Haines School
Wood Fired Boiler Plant
Siting Evaluation
Final Report
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Haines Borough
Haines, Alaska

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1.0 Introduction

The following evaluation was commissioned to help evaluate two potential wood fired boiler plant locations for Haines School. The Borough has purchased three ACT pellet boilers systems from the Coast Guard and would like to use one or more of the boilers to serve the school. The existing school boiler room does not have space to house a new boiler, and there are no other spaces in the school building itself to install the boilers, so a new stand-alone plant will be required. The school boiler room is located on the east side of the school, on the new north wing. On the east side of the school, the site is very tight and parking is limited, so doing any new construction near the existing boiler room is not possible. Two nearby sites that will be evaluated are the south end of the Elk's Lodge property and the south end of the 5th Avenue right of way.

2.0 Boiler Sizing

Haines school is approximately 96,500 square feet and is heated with three oil fired, hot water, Weil McLain model 788, cast iron boilers, each rated at 1,488,000 Btu/hr output. Over the past 4 heating seasons, the school is using on average 35,300 gallons of fuel oil annually. See the appendix for a summary of fuel use over the past four heating seasons. The heating hot water is pumped through the school to various heating equipment by base mounted pumps with variable speed drives. The boilers also provide heat for the domestic hot water system and the pool. The boilers operate in a lead, lag, standby configuration, with each boiler sized to provide approximately 43% of the building heating load. This equates to a peak building heating design load of approximately 3,400,000 Btu/hr. Maintenance staff has indicated that one boiler handles the load for the majority of the time. At higher heating loads a second boiler comes on and usually only fires at low fire with the first boiler at high fire. The second boiler will sometimes run at high fire a peak heating times (for example in very cold weather and the school coming on from night setback temperatures in the morning). The boilers run through the summer to provide heat for the pool.

A basic bin data heating analysis was performed to help determine which boiler would be the best fit for the school. Wood boilers modulate well in their operating range, but are unable to modulate down as far as many fossil fuel boilers. The ACT boilers have a 3:1 turndown and fossil fuel boilers typically have a 4:1 or 5:1 turndown. Wood boilers should be sized to operate at full loads as much as possible, and then supplement the peak times with the existing fuel oil boilers. In general, previous energy models of various school buildings have shown that a boiler sized at approximately 50% of the peak load will accommodate approximately 85% of the heating run hours.

The analysis estimated energy use from envelope losses all year long and for heating ventilation air (estimated at 7,500 CFM based on the building mechanical plans) for the hours of 8:00 a.m. to 4:00 p.m. from September through May. The pool is also part of the energy use, but to keep the analysis simple, the pool energy was no was not directly calculated and is incorporated into the overall heating loss. In order to get close to the average annual fuel oil use, the peak load was estimated to actually be approximately 1,780,000 Btu/hr. This appears to be similar to the boiler operation experienced by the maintenance staff. They indicated one boiler usually handles the load, with the second one coming on in low fire. Anecdotally, this would indicate an estimated peak heating load of approximately 2,100,000 Btu/hr. The peak fuel use in one day was recorded as 310 gallons, which equates to a steady state load of approximately 1,500,000 Btu/hr. The analysis shows a boiler sized at approximately 1,200,000 Btu/hr will accommodate just

over 90% of the total heating energy. In the summer, when just the pool is the primary load, fuel use is on average approximately 45 gallons per day, which equates to a steady state load of approximately 220,000 Btu/hr.

The three ACT boilers that were purchased by the Borough have the following nominal outputs: 1,700,000 Btu/hr, 1,350,000 Btu/hr, and 500,000 Btu/hr. The boiler output data is based on burning pellets with low (8 – 10%) moisture content. When local microchips are used, they will have a higher moisture content than the pellets. The target moisture content is 20%, but it could be up to 30%. The ACT boilers can accommodate fuel up to 30% moisture content, but the higher moisture content will de-rate the boiler outputs as more energy will be taken to vaporize the additional water. To be conservative, the 30% moisture content value was used and so the de-rated outputs are estimated to be 1,250,000 Btu/hr, 950,000 Btu/hr, and 370,000 Btu/hr respectively. Based on these estimated de-rated outputs, the ACT CP1700 boiler would be the best fit for the school.

Since the Borough also has the smaller CP500 boiler as part of the overall package of equipment it purchased, it would be advantageous to use the smaller boiler in conjunction with the larger CP1700 boiler in a single plant to lower the effective system turn down, and be able to operate more efficiently in the summer months when the pool is the only load on the system.

To minimize the wood fired boiler cycling, a thermal storage tank should be utilized in conjunction with the boiler. The ACT boiler systems came with a 1040 gallon thermal storage tank, and a 3,000 gallon thermal storage tank. The 3,000 gallon thermal storage tank would be utilized with both boilers in a new boiler plant. With a 30 degree temperature difference in the tank, that would allow for a 35 minute run time for the larger boiler at full fire, and over 2 hours at minimum fire. For the smaller boiler, the tank would allow for approximately 2 hour run time at full fire and approximately 6 hours at minimum fire.

3.0 Integration with the Existing Heating System

As indicated above, the entire school is served by the new boiler room that was constructed in the 2007 addition and renovation project. This new plant was connected into the existing branches that served existing equipment in the original school building, the gym, and the pool. New 5” heating water supply and return mains were routed from the new boiler plant to the original boiler room location next to the gym to connect to these branches. There are also 3-1/2” mains that run from the old boiler room to the pool area primarily via a tunnel. Unfortunately, these branches cannot be utilized to inject heat from the wood fired boiler plant. The heating system uses two way control valves and variable speed pumps. The valves modulate as needed to meet the loads at each piece of equipment. As the valves open and close, the system pressure changes and the pumps adjust speed. As heating equipment is satisfied, the valves close and the pumps slow down and reduce flow. This is an energy saving feature of the heating system to save pump energy. Because of the dynamics of how the heating water system works it is not possible to guarantee that there would be enough flow or enough temperature differential in any of the existing branches to be able to absorb all the heat from the new boiler plant, and/or get the heat back to the boiler room where it can then be distributed to the rest of the building.

The best location to inject the heat from a wood fired boiler would the existing boiler room itself. The heat injection should occur in the heating water return main, after the last major branch joins the main and before the connections for the boilers.

Routing of the piping from the new boiler plant to the school boiler room from the Elk's Lot location would be very straight forward. The piping would run to the west and enter directly into the boiler room. Trenching would be required and the asphalt drive would need to be repaired.

Routing of the piping from the new boiler plant to the school boiler room from the 5th Ave location would be more involved. Three potential options are:

1. Route the piping underground from the new boiler plant to the pool building, and then route through the school to the boiler room. This would involve the least amount of trenching and asphalt repair, however, routing through the building is difficult. Ceiling space is very constricted, especially where the 2007 addition connected to the original high school building.

2. Route the piping underground from the new boiler plant to the west in the access road. Trenching would be required and the asphalt drive would need to be repaired. This route would require the most asphalt repair. There are also several utilities buried in this access drive that would need to be coordinated with.

3. Route the piping underground from the new boiler plant to the north and then west. The piping would run to the west and enter directly to the boiler room. Trenching would be required and the asphalt drive would need to be repaired across the access road. This route is appealing because it could be installed through unfinished areas just north of the tree line. An easement would need to be obtained to run along the back of the properties.

As the design develops further in the next phase of the project, other routing options could be investigated as well, including other options running through the school or along the perimeter of the school.

A surveyor should be hired and a preliminary site survey should be undertaken to get a better understanding of the various site utilities, buildings, and other site issues that could potentially be involved in developing these options.

4.0 Boiler Plant Building Concept

The base boiler building is illustrated in the appendix. The equipment that must fit in the boiler building include two boilers, two cyclone separator/induced draft fans, the thermal storage tank, boiler pumps, a heat injection pump, a heat exchanger, and two glycol systems pumps. The existing 3,000 gallon storage tank is approximately 15'-6" tall, and drives the height of the boiler plant. The base boiler plant is proposed to be slab on grade construction with wood stud walls and wood truss roof. The silo would be located adjacent to the building.

Because the heating water piping must run underground on the exterior, a 30% propylene glycol fluid is recommended to prevent any freezing issues. The existing school system

does not use glycol, so a heat exchanger would be required in the school boiler room. Because of the large thermal storage tank, a heat exchanger is proposed in the boiler plant as well to minimize the amount of glycol required. The wood boiler will be enabled and will only operate to maintain the set point in the thermal storage tank. The heat injection pump would pull the heated water from the thermal storage tank and heat the glycol loop. The flow diagram in the appendix illustrates the piping concept.

In the next phase of design development, if the Elk's site is selected, the distance is short enough that the piping running between the buildings could be buried below the frost level and this could avoid the need for glycol and system isolation heat exchangers and pumps. This should be reviewed in further detail in the future design phase.

The boiler plant should also be designed to allow for future expansion. If a small district heating system beyond the school is pursued in the future, the plant should be planned to allow expansion to add boilers as needed to accommodate the future loads.

Locating a greenhouse next the boiler plant would be another consideration when looking at the different sites. A couple of recent wood fired heating projects, such as plant in Tok, have used the wood fired heat for greenhouses and this has proved to be successful and popular. This would also influence the final layout and design of a boiler plant.

We recommend the building be served by its own electrical service from the local utility AP&T. There is space available in the MDP in the school boiler room to serve the boiler plant, but since the plant will be a remote standalone building, a new service should be planned for. This will allow the spare capacity at the MDP to be used by the school in the future. It will also allow the boiler plant to be separately metered.

5.0 Wood Fuel Types/Fuel Handling/Fuel Storage

The wood boilers burned wood pellets in their previous installation. The boiler systems came with the original pellet silos. Our understanding is the Borough would like to utilize the pellet silos and use pellets to operate the boilers initially. There is a desire to then convert to locally produced microchips. The ACT boilers can burn both pellets and microchips as long as the chips are less than 1-1/4" in size and have a maximum moisture content of 30%. The controls would just need to be adjusted for the fuel type to modify the feed rates and combustion air. The metering bin can also handle either type of wood fuel. This switch over is NOT automatic. Switching from one fuel type to another is possible, but several settings need to be adjusted with the boiler controls so the switch over should only be done after a lot of thought and a deliberate decision to switch fuels.

The biggest effect of changing from pellets to microchips is the fuel storage and fuel handling. The microchips are not as consistent in shape and size and are a bit more of a challenge to handle and move around. The microchips also have a lower bulk density (approximately 1/3 to 1/2 of pellets), so more chips are required for the same amount of energy compared to pellets.

ACT doesn't recommend using microchips in the pellet silos. The flex augers from the base of the silo do not handle the microchips well and can be problematic. ACT makes a rotating arm turntable style fuel handling system that works for pellets or microchips. The turntable typically operates in a 10 foot diameter and arms attached to the turntable sweep

the material into an auger which then feeds the metering bin. The drawback to this style of fuel handling unit is that the sweep arm can only handle about 3 feet of material on top of it. So it essentially is a day bin and would need to be refilled daily. It also requires additional building area to create the storage bin.

Another option for fuel storage and handling would be a bunker or large bin style storage system with a travelling auger or hydraulic wedge floor. This has been used successfully on larger projects that used ground wood fuel or wood chips, such as in Craig or Tok. Craig utilizes a wedge floor, and Tok utilizes a traveling auger. The traveling auger systems have worked well for many of the Fuels for Schools projects in the Western Continental United States and would be a potential way of storing and moving the microchips. The traveling auger would move from one end of the fuel bin to the other and pull the microchips onto a conveyor which would then deliver the microchips to the metering bin. Using a system like this will increase capital costs because of the bunker construction and the additional conveying equipment. This would, however, allow much more flexibility in how the chips are produced and delivered.

Another option is a hybrid option using roll off containers. A live bottom roll off container could be used in conjunction with a receiving bin, similar to the sweeper arm option. This has been done for a high school project in Colorado. Two or three containers could be installed just outside the boiler plant with controls that are set up to offload the roll off container and feed the receiving bin. The roll off containers would be designed specifically to hold and move the microchips. The roll off bins can hold approximately 10-15 tons of material and would need the use of a typical roll of container transport truck. As one container becomes empty, it could be removed and taken to a chip processing site to be filled. This could be done with a central chip processing facility that would fill the bin, and then it could be taken to the school. This option could be very functional and be used with various methods of producing the chips. Incorporating chip drying with this type of bin should also be investigated further.

The drawings in the appendix illustrate a couple of these concepts and what the boiler plant could look like.

The volume of microchips required for one week of peak heating would be approximately 22 tons and the volume for one month of peak heating would be approximately 87 tons.

When the boiler plant site is selected and the design of the plant moves to the next phase, a wood fuel handling vendor should be brought onto the team to assist with determining the most appropriate equipment to be used. This will allow the Borough to select the equipment that matches up best for the way the microchips are planned to be produced and delivered. This will also inform the boiler plant design so the building can be designed to accommodate the equipment in the most efficient manner possible and allow for future expansion as well.

If pellets are used initially, it is recommended to use the silo and flex auger provided with the boiler systems. The silo and auger were made for the pellets and works very well and would be virtually trouble free. Pellets could be used in the large bulk storage options mentioned above, however, the augers would be designed for the microchips and may not handle the pellets as well. Also, the more pellets are handled, the more they can start to break up and degrade, so minimizing the times they are moved and transferred is

beneficial. The boiler metering bins could have a pants type fitting installed on top of them that would receive pellets from the flex auger in one leg and chips from the chip conveying system in the other leg. Manual dampers would be needed to make sure only one fuel type is used a time, but this could be done to allow using two different fuel types.

6.0 Vocational Education Building

The vocational education building is served by a fuel oil fired boiler with a net output of 190,000 Btu/hr. It uses approximately 1,200 gallons annually. It would be hard to obtain an economic benefit to install a standalone pellet boiler for just this building. Instead of injecting heat from a potential wood plant directly into the heating hot water system, one consideration would be to connect this building to the main school heating system. There appears to be capacity in the branch lines serving the air handling units in the fan room on the south end of the elementary gym. A heat exchanger and pump could be added there and a 30% propylene glycol fluid pumped through the school and on to the Vocation Education Building where the heat could be added to that building loop via another heat exchanger and pump. The estimated cost for this work is shown in the appendix.

7.0 Estimated Costs

The total project costs are at a schematic design level and based on RS Means and recent biomass project construction cost data. The estimates are shown in the appendix and include a remote location factor.

Option Summaries				
	Elks	**5th North**	**5th Road**	**5th School**
Base	$ 461,725	$ 461,725	$ 461,725	$ 461,725
Integration	$ 71,156	$ 181,844	$ 213,469	$ 169,984
Total	**$ 532,881**	**$ 643,569**	**$ 675,194**	**$ 631,709**
Sweeper	$ 77,481	$ 77,481	$ 77,481	$ 77,481
Total	**$ 610,363**	**$ 721,050**	**$ 752,675**	**$ 709,191**
Auger	$ 379,500	$ 379,500	$ 379,500	$ 379,500
Total	**$ 912,381**	**$ 1,023,069**	**$ 1,054,694**	**$ 1,011,209**
Roll Off Bin	$ 196,075	$ 196,075	$ 196,075	$ 196,075
Total	**$ 806,438**	**$ 917,125**	**$ 948,750**	**$ 905,266**

The costs for the Elks location do not include any land purchase price or lease agreement costs. If that site is pursued, those additional costs need to be added into the estimate.

As can be seen above, adding the larger storage and fuel handing equipment has a significant impact in the capital costs. It should be noted that these costs are construction costs for building a boiler plant and are just one part of the larger fuel supply/fuel handling equation. While one fuel storage and handling option may be more or less expensive than another option, the total cost of fuel handling and delivery from forest to boiler should be factored in.

8.0 Advantages and Disadvantages of Each Site

The advantages and disadvantages of each list are listed below:

Elks Site

Advantages

Lowest capital cost.
Shorter distance to school boiler room (less pump energy).

Disadvantages

Property not owned by Borough.
Ability to expand on the site may be limited.

5th Ave Site

Advantages

On property already owned by Borough.
Grade change could be utilized to help with building and chip storage concepts.
Most suitable for a co-located greenhouse to be built next to the plant.

Disadvantages

Highest capital cost.
Each possible pipe route to the school boiler room has challenges and potential risk.
- North route requires an easement and goes through some urban forest area.
- Road route must be carefully installed to miss utilities.
- School route must run through some constricted spaces and may finished spaces.

9.0 ACT Maintenance Information

Maintenance for the ACT boilers does not entail much more than any other typical boiler system. For example, all boilers should be checked once a day regardless of type. The maintenance section of the boiler manual has been included in the appendix for reference. There will likely be on average additional maintenance of 1 to 2 hours per week for the ACT boilers. When the microchips are used, the maintenance may go up an additional 1 to 2 hours per week because the larger fuel handling components require more attention.

10.0 Summary

This siting report reviewed potential wood fired boiler plant locations, potential boiler sizes, possible building layouts, and estimates of probable cost for the respective options. There are other components to developing a successful wood fired heating project that include identifying fuel supply, determining fuel processing, identifying local contractors that can perform the work, and developing community support. These are outside of the scope of this report, but are still important and should be considered when developing a wood fired heating project.

Based on the fuel use and the basic temperature bin energy analysis, we recommend using a combination of the large and small boilers (model CP1700 and CP500) boilers for heating the school. This allows for a good overall system turn down and effective operation when just the pool is operating. We also recommend using the 3,000 gallon thermal storage tank in conjunction with the boilers to minimize cycling.

The best site location would be the Elk's Club lot mainly because of proximity to the school's boiler room where the heat injection should occur. However the Elk's site also has the biggest disadvantage because the site is not owned by the Borough. The costs for acquiring or developing a lease agreement are unknown at this time and could end up making this option cost more than the 5th Ave site.

The 5th Ave site is already owned by the Borough, and the grade change could be utilized in creating bulk storage of the microchips. This site would also accommodate a community greenhouse next the boiler plant. There are three potential routes to run piping from the wood boiler plant to connect to school boiler plant. Each are possible, but they have their own challenges and should be reviewed in closer detail.

A site survey should be performed in the areas where the buildings may be located and along the routes the piping may run to identify utilities and other site issues that could affect development in these locations.

Adding area to the building for bulk storage and larger fuel handling equipment in preparation for the microchips adds significantly to the capital cost of the project. Adding on to the boiler plant for the microchips storage could be done at a later date, however, the most cost effective time to construct that space would be when the boiler plant is constructed initially. Some cost savings could be achieved by constructing the larger building now, and purchase and install the fuel handling equipment at a later date. Since the long term viable wood fuel source to be used is likely to be the locally produced microchips, and that fuel source will likely be used within two years, it would be best to build out for the larger bulk storage and fuel handling to accommodate the microchips as part of the base project as funding allows.