling.

Boltz Middle School

Existing Infrastructure

- 2012 HVAC updates installed a "tempered air" system utilizing indirect evaporative cooling Dedicated Outside Air Systems (DOAS) for the northeast and northwest classroom areas.
    - This strategy is to deliver outside air into the classrooms that is approximately 17 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 73 degrees.
    - VAV boxes regulate air flow quantity into each zone/classroom
    - The northwest classroom air is delivered overhead in some rooms. In other rooms air is supplied via displacement ventilation diffusers. Return air is at the ceiling. Air quantity, depending on room size and purpose varies between 500 and 2,000 cfm. 1971 ductwork was reused downstream of the new VAV boxes.
    - The northeast classroom air is delivered via displacement ventilation diffusers on the floor. Return air is also at floor level. The strategy is to deliver the air down in the occupant zone in lieu of overhead at the ceiling. Air quantity varies between 650 and 2,000 cfm, depending on room size, orientation and function. 1971 ductwork was reused downstream of the new VAV boxes.

    - RTUs do not have room for a future cooling coil.
- Heating water piping and boilers were installed in 1971 and were all reused in the 2012 HVAC updates.
- Four indoor heating and ventilating air handlers, installed in a mechanical mezzanine, above the acoustic tile ceiling serve areas such as cafeteria, stage, music rooms, and administration area. These units are original to the 1971 construction. Access is a maintenance nightmare.
- Heating and ventilating RTUs installed in 1971 serve the gyms and Tech Ed areas.
- A heating and ventilating RTU installed in 1971 serve the classroom pod just east of the administration area.
- The 1993 addition is served by a constant volume RTU.
- Computer labs are air conditioned with packaged DX RTUs.
- Existing structure is wood so ducted return is required.
- Locker rooms do not have direct fresh air supply, only exhaust.

Air Conditioning Strategies

- Install chiller and chilled water piping and route to new RTUs
- Replace all existing RTUs, AHUs, piping and ductwork in the building, including work installed in 2012. Energy Code and best practice will require zoning control in these areas to be VAV.
- Install new RTUs with cooling for the Tech Ed rooms.
- Packaged DX RTU for admin
- Install new make-up air unit with evaporative cooling for the kitchen
- This building requires a total HVAC system removal and replacement. The extent of work required in this building will be so extensive that the work will not be able to be completed during a typical summer break. Moving of students and staff should be included in any plan to improve/update the HVAC system in this building.
    - To remove the air handlers installed in the mezzanine above the ceiling will requiring removing the roof.
    - Installing a roof capable of supporting RTUs is advised so that units are no longer installed in such an unfriendly maintenance location. In addition, modern units will not fit in the existing mezzanine, nor does access to install new units exist.
- Consider reusing the DOAS units from 2012 in other locations that could utilize some tempered air – such as gyms that frequently hold spectator sports.

Life Cycle Needs Due to Aging Equipment

- Install new heating and ventilation only RTUs for the gyms.
- Install new heating and ventilation only ERVs for the boys and girls locker rooms.
- Install new RTUs for the Tech Ed rooms.
- Replace all existing RTUs, AHUs, piping and ductwork in the building, except 2012 RTUs
- Install new packaged DX RTU for administration.
- Install new make-up air unit with evaporative cooling for the kitchen

Improvement Strategies for DOAS

- Install return air grilles at the ceiling, opposite the displacement diffuser in the areas that currently have floor return. This is best practice for displacement ventilation diffusers. Install 2 small grilles in opposite corners.
- Determine how the sequence of operation currently functions.
- Review sequence and determine changes that can optimize the current installation.
- Activate night cooling sequence to get building as cool as possible when occupants arrive in the morning.
- With no cooling coil space available in this unit, there are no other measures that would improve the cooling capability of these units.

AIR CONDITIONED

BETHKE ELEMENTARY SCHOOL

Existing Infrastructure

- This school was built in 2008. It is not "air conditioned" in the traditional sense. However, with the sustainable building construction and system installed – it has, according to PSD personnel, consistently provided adequate comfort in the warmer times of the year.
- The 2008 system consists of the following
    - VAV RTUs – 3 of which utilize a heat wheel for energy recovery.
    - VAV reheat zoning at each classroom, office area, etc
    - Cooling tower to create cool water coupled with a flat plate heat exchanger.
    - Chilled water piping routed to all RTUs except the gym and administration area.
    - The administration area is served by DX cooling
    - The gym is provided with heating and ventilation only.

- High efficiency boilers were installed in 2008 as well.
- Kitchen does not have any dedicated make-up air unit. Make-up air is via transfer air from the adjacent cafeteria RTU.

FULLANA LEARNING CENTER

Existing Infrastructure

- 2006 a residential style evaporative cooler was installed for the kitchen. The kitchen and storage rooms on the east end have no heat if the indoor AHU is not running. Doors to the gym and storage areas must be left open to insure no pipes freeze during cold spells.
- 1974 Building installed furnaces with DX condensing units – residential type installation. Total of eight furnaces was installed in the early education classroom and office area. Furnaces appear to have been replaced in 1996. Condensing units are replaced as they fail.
    - Return air path in some areas appears to have been comprised in various floor plan remodels that have happened through the years. Future HVAC projects should examine and rectify these issues.
    - Return duct is underground in some places.
    - Ductwork is 40 years in service, replacement should be done in the next 0-5 years.
- 1974 an indoor AHU with gas-fired duct furnace was installed for the Gym/Cafeteria.
    - Ductwork and AHU is 40 years in service, replacement should be done in the next 0-5 years.
- Annex has hot water heat from a small boiler that just serves the Annex. Heat is via UVs. Cooling is via ceiling mounted fan coils with condensing units on the east end at grade. Relief air for economizer mode is via barometric dampers under the high windows on the west side.

Equipment Replacement Strategies

- Install new furnaces and condensing units in Early Childhood area. Replace duct while work is done. Condensing furnaces are probably not feasible due to no presence of floor drains in existing furnace closets. Cooling coil condensate currently drains out through the wall. Find feasible solution for return air to all furnaces that can allow existing underground duct to be abandoned.
- Install new gas-fired, DX RTU for the gym/cafeteria. Replace duct while work is done.

- Install hot water heat, DX cooling indoor AHU in ceiling of Annex. VAV with 3 zones for each room. Create platform and access for unit. Patch UV outside air louvers and barometric relief damper openings in exterior wall.
- Add some gas-fired unit heaters on the east end where the kitchen and storage is to prevent pipes from freezing during cold spells – this will eliminate relying on staff to open doors.

Life Cycle Needs Due to Aging Equipment

- Install new gas-fired, DX RTU for the gym/cafeteria. Replace duct while work is done.
- Install hot water heat, DX cooling indoor AHU in ceiling of Annex. VAV with 3 zones for each room. Create platform and access for unit. Patch UV outside air louvers and barometric relief damper openings in exterior wall.
- Add some gas-fired unit heaters on the east end where the kitchen and storage is to prevent pipes from freezing during cold spells – this will eliminate relying on staff to open doors.

Recommendations for 2010 Bond project

- The monies slated for the 2017 HVAC updates from the 2010 Bond will likely allow for replacement of much of the equipment at this school.
- The updates to implement are listed below in order of priority, in case the allocated monies fall short.
    - Replace the existing AHU for the gym. Provide with a space for a future cooling coil since this space is also the cafeteria. Install new gas-fired RTU. Distribute air via Ductsox in the gym. Route some supply air into the kitchen area. Install a gas-fired unit heater in the water entry room where the existing AHU is installed.
    - Remove the existing unit ventilators, DX fan coils and barometric dampers in the Annex. Install a VAV air handler in the attic space. Provide three VAV boxes for zoning.
    - Replace boiler in the Annex
    - Replace furnaces with new DX coils and condensing units for the classroom and office areas.
        - Install new ductwork. Supply and return. Cap existing underground return. The duct is reaching the end of its service life.

- Note that the existing furnace rooms have no floor drains so condensing furnaces are probably an unlikely strategy. DX condensate currently discharges to grade. Gas heat exchanger condensate is not allowed to drain to storm like cooling coil condensate.

RICE ELEMENTARY SCHOOL

Existing Infrastructure

- This school was built in 2007. It is not "air conditioned" in the traditional sense. However, with the sustainable building construction and system installed – it has, according to PSD personnel, consistently provided adequate comfort in the warmer times of the year.
- The 2007 system consists of the following
  - VAV RTUs
  - VAV reheat zoning at each classroom, office area, etc
  - Cooling tower to create cool water coupled with a flat plate heat exchanger.
  - Chilled water piping routed to all RTUs except the gym and administration area.
  - The administration area is served by DX cooling
  - The gym is provided with heating and ventilation only.
- High efficiency boilers were installed in 2007 as well.
- Kitchen does not have any dedicated make-up air unit. Make-up air is via transfer air from the adjacent cafeteria RTU.

Equipment Replacement Strategies

- Install a new chiller and route chilled water piping to the existing piping network that is currently served by the cooling tower.
- Install a dedicated make-up air unit with evaporative cooling for the kitchen.

WELLINGTON MIDDLE SCHOOL

Existing Infrastructure

- In 2001 four classrooms were added on the northwest corner. This area is served by a packaged DX RTU.
- In 1993 a major addition was constructed on the north side of the building and south side of the building.

    - The entire addition is air conditioned by a number of constant volume packaged DX RTUs.
    - Zone control is achieved via duct reheat coils.
    - A boiler was installed to serve this area of the building.
- In 1982, 3 classrooms were added on the northeast side of the building. Each classroom is now served by a VUV with a DX cooling coil. The VUVs were installed in 2012.
- In 1979 locker rooms were built to the east and are still served by the original equipment. The original boiler still serves this portion of the building.
- 1978 a gym was constructed to the north of the original school, which is no longer standing. The gym is still served from 1978 equipment.
- Kitchen make-up air is from cafeteria transfer only, no dedicated make-up air unit exists.
- The corridors in the 1993 addition have very little to no air provided into them.

Equipment Replacement Strategies

- Install a new chiller and route chilled water piping to RTUs.
- Install new VAV RTUs for all areas.
- Install new ductwork and VAV boxes in the 1980 areas that have not been recently remodeled.
- Install new VAV boxes in the 1993 areas for VAV zone control to bring these areas up to current Energy Code and reduce utility costs.
- Provide supply and return air into the corridors.
- Install new AHUs for the gym and locker rooms.
- Ceiling diffusers throughout the original construction areas should be replaced.
- Install a dedicated make-up air unit with evaporative cooling for the kitchen.

Life Cycle Needs Due to Aging Equipment

- New Gym RTU
- New locker room ERVs
- Additional boiler to replace 1979 boiler and provide redundancy

ROCKY MOUNTAIN HIGH SCHOOL

Existing Infrastructure

- In 2012, DOAS RTUs were installed to serve the classroom area originally built in 1971 that faces south and had additions to both the east and west in 1994. 5

RTUs were added. Air quantity varies between 600 and 1,000 cfm. Ductwork from 1971 was reused in many locations.
    - Tempered air is delivered into the spaces from the RTUs
    - Air into each space is via ceiling diffusers
    - VAV boxes provide airflow control for each zone.
    - Heat is provided by reheating at the VAV boxes
    - Return air grilles are located down low
- New boilers were installed in both boiler rooms in 2012.
- Kitchen was provided with new evaporative cooling make-up air units in 2012.
- A gym addition was built in 2005. The gym is heating and ventilating only. The addition to the east side of the locker rooms is air conditioned by a packaged DX RTU.
- In 1994 significant additions were made to the building. Most of these areas are air conditioned via constant volume packaged DX RTUs.
    - Zone control is via reheat coils at each classroom.
- 1971 original construction consisted of mostly MZ RTUs. These systems provide heating and ventilation only. Areas such as Tech Ed, gyms, and locker rooms are still served by the original equipment. The auditorium, stage and theater rooms are served from three indoor AHUs installed in a mezzanine accessible from the roof; these units are original equipment as well.

Equipment Replacement Strategies

- Install a new chiller and route chilled water piping to RTUs.
- Install new RTUs for all the areas served by 1994 and 1971 era equipment
    - All areas that are to be air conditioned will receive cooling coils.
    - Areas such as gyms, will be heating and ventilation only.
- Install new ductwork and VAV boxes in the 1971 areas that have not been recently remodeled in 2012.
- Install new VAV boxes in the 1994 areas for VAV zone control to bring these areas up to current Energy Code and reduce utility costs.
- Install new AHUs with cooling coils in the roof mezzanine that serve the auditorium, theater, and stage areas. Significant structural modifications may be required to remove and replace these units.
- Ceiling diffusers throughout the 1971 original construction areas should be replaced.
- Install cooling coils in 2012 DOAS RTUs.

Life Cycle Needs Due to Aging Equipment

- Install new RTUs for all the areas served by 1994 and 1971 era equipment
    - Areas such as gyms, will be heating and ventilation only.
- Install new ductwork and VAV boxes in the 1971 areas that have not been recently remodeled in 2012.
- Install new VAV boxes in the 1994 areas for VAV zone control to bring these areas up to current Energy Code and reduce utility costs.
- Install new AHUs in the roof mezzanine that serve the auditorium, theater, and stage areas.
- Ceiling diffusers throughout the 1971 original construction areas should be replaced.

Improvement Strategies for DOAS

- Install cooling coils in the 2012 DOAS units and speed up the RTUs to provide more CFM to each classroom.