Pre-Feasibility Assessment for Integration of Wood-Fired Heating Systems
Final Report
July 24, 2012

Ketchikan Gateway Borough School District
Ketchikan High School
Ketchikan, Alaska

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Ketchikan Gateway Borough School
Ketchikan Indian Association

In partnership with
Fairbanks Economic Development Corporation
Alaska Wood Energy Development Task Group

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1.0 Executive Summary

The following assessment was commissioned to determine the preliminary technical and economic feasibility of integrating a wood fired heating system at the Ketchikan High School in Ketchikan, Alaska.

The following tables summarize the current fuel use and the potential wood fuel use:

Table 1.1 - Annual Fuel Use Summary				
Facility Name	Fuel Type	Avg. Use (Gallons)	Current Cost/Gal	Annual Cost
High School	Fuel Oil	127,900	$3.70	$473,230

Table 1.2 - Annual Wood Fuel Use Summary			
	Fuel Oil (Gallons)	Wood Pellets (Tons)	Chipped/ Ground Wood (Tons)
High School	127,900	1049.3	1715.9
Note: Wood fuel use assumes offsetting 85% of the current energy use.			

Due to the large volume of wood needed to heat the building, pellet and chipped/ground fuel boilers were evaluated and cord wood systems were not considered. The options reviewed were as follows:

Chipped/Ground Wood Boiler Options:
A.1: A freestanding boiler building with interior wood storage.

Wood Pellet Boiler Options:
B.1: A freestanding boiler building with adjacent free standing pellet silo.

The following table summarizes the economic evaluation for each option:

Table 1.3 - Economic Evaluation Summary Ketchikan High School Biomass Heating System									
	Project Cost	Year 1 Operating Savings	NPV 30 yr at 3%	NPV 20 yr at 3%	20 Yr B/C Ratio	30 Yr B/C Ratio	ACF YR 20	ACF YR 30	YR ACF=PC
A.1	$1,793,000	$212,455	$10,179,110	$5,726,532	3.19	5.68	$8,187,188	$17,745,555	8
B.1	$1,400,000	$80,164	$6,373,815	$3,213,382	2.30	4.55	$4,694,187	$11,496,899	11

Ketchikan Gateway Borough School High School appears to be a good candidate for the use of a wood biomass heating systems. With the current economic assumptions and the current fuel use this wood chip boiler option has a very strong 20 year B/C ratio of 3.9, and the wood pellet boiler a strong 20 year B/C ratio of 2.3.

Because of the site constraints and air quality issues, the pellet boiler system would be recommended over the chip system.

2.0 Introduction

The following assessment was commissioned to determine the preliminary technical and economic feasibility of integrating a wood fired heating system at the Ketchikan High School in Ketchikan, Alaska.

3.0 Existing Building Systems

The Ketchikan High School is a steel and concrete framed building originally constructed in 1953 and expanded and remodeled extensively in mid 1990's. The facility is approximately 110,000 square feet and is heated by one 3,770,000 Btu/hr output hot water boiler and two 4,070,000 Btu/hr output hot water boilers. Domestic hot water is provided by three 120 gallon indirect water heaters using the boiler water as a heating source. These domestic water heaters then feed a single 1,500 gallon storage tank. The existing boilers are original to the renovation work in the mid 1990's and are in good condition. Most of the heating system infrastructure was also updated in the mid 1990's and is in good condition.

Facilities Dropped from Feasibility Study
No facilities were dropped from the feasibility study.

Facilities Added to Feasibility Study
No facilities were added to the feasibility study.

4.0 Energy Use

Fuel oil bills for the facilities were provided. The following table summarizes the data:

Table 4.1 - Annual Fuel Use Summary

Facility Name	Fuel Type	Avg. Use (Gallons)	Current Cost/Gal	Annual Cost
High School	Fuel Oil	127,900	$3.70	$473,230

Electrical energy consumption will increase with the installation of the wood fired boiler system because of the power needed for the biomass boiler components such as augers, conveyors, draft fans, etc. and the additional pumps needed to integrate into the existing heating systems. The cash flow analysis accounts for the additional electrical energy consumption and reduces the annual savings accordingly.

5.0 Biomass Boiler Size

The following table summarized the connected load of fuel fired boilers:

Table 5.1 - Connected Boiler Load Summary

			Output MBH	Peak Load Factor	Likely System Peak MBH
Gateway Borough School	Boiler 1	Fuel Oil	3770	0.65	2451
	Boiler 2	Fuel Oil	4070	0.65	2646
	Boiler 3	Fuel Oil	4070	0.65	2646
Total			11910		7742

Typically a wood heating system is sized to meet approximately 85% of the typical annual heating energy use of the building. The existing heating boilers would be used for the other 15% of the time during peak heating conditions, during times when the biomass boiler is down for servicing, and during swing months when only a few hours of heating each day are required. Recent energy models have found that a boiler sized at 50% to 60% of the building peak load will typically accommodate 85% of the boiler run hours.

Table 5.2 - Proposed Biomass Boiler Size			
	Likely System Peak MBH	Biomass Boiler Factor	Biomass Boiler Size MBH
High School	7742	0.6	4645

6.0 <u>Wood Fuel Use</u>

The types of wood fuel available in the area include wood pellets and chipped/ground wood fuel. The estimated amount of wood fuel needed for each wood fuel type for each building was calculated and is listed below:

Table 6.1 - Annual Wood Fuel Use Summary			
	Fuel Oil (Gallons)	Wood Pellets (Tons)	Chipped/ Ground Wood (Tons)
High School	127,900	1049.3	1715.9
Note: Wood fuel use assumes offsetting 85% of the current energy use.			

The amount of wood fuel shown in the table is for offsetting 85% of the total fuel oil use. The moisture content of the wood fuels and the overall wood burning system efficiencies were accounted for in these calculations. The existing fuel oil boilers were assumed to be 80% efficient. Wood pellets were assumed to be 7% MC with a system efficiency of 70%. Chipped/ground fuel was assumed to be 40% MC with a system efficiency of 65%.

As can be seen from the potential wood fuel use, the volume of wood is such that a cord wood system is not really practical and further analysis will look at pellet and chipped/ground fuel options.

There are sawmills and active logging operations in the region. Tongass Forest Enterprises has stared up a pellet plant in Ketchikan and is providing pellets to Sealaska. Pellets are also available from plants in British Columbia, Washington, and Oregon. There appears to be a sufficient available supply to service the boiler plant.

The unit fuel costs for fuel oil and the different fuel types were calculated and equalized to dollars per million Btu ($/MMBtu) to allow for direct comparison. The Delivered $/MMBtu is the cost of the fuel based on what is actually delivered to the heating system, which includes all the inefficiencies of the different systems. The Gross $/MMBtu is the cost of the fuel based on raw fuel, or the higher heating value and does not account for any system inefficiencies. The following table summarizes the equalized fuel costs at different fuel unit costs:

Table 6.2 - Unit Fuel Costs Equalized to $/MMBtu

Fuel Type	Units	Gross Btu/unit	System Efficiency	Net System Btu/unit	$/unit	Delivered $/MMBtu	Gross $/MMBtu
Fuel Oil	gal	138500	0.8	110800	$3.50	$31.59	$25.27
					$4.00	$36.10	$28.88
					$4.50	$40.61	$32.49
Pellets	tons	16400000	0.7	11480000	$300.00	$26.13	$18.29
					$350.00	$30.49	$21.34
					$400.00	$34.84	$24.39
Chips	tons	10800000	0.65	7020000	$75.00	$10.68	$6.94
					$100.00	$14.25	$9.26
					$125.00	$17.81	$11.57

7.0 <u>Boiler Plant Location and Site Access</u>

The boiler room is not large enough to accommodate a new wood fired boiler so a new stand-alone plant would be required. The best location for a plant would be just northwest of the boiler room, adjacent to the tennis courts to the north.

Any type of biomass boiler plant will require access by delivery vehicles, typically 40 foot long vans or some similar type of trailer. The school is built on a steep site, limiting vehicle access and space for constructing wood heating systems. A wood pellet boiler with adjacent silos appear to the most appropriate solution. Wood pellet fuel would need to be conveyed into the silo utilizing a pneumatic blower or grain auger. A pneumatic blower allows greater flexibility in the relationship between the delivery vehicle and silo.

8.0 <u>Integration with Existing Heating System</u>

Integration of a wood fired boiler system would be relatively straight forward in the building. The field visit confirmed the location of the boiler room in order to identify an approximate point of connection from a biomass boiler to the existing building. Piping from the biomass boiler plant would be run below ground with pre-insulated pipe and extended to the face of each building, and extended up the exterior surface of the school in order to penetrate exterior wall into the boiler room. Once the hot water supply and return piping enters the existing boiler room it would be connected to existing supply and return pipes in appropriate locations in order to utilize existing pumping systems within each building.

9.0 <u>Air Quality Permits</u>

Resource System Group has done a preliminary review of potential air quality issues in the area. Southeast Alaska is has meteorological conditions that can create thermal inversions, which are unfavorable for the dispersion of emissions. The proposed boiler size at this location is small enough, that the boiler is not likely to require any State or Federal permits. Since this plant will be located at a school and is also located in the populated area, the air quality will likely be scrutinized and modeling of emissions, the stack height, and of air pollution control devices is recommended. RSG also recommends pellet systems over chip systems for the ability of pellets to burn cleaner than chip systems. See the air quality memo in Appendix D.

10.0 Wood Heating Options

The technologies available to produce heating energy from wood based biomass are varied in their approach, but largely can be separated into three types of heating plants: cord wood, wood pellet and wood chip/ground wood fueled. See Appendix E for these summaries.

Due to the large volume of wood needed to heat the building, pellet and chipped/ground fuel boilers were evaluated and cord wood systems were not considered. The options reviewed were as follows:

Chipped/Ground Wood Boiler Options:

A.1: A freestanding boiler building with interior wood storage.

Wood Pellet Boiler Options:

B.1: A freestanding boiler building with adjacent free standing pellet silo.

11.0 Estimated Costs

The total project costs are at a preliminary design level and are based on RS Means and recent biomass project bid data. The estimates are shown in the appendix. These costs are conservative and if a deeper level feasibility analysis is undertaken and/or further design occurs, the costs may be able to be reduced.

12.0 Economic Analysis Assumptions

The cash flow analysis assumes fuel oil at $3.70/gal, electricity at $0.10/kwh, wood pellets delivered at $300/ton, and ground/chipped wood fuel delivered at $100/ton. The fuel oil and electricity costs were based on utility bills. Pellet costs were obtained from Tongass Forest Enterprises.

It is assumed that the wood boiler would supplant 85% of the estimated heating use, and the existing heating systems would heat the remaining 15%. Each option assumes the total project can be funded with grants and non obligated capital money. The following inflation rates were used: O&M - 2%, Fossil Fuel – 5%, Wood Fuel – 3%, Discount Rate for NPV calculation – 3%. The fossil fuel inflation rate is based on the DOE EIA website. DOE is projecting a slight plateau with a long term inflation of approximately 5%. As a point of comparison, oil prices have increased at an annual rate of over 8% since 2001.

The analysis also accounts for additional electrical energy required for the wood fired boiler system as well as the system pumps to distribute heating hot water to the buildings. Wood fired boiler systems also will require more maintenance, and these additional maintenance costs are also factored into the analysis.

13.0 Results of Evaluation

The following table summarizes the economic evaluation for each option:

Table 13.1 - Economic Evaluation Summary
Ketchikan High School Biomass Heating System

	Project Cost	Year 1 Operating Savings	NPV 30 yr at 3%	NPV 20 yr at 3%	20 Yr B/C Ratio	30 Yr B/C Ratio	ACF YR 20	ACF YR 30	YR ACF=PC
A.1	$1,793,000	$212,455	$10,179,110	$5,726,532	3.19	5.68	$8,187,188	$17,745,555	8
B.1	$1,400,000	$80,164	$6,373,815	$3,213,382	2.30	4.55	$4,694,187	$11,496,899	11

The benefit to cost ratio (B/C) takes the net present value (NPV) of the net energy savings and divides it by the construction cost of the project. A B/C ratio greater than or equal to 1.0 indicates an economically advantageous project.

Accumulated cash flow (ACF) is another evaluation measure that is calculated in this report and is similar to simple payback with the exception that accumulated cash flow takes the cost of financing and fuel escalation into account. For many building owners, having the accumulated cash flow equal the project cost within 15 years is considered necessary for implementation. If the accumulated cash flow equals project cost in 20 years or more, that indicates a challenged project. Positive accumulated cash flow should also be considered an avoided cost as opposed to a pure savings.

Because this project involves as school, a life cycle cost analysis following the requirements of the State of Alaska Department of Education & Early Development was completed and the data is summarized in the following table:

Table 13.2 Life Cycle Costs of Project Alternatives

	Alternate #1 Existing Boiler	Alternate #2 Wood Pellet Boiler
Initial Investment Cost	$0	$1,400,000
Operations Cost	$11,098,820	$6,160,797
Maintenance & Repair Cost	$0	$56,725
Replacement Cost	$0	$0
Residual Value	$0	$0
Total Life Cycle Cost	$11,098,820	$7,617,523

This life cycle cost analysis also indicates a pellet boiler system is a strong project.

14.0 Project Funding

The Ketchikan Gateway Borough School District may pursue a biomass project grant from the Alaska Energy Authority.

The Ketchikan Gateway Borough School District could also enter into a performance contract for the project. Companies such as Siemens, McKinstry, Johnson Controls and Chevron have expressed an interest in participating in funding projects of all sizes throughout Alaska. This allows the facility owner to pay for the project entirely from the guaranteed energy savings, and to minimize the project funds required to initiate the project. The scope of the project may be expanded to include additional energy conservation measures such as roof and wall insulation and upgrading mechanical systems.

15.0 <u>Summary</u>

Ketchikan Gateway Borough School High School appears to be a good candidate for the use of a wood biomass heating systems. With the current economic assumptions and the current fuel use this wood chip boiler option has a very strong 20 year B/C ratio of 3.9, and the wood pellet boiler a strong 20 year B/C ratio of 2.3.
Because of the site constraints and air quality issues, the pellet boiler system would be recommended over the chip system.

Additional sensitivity analysis was performed on the wood pellet option. The cost of the wood fuel was varied, and the 20 year B/C ratio exceeds 1.0 up to $385/ton.

16.0 <u>Recommended Actions</u>

Most grant programs will likely require a full feasibility assessment. A full assessment would provide more detail on the air quality issues, wood fuel resources, and a schematic design of the boiler systems and system integration to obtain more accurate costs.

It is recommended that the best location for a boiler plant be reviewed in more detail. A boiler plant located further east than shown on the drawing may be avoid taking up parking spots, but a portion of the tennis court may be lost to accommodate the plant. The route and method of delivering pellets needs to be investigated further as this will affect the best location for the boiler plant as well.

APPENDIX A

Preliminary Estimates of Probable Cost

Preliminary Estimates of Probable Cost
Ketchikan High School Biomass Heating Options
Ketchikan, AK

Option A.1 Wood Chip

Chip Storage/ Boiler Building:	$270,000
Wood Heating & Wood Handling System:	$325,000
Stack/Air Pollution Control Device:	$180,000
Mechanical/Electrical within Boiler Building:	$150,000
Underground Piping	$25,000
KHS Integration	$56,000
Subtotal:	$1,006,000
30% Remote Factor	$301,800
Subtotal:	$1,307,800
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$196,170
Subtotal:	$1,503,970
15% Contingency:	$225,596
Total Project Costs	**$ 1,729,566**

Option B.1 Pellet

Chip Storage/ Boiler Building:	$270,000
Wood Heating & Wood Handling System:	$265,000
Stack/Air Pollution Control Device:	$50,000
Mechanical/Electrical within Boiler Building:	$150,000
Underground Piping	$25,000
KHS Integration	$56,000
Subtotal:	$816,000
30% Remote Factor	$244,800
Subtotal:	$1,060,800
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$159,120
Subtotal:	$1,219,920
15% Contingency:	$182,988
Total Project Costs	**$ 1,402,908**

APPENDIX B

Cash Flow Analysis

Ketchikan High School

Ketchikan, AK

Option A.1

Wood Chip Boiler

Date: July 24, 2012
Analyst: CTA Architects Engineers - Nick Salmon & Nathan Ratz

EXISTING CONDITIONS	**KHS**				**Total**
Existing Fuel Type:	Fuel Oil	Fuel Oil	Fuel Oil	Fuel Oil	
Fuel Units:	gal	gal	gal	gal	
Current Fuel Unit Cost:	$3.70	$3.60	$3.60	$3.60	
Estimated Average Annual Fuel Usage:	127,900				127,900
Annual Heating Costs:	$473,230	$0	$0	$0	$473,230
ENERGY CONVERSION (to 1,000,000 Btu; or 1 dkt)					
Fuel Heating Value (Btu/unit of fuel):	138500	138500	138500	138500	
Current Annual Fuel Volume (Btu):	17,714,150,000	0	0	0	
Assumed efficiency of existing heating system (%):	80%	80%	80%	80%	
Net Annual Energy Produced (Btu):	14,171,320,000	0	0	0	14,171,320,000

WOOD FUEL COST	**Wood Chips**
$/ton:	$100.00
Assumed efficiency of wood heating system (%):	65%
PROJECTED WOOD FUEL USAGE	
Estimated Btu content of wood fuel (Btu/lb) - **Assumed 40% MC**	5400
Tons of wood fuel to supplant net equivalent of 100% annual heating load.	2,019
Tons of wood fuel to supplant net equivalent of 85% annual heating load.	1,716
25 ton chip van loads to supplant net equivalent of 85% annual heating load.	69

Project Capital Cost	**-$1,730,000**

Project Financing Information	
Percent Financed	**0.0%**
Amount Financed	$0
Amount of Grants	$1,730,000
Interest Rate	5.00%
Term	10
Annual Finance Cost (years)	$0

Additional Power Use		
Est. Pwr Use	45000	kWh
Elec Rate	$0.280	/kWh

Additional Maintenance					
Type	Hr/Wk	Wk/Yr	Total Hr	Wage/Hr	Total
Biomass System	4.0	40	160	$20.00	$3,200
Other	0.0	40	0	$20.00	$0
1st 2 Year Learning	3.0	40	120	$20.00	$2,400

		Net Benefit	B/C Ratio
Simple Payback: Total Project Cost/Year One Operating Cost Savings:	8.1 years		
Net Present Value (30 year analysis):	$10,248,706	$8,518,706	5.92
Net Present Value (20 year analysis):	$5,796,128	$4,066,128	3.35
Year Accumulated Cash Flow > 0	#N/A		
Year Accumulated Cash Flow > Project Capital Cost	7		

Inflation Factors	
O&M Inflation Rate	2.0%
Fossil Fuel Inflation Rate	5.0%
Wood Fuel Inflation Rate	3.0%
Electricity Inflation Rate	3.0%
Discount Rate for Net Present Value Calculation	3.0%

Cash flow Descriptions	**Unit Costs**	**Heating Source Proportion**	**Annual Heating Source Volumes**	**Heating Units**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**	**Year 20**	**Year 25**	**Year 30**
Existing Heating System Operating Costs																						
Displaced heating costs	$3.70		127900	gal	$473,230	$496,892	$521,736	$547,823	$575,214	$603,975	$634,173	$665,882	$699,176	$734,135	$770,842	$809,384	$849,853	$892,346	$936,963	$1,195,829	$1,526,214	$1,947,879
Displaced heating costs	$3.60		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Displaced heating costs	$3.60		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Displaced heating costs	$3.60		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Biomass System Operating Costs																						
Wood Fuel ($/ton, delivered to boiler site)	$100.00	85%	1716	tons	$171,590	$176,738	$182,040	$187,501	$193,126	$198,920	$204,888	$211,034	$217,365	$223,886	$230,603	$237,521	$244,646	$251,986	$259,545	$300,884	$348,807	$404,363
Small load existing fuel	$3.70	15%	19185	gal	$70,985	$74,534	$78,260	$82,173	$86,282	$90,596	$95,126	$99,882	$104,876	$110,120	$115,626	$121,408	$127,478	$133,852	$140,544	$179,374	$228,932	$292,182
Small load existing fuel	$3.60	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Small load existing fuel	$3.60	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Small load existing fuel	$3.60	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Additional Operation and Maintenance Costs					$3,200	$3,264	$3,329	$3,396	$3,464	$3,533	$3,604	$3,676	$3,749	$3,824	$3,901	$3,979	$4,058	$4,140	$4,222	$4,662	$5,147	$5,683
Additional Operation and Maintenance Costs First 2 years					$2,400	$2,448																
Additional Electrical Cost	$0.280				$12,600	$12,978	$13,367	$13,768	$14,181	$14,607	$15,045	$15,496	$15,961	$16,440	$16,933	$17,441	$17,965	$18,504	$19,059	$22,094	$25,613	$29,693
Annual Operating Cost Savings					***$212,455***	***$226,930***	***$244,739***	***$260,984***	***$278,161***	***$296,319***	***$315,511***	***$335,793***	***$357,224***	***$379,864***	***$403,779***	***$429,035***	***$455,706***	***$483,865***	***$513,592***	***$688,814***	***$917,714***	***$1,215,958***
Financed Project Costs - Principal and Interest					***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***								
Displaced System Replacement Costs (year one only)					***0***																	
Net Annual Cash Flow					***212,455***	***226,930***	***244,739***	***260,984***	***278,161***	***296,319***	***315,511***	***335,793***	***357,224***	***379,864***	***403,779***	***429,035***	***455,706***	***483,865***	***513,592***	***688,814***	***917,714***	***1,215,958***
Accumulated Cash Flow					***212,455***	***439,385***	***684,125***	***945,109***	***1,223,269***	***1,519,588***	***1,835,099***	***2,170,893***	***2,528,117***	***2,907,981***	***3,311,760***	***3,740,795***	***4,196,501***	***4,680,366***	***5,193,958***	***8,268,776***	***#########***	***17,827,143***

Ketchikan High School
Ketchikan, AK

Option B.1
Wood Pellet Boiler

Date: July 24, 2012
Analyst: CTA Architects Engineers - Nick Salmon & Nathan Ratz

EXISTING CONDITIONS	**KHS**				**Total**
Existing Fuel Type:	Fuel Oil	Fuel Oil	Fuel Oil	Fuel Oil	
Fuel Units:	gal	gal	gal	gal	
Current Fuel Unit Cost:	$3.70	$3.70	$3.70	$3.70	
Estimated Average Annual Fuel Usage:	127,900				127,900
Annual Heating Costs:	$473,230	$0	$0	$0	$473,230
ENERGY CONVERSION (to 1,000,000 Btu; or 1 dkt)					
Fuel Heating Value (Btu/unit of fuel):	138500	138500	138500	138500	
Current Annual Fuel Volume (Btu):	17,714,150,000	0	0	0	
Assumed efficiency of existing heating system (%):	80%	80%	80%	80%	
Net Annual Energy Produced (Btu):	14,171,320,000	0	0	0	14,171,320,000

WOOD FUEL COST	**Wood Pellets**
$/ton:	$300.00
Assumed efficiency of wood heating system (%):	70%
PROJECTED WOOD FUEL USAGE	
Estimated Btu content of wood fuel (Btu/lb) - **Assumed 7% MC**	8200
Tons of wood fuel to supplant net equivalent of 100% annual heating load.	1,234
Tons of wood fuel to supplant net equivalent of 85% annual heating load.	1,049
25 ton chip van loads to supplant net equivalent of 85% annual heating load.	42

Project Capital Cost	**-$1,400,000**

Project Financing Information	
Percent Financed	**0.0%**
Amount Financed	$0
Amount of Grants	$1,400,000
Interest Rate	5.00%
Term	10
Annual Finance Cost (years)	$0

Additional Power Use		
Est. Pwr Use	25000	kWh
Elec Rate	$0.100	/kWh

Additional Maintenance					
Type	Hr/Wk	Wk/Yr	Total Hr	Wage/Hr	Total
Biomass System	4.0	40	160	$20.00	$3,200
Other	0.0	40	0	$20.00	$0
1st 2 Year Learning	2.0	40	80	$20.00	$1,600

		Net Benefit	B/C Ratio
Simple Payback: Total Project Cost/Year One Operating Cost Savings:	17.5 years		
Net Present Value (30 year analysis):	$6,373,815	$4,973,815	4.55
Net Present Value (20 year analysis):	$3,213,382	$1,813,382	2.30
Year Accumulated Cash Flow > 0	#N/A		
Year Accumulated Cash Flow > Project Capital Cost	11		

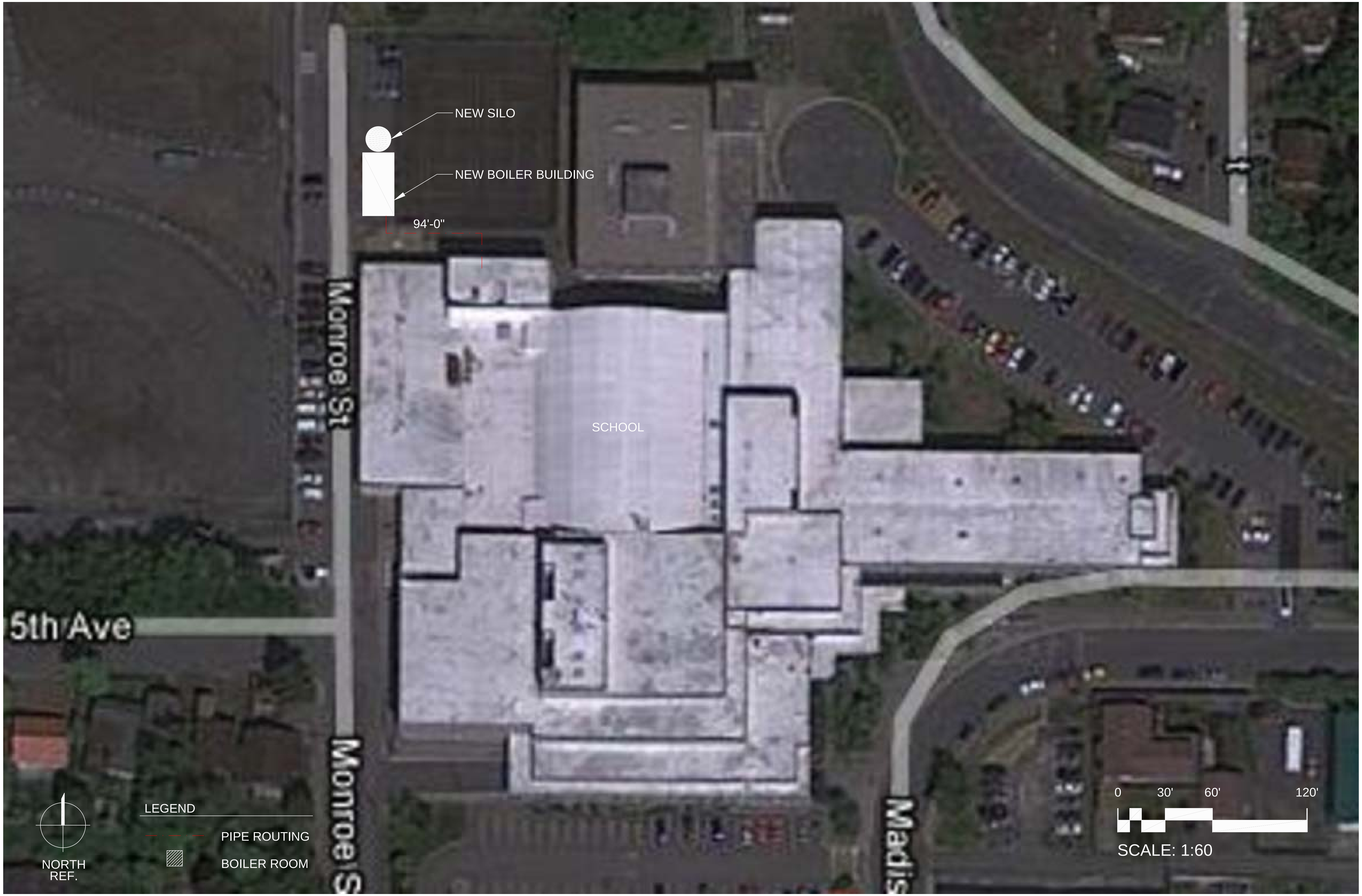
Inflation Factors	
O&M Inflation Rate	2.0%
Fossil Fuel Inflation Rate	5.0%
Wood Fuel Inflation Rate	3.0%
Electricity Inflation Rate	3.0%
Discount Rate for Net Present Value Calculation	3.0%

Cash flow Descriptions	**Unit Costs**	**Heating Source Proportion**	**Annual Heating Source Volumes**	**Heating Units**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Existing Heating System Operating Costs														
Displaced heating costs	$3.70		127900	gal	$473,230	$496,892	$521,736	$547,823	$575,214	$603,975	$634,173	$665,882	$699,176	$734,135
Displaced heating costs	$3.70		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Displaced heating costs	$3.70		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Displaced heating costs	$3.70		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Biomass System Operating Costs														
Wood Fuel ($/ton, delivered to boiler site)	$300.00	85%	1049	tons	$314,781	$324,224	$333,951	$343,970	$354,289	$364,918	$375,865	$387,141	$398,755	$410,718
Small load existing fuel	$3.70	15%	19185	gal	$70,985	$74,534	$78,260	$82,173	$86,282	$90,596	$95,126	$99,882	$104,876	$110,120
Small load existing fuel	$3.70	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Small load existing fuel	$3.70	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Small load existing fuel	$3.70	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Additional Operation and Maintenance Costs					$3,200	$3,264	$3,329	$3,396	$3,464	$3,533	$3,604	$3,676	$3,749	$3,824
Additional Operation and Maintenance Costs First 2 years					$1,600	$1,632								
Additional Electrical Cost	$0.100				$2,500	$2,575	$2,652	$2,732	$2,814	$2,898	$2,985	$3,075	$3,167	$3,262
Annual Operating Cost Savings					***$80,164***	***$90,662***	***$103,543***	***$115,552***	***$128,366***	***$142,030***	***$156,594***	***$172,108***	***$188,628***	***$206,211***
Financed Project Costs - Principal and Interest					***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***
Displaced System Replacement Costs (year one only)					***0***									
Net Annual Cash Flow					***80,164***	***90,662***	***103,543***	***115,552***	***128,366***	***142,030***	***156,594***	***172,108***	***188,628***	***206,211***
Accumulated Cash Flow					***80,164***	***170,827***	***274,370***	***389,922***	***518,287***	***660,317***	***816,910***	***989,019***	***1,177,647***	***1,383,858***

Cash flow Descriptions	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**	**Year 20**	**Year 25**	**Year 30**
Existing Heating System Operating Costs								
Displaced heating costs	$770,842	$809,384	$849,853	$892,346	$936,963	$1,195,829	$1,526,214	$1,947,879
Displaced heating costs	$0	$0	$0	$0	$0	$0	$0	$0
Displaced heating costs	$0	$0	$0	$0	$0	$0	$0	$0
Displaced heating costs	$0	$0	$0	$0	$0	$0	$0	$0
Biomass System Operating Costs								
Wood Fuel ($/ton, delivered to boiler site)	$423,039	$435,731	$448,803	$462,267	$476,135	$551,970	$639,885	$741,802
Small load existing fuel	$115,626	$121,408	$127,478	$133,852	$140,544	$179,374	$228,932	$292,182
Small load existing fuel	$0	$0	$0	$0	$0	$0	$0	$0
Small load existing fuel	$0	$0	$0	$0	$0	$0	$0	$0
Small load existing fuel	$0	$0	$0	$0	$0	$0	$0	$0
Additional Operation and Maintenance Costs	$3,901	$3,979	$4,058	$4,140	$4,222	$4,662	$5,147	$5,683
Additional Operation and Maintenance Costs First 2 years								
Additional Electrical Cost	$3,360	$3,461	$3,564	$3,671	$3,781	$4,384	$5,082	$5,891
Annual Operating Cost Savings	***$224,916***	***$244,806***	***$265,950***	***$288,416***	***$312,280***	***$455,438***	***$647,168***	***$902,321***
Financed Project Costs - Principal and Interest								
Displaced System Replacement Costs (year one only)								
Net Annual Cash Flow	***224,916***	***244,806***	***265,950***	***288,416***	***312,280***	***455,438***	***647,168***	***902,321***
Accumulated Cash Flow	***1,608,773***	***1,853,580***	***2,119,529***	***2,407,946***	***2,720,226***	***4,694,187***	***7,524,448***	***11,496,899***

APPENDIX C

Site Plan



Drawn By SSF
Checked By NHR
Date 07/24/12
CTA # FEDC
Cad File: J:ketchSCOL

BIOMASS PRE-FEASIBILITY ASSESSMENT
KETCHIKAN HIGH SCHOOL
KETCHIKAN, ALASKA

CTA
MISSOULA, MT
(406)728-9522
Fax (406)728-8287

SITE PLAN

APPENDIX D

Air Quality Report

To:	Nick Salmon
From:	John Hinckley
Subject:	Ketchikan-Craig Cluster Feasibility Study
Date:	24 July 2012

INTRODUCTION

At your request, RSG has conducted an air quality feasibility study for seven biomass energy installations in Ketchikan and Craig, Alaska. These sites are located in the panhandle of Alaska. The following equipment is proposed:

- Ketchikan
    - One 4,700,000 Btu/hr (heat output) pellet boiler at the Ketchikan High School.
    - One 800,000 Btu/hr (heat output) pellet boiler at the Ketchikan Indian Council Medical Facility.
    - One 150,000 Btu/hr (heat output) pellet boiler at the Ketchikan Indian Council Votec School.
    - One 200,000 Btu/hr (heat output) pellet boiler at the old Ketchikan Indian Council Administration Building.
- Craig
    - One 450,000 Btu/hr (heat output) cord wood boiler at the Craig Tribal Association Building.
    - One 450,000 Btu/hr (heat output) cord wood boiler near the Fire Hall.
    - One 250,000 Btu/hr (heat output) cord wood boiler at the Shaan-Seet Office.

A USGS map of the Ketchikan study area is provided in Figure 1 below. As shown, the area is mountainous, with Ketchikan located on the southwest side of a mountain range. Ketchikan has a population of 14,070. The area is relatively fairly well populated and developed relative to other areas in Alaska. The area is also a port for cruise ships, which are significant sources of air pollution. The topography, population, level of development, and existing emission sources has the potential to create localized, temporary problematic air quality.

Figure 1: USGS Map Illustrating the Ketchikan Study Area

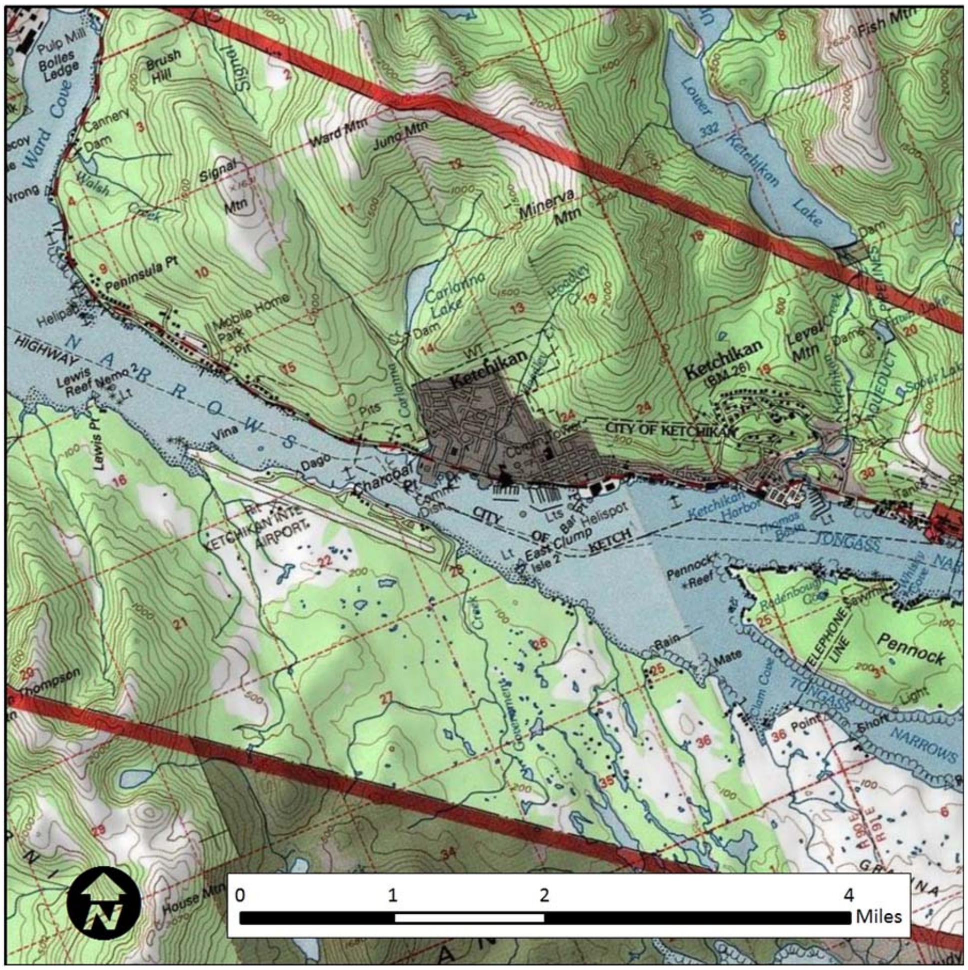


Figure 2 shows CTA Architects' plan of the location of the proposed biomass facility at the Ketchikan High School. The site slopes moderately to steeply downward in the southeasterly direction with the grade becoming very steep to the northeast of the High School building. The school building is between two to three stories high. The biomass facility will be located in a stand-alone building on the north side of the school building, which is the high side of the building. There are residential areas west, north, and east of the proposed biomass facility which are uphill (above) the facility. The precise dimensions of that building, the stack location and dimensions, and the biomass equipment specifications have not been determined. The degree of separation of the biomass building from the other buildings will create a buffer for emissions dispersion.

Figure 2: Site Map of the Ketchikan High School Project

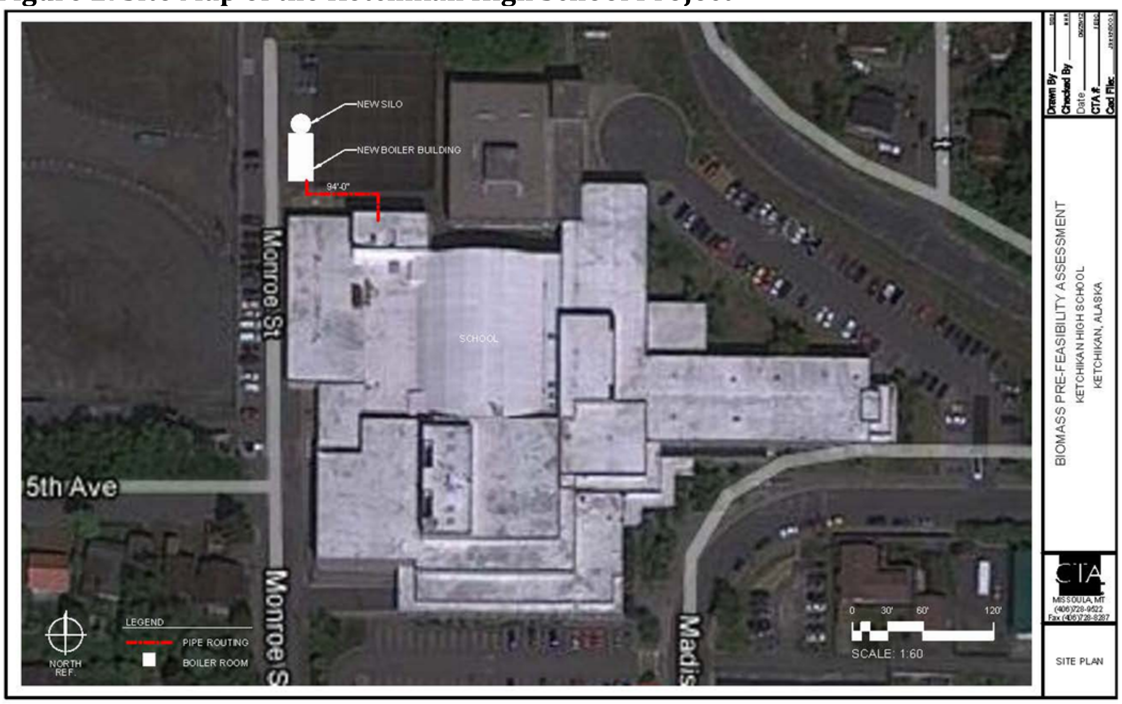


Figure 3 shows CTA Architects' plan of the location of the proposed biomass facility at the Ketchikan Indian Council Medical Facility. The site slopes moderately to steeply downward in the southeasterly direction. As a result, there are buildings above and below the site. The biomass facility will be located in a stand-alone building on the northeast (uphill) side of the school building. The precise dimensions of that building, the stack location and dimensions, and the biomass equipment specifications have not been determined. The degree of separation of the biomass building from the other buildings will create a small buffer for emissions dispersion.

Figure 3: Site Map of the Ketchikan Indian Council Medical Facility

Figure 4 shows CTA Architects' plan of the location of the Ketchikan Indian Council Votec School (marked Stedman) and Ketchikan Indian Council Admin Building (marked Deermount). The sites slope moderately to steeply downward in the southeasterly direction. As a result, there are buildings above and below the sites. The precise dimensions of that building, the stack location and dimensions, and the biomass equipment specifications have not been determined.

Figure 4: Site Map of Ketchikan Indian Council Votec School (Stedman) and the Admin Building (Deermount)

A USGS map is provided below in Figure 5. As shown, Craig Island is relatively flat with mountainous terrain to the west, and water in all other directions. The area is relatively sparsely populated. The population of Craig is 1,397. Our review of the area did not reveal any significant emission sources or ambient air quality issues.

Figure 5: USGS Map Illustrating the Craig Study Area

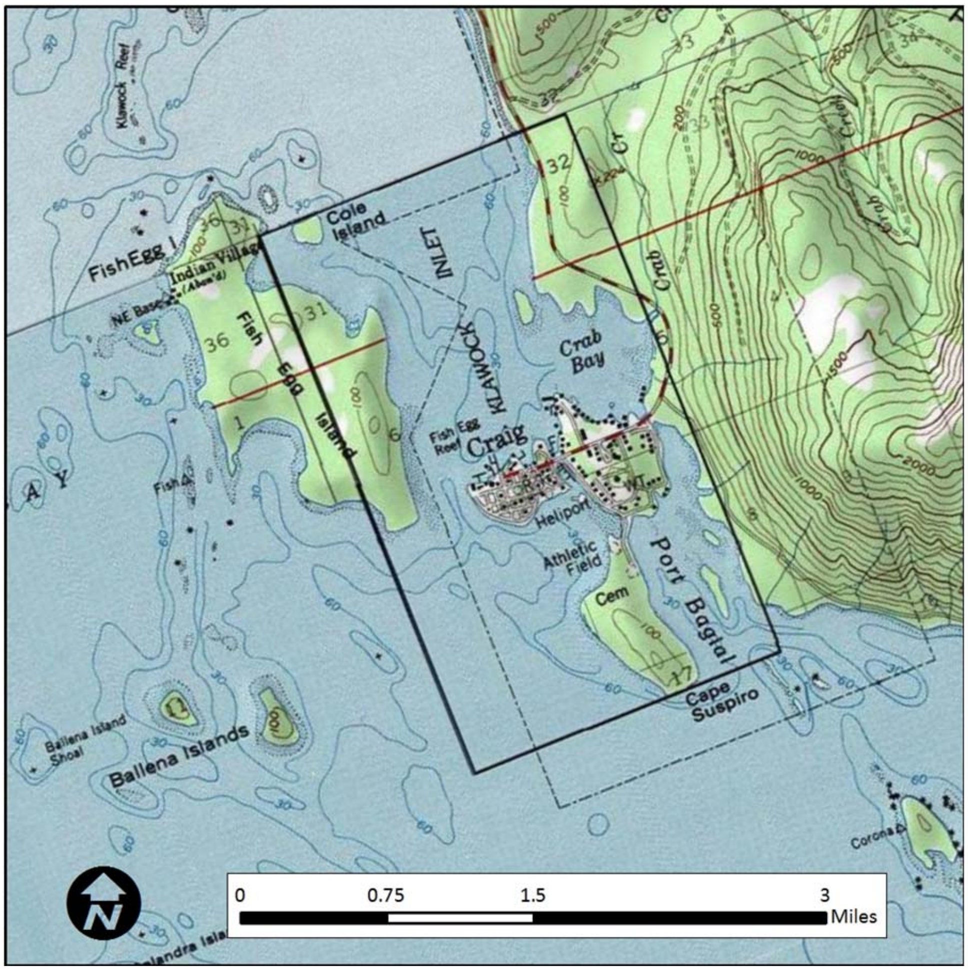


Figure 6 shows CTA Architects' plan of the location of the proposed biomass facility and the surrounding buildings. The site is relatively flat and moderately populated with one and two story high buildings. The boiler plant is located in a stand-alone building to the west of the Tribal Association Building and east of another building. The stack should be designed to provide plume rise above both of these buildings. The precise dimensions of that building, the stack location and dimensions, and the biomass equipment specifications have not been determined.

Figure 6: Site Map of the Craig Tribal Association Building

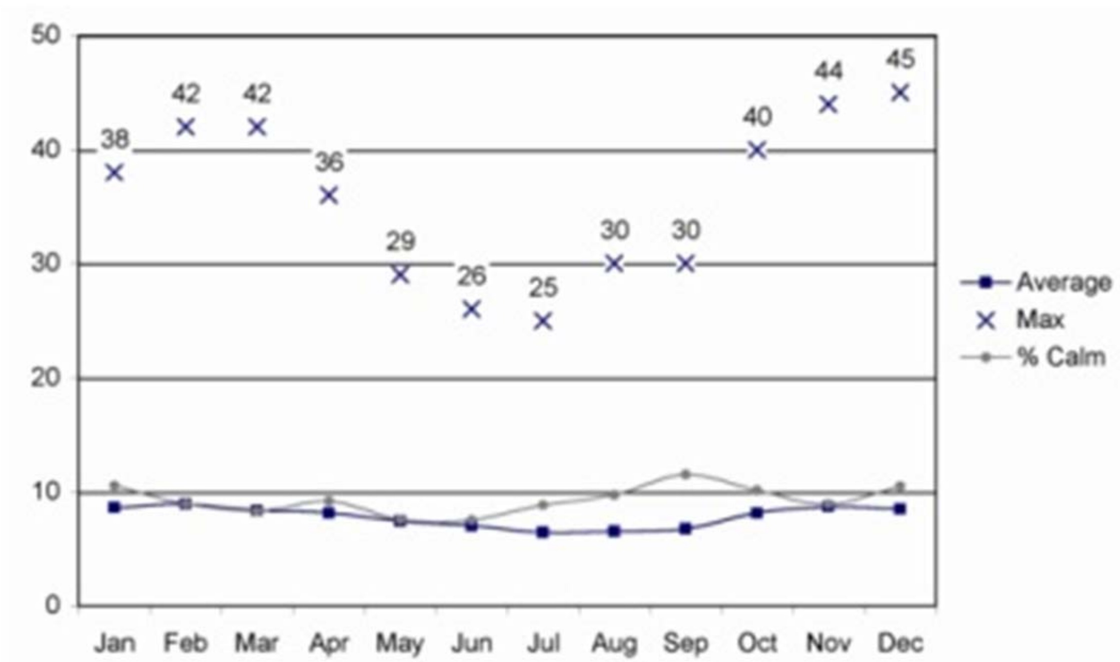
Figure 7 shows CTA Architects' plan of the proposed Shaan-Seet biomass facility and the surrounding buildings. The site is relatively flat and moderately populated with one and two story high buildings. The boiler plant is located in a stand-alone building. The precise dimensions of that building, the stack location and dimensions, and the biomass equipment specifications have not been determined.

Figure 7: Site Map of Shaan-Seet Boiler Plant Site

METEOROLOGY

Meteorological data from Annette, AK, was reviewed to develop an understanding of the weather conditions. Annette is the closest weather data representing the climactic conditions occurring in the Panhandle and is therefore a good proxy of Ketchikan and Craig weather conditions. This data indicates calm winds occur only 10% of the year when, which suggests there will be minimal time periods when thermal inversions and therefore poor emission dispersion conditions can occur.[1]

Figure 8: Wind Speed Data from Annette, AK



[1] See: http://climate.gi.alaska.edu/Climate/Wind/Speed/Annette/ANN.html

DESIGN & OPERATION RECOMMENDATIONS

The following are suggested for designing this project:

- Burn natural wood, whose characteristics (moisture content, bark content, species, geometry) results in optimal combustion in the equipment selected for the project.
- Do not install a rain cap above the stack. Rain caps obstruct vertical airflow and reduce dispersion of emissions.
- Construct the stack to at least 1.5 times the height of the tallest roofline of the adjacent building. Hence, a 20 foot roofline would result in a minimum 30 foot stack. ***Attention should be given to constructing stacks higher than 1.5 times the tallest roofline given higher elevations of surrounding residences due to the moderate to steep slopes present.***
- Operate and maintain the boiler according to manufacturer's recommendations.
- Perform a tune-up at least every other year as per manufacturer's recommendations and EPA guidance (see below for more discussion of EPA requirements)
- Conduct regular observations of stack emissions. If emissions are not characteristic of good boiler operation, make corrective actions.
- For the Ketchikan High School: install at minimum a multicyclone to filter particulate matter emissions.

These design and operation recommendations are based on the assumption that state-of-the-art combustion equipment is installed.

STATE AND FEDERAL PERMIT REQUIREMENTS

This project will not require an air pollution control permit from the Alaska Department of Environmental Quality given the boilers' relatively small size and corresponding quantity of emissions. However, this project will be subject to new proposed requirements in the federal "Area Source Rule" (40 CFR 63 JJJJJJ). A federal permit is not needed. However, there are various record keeping, reporting and operation and maintenance requirements which must be performed to demonstrate compliance with the requirements in the Area Source Rule. The proposed changes have not been finalized. Until that time, the following requirements are applicable:

- Submit initial notification form to EPA within 120 days of startup.
- Complete biennial tune ups per EPA method.
- Submit tune-up forms to EPA.

Please note the following:

- Oil and coal fired boilers are also subject to this rule.

- Gas fired boilers are not subject to this rule.
- More requirements are applicable to boilers equal to or greater than 10 MMBtu/hr heat input. These requirements typically warrant advanced emission controls, such as a baghouse or an electrostatic precipitator (ESP).

The compliance guidance documents and compliance forms can be obtained on the following EPA web page: http://www.epa.gov/boilercompliance/

SUMMARY

RSG has completed an air quality feasibility study for Ketchikan and Craig, Alaska. These boilers are not subject to state permitting requirements, but are subject to federal requirements. Design criteria have been suggested to minimize emissions and maximize dispersion.

The following conditions suggest advanced emission control devices (ESP, baghouse) are not mandatory in Ketchikan and Craig:

1. The wood boilers will be relatively small emission sources.
2. Most of the wood boilers will be located in a separate building which will create a dispersion buffer between the boiler stack and the building.
3. There are no applicable federal or state emission limits.
4. Meteorological conditions are favorable for dispersion.

The following conditions suggest additional attention should be given to controlling emissions in Ketchikan:

1. Presence of other emission sources.
2. Relatively high population density.
3. The sensitive populations housed by all Ketchikan buildings.

While not mandatory, we recommend exploring the possibility of a cyclone or multi-cyclone technology for control of fly ash and larger particulate emissions for all the aforementioned boilers. We also recommend developing a compliance plan for the aforementioned federal requirements.

Given its size and sensitive population served, air dispersion modeling can be performed for the Ketchikan High School site to determine the stack height and degree of emission control (multicyclone vs ESP).

Please contact me if you have any comments or questions.

APPENDIX E

Wood Fired Heating Technologies

WOOD FIRED HEATING TECHNOLOGIES

CTA has developed wood-fired heating system projects using cord wood, wood pellet and wood chips as the primary feedstock. A summary of each system type with the benefits and disadvantages is noted below.

Cord Wood

Cord wood systems are hand-stoked wood boilers with a limited heat output of 150,000-200,000 British Thermal Units per hour (Btu/hour). Cord wood systems are typically linked to a thermal storage tank in order to optimize the efficiency of the system and reduce the frequency of stoking. Cord wood boiler systems are also typically linked to existing heat distribution systems via a heat exchanger. Product data from Garn, HS Tarm and KOB identify outputs of 150,000-196,000 Btu/hr based upon burning eastern hardwoods and stoking the boiler on an hourly basis. The cost and practicality of stoking a wood boiler on an hourly basis has led most operators of cord wood systems to integrate an adjacent thermal storage tank, acting similar to a battery, storing heat for later use. The thermal storage tank allows the wood boiler to be stoked to a high fire mode 3 times per day while storing heat for distribution between stoking. Cord wood boilers require each piece of wood to be hand fed into the firebox, hand raking of the grates and hand removal of ash. Ash is typically cooled in a barrel before being stock piled and later broadcast as fertilizer.

Cordwood boilers are manufactured by a number of European manufacturers and an American manufacturer with low emissions. These manufacturers currently do not fabricate equipment with ASME (American Society of Mechanical Engineers) certifications. When these non ASME boilers are installed in the United States, atmospheric boilers rather than pressurized boilers are utilized. Atmospheric boilers require more frequent maintenance of the boiler chemicals.

Emissions from cord wood systems are typically as follows:

PM2.5	>0.08 lb/MMbtu
NOx	0.23 lb/MMbtu
SO2	0.025 lb/MMbtu
CO2	195 lb/MMbtu

Benefits:

Small size
Lower cost
Local wood resource
Simple to operate

Disadvantages:

Hand fed - a large labor commitment
Typically atmospheric boilers (not ASME rated)
Thermal Storage is required

Wood Pellet

Wood pellet systems can be hand fed from 40 pound bags, hand shoveled from 2,500 pound sacks of wood pellets, or automatically fed from an adjacent agricultural silo with a capacity of 30-40 tons. Pellet boilers systems are typically linked to existing heat distribution systems via a heat exchanger. Product data from KOB, Forest Energy and Solagen identify outputs of 200,000-5,000,000 Btu/hr based upon burning pellets made from waste products from the western timber industry. A number of pellet fuel manufacturers produce all tree pellets utilizing bark and needles. All tree pellets have significantly higher ash content, resulting in more frequent ash removal. Wood pellet boilers typically require hand raking of the grates and hand removal of ash 2-3 times a week. Automatic ash removal can be integrated into pellet boiler systems. Ash is typically cooled in a barrel before being stock piled and later broadcast as fertilizer. Pellet storage is very economical. Agricultural bin storage exterior to the building is inexpensive and quick to install. Material conveyance is also borrowed from agricultural technology. Flexible conveyors allow the storage to be located 20 feet or more from the boiler with a single auger.

Emissions from wood pellet systems are typically as follows:

PM2.5	>0.09 lb/MMbtu
NOx	0.22 lb/MMbtu
SO2	0.025 lb/MMbtu
CO2	220 lb/MMbtu

Benefits:

Smaller size (relative to a chip system)
Consistent fuel and easy economical storage of fuel
Automated

Disadvantages:

Higher system cost
Higher cost wood fuel ($/MMBtu)

Wood Chip
Chip systems utilize wood fuel that is either chipped or ground into a consistent size of 2-4 inches long and 1-2 inches wide. Chipped and ground material includes fine sawdust and other debris. The quality of the fuel varies based upon how the wood is processed between the forest and the facility. Trees which are harvested in a manner that minimizes contact with the ground and run through a chipper or grinder directly into a clean chip van are less likely to be contaminated with rocks, dirt and other debris. The quality of the wood fuel will also be impacted by the types of screens placed on the chipper or grinder. Fuel can be screened to reduce the quantity of fines which typically become airborne during combustion and represent lost heat and increased particulate emissions.

Chipped fuel is fed from the chip van into a metering bin, or loaded into a bunker with a capacity of 60 tons or more. Wood chip boilers systems are typically linked to existing heat distribution systems via a heat exchanger. Product data from Hurst, Messersmith and Biomass Combustion Systems identify outputs of 1,000,000 - 50,000,000 Btu/hr based upon burning western wood fuels. Wood chip boilers typically require hand raking of the grates and hand removal of ash daily. Automatic ash removal can be integrated into wood chip boiler systems. Ash is typically cooled in a barrel before being stock piled and later broadcast as fertilizer.

Emissions from wood chip systems are typically as follows:

PM2.5	0.21 lb/MMbtu
NOx	0.22 lb/MMbtu
SO2	0.025 lb/MMbtu
CO2	195 lb/MMbtu

Benefits:
Lowest fuel cost of three options ($/MMBtu)
Automated
Can use local wood resources

Disadvantages:
Highest initial cost of three types
Larger fuel storage required
Less consistent fuel can cause operational and performance issues