

**Pre-Feasibility Assessment for
Integration of Wood-Fired Heating Systems
Draft Report
July 11, 2013**

**Emmonak Corporation Store and Offices
Emmonak, Alaska**

Presented by
**CTA Architects Engineers
Nathan Ratz**

**R&M Engineering-Ketchikan, Inc.
Trevor Sande**

For
Emmonak Corporation

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

Funded by
Alaska Energy Authority and U.S. Forest Service



306 W. Railroad, Suite 104
Missoula, MT 59802
406.728.9522
www.ctagroup.com
CTA Project: FEDC_EMMONAK

TABLE OF CONTENTS

1.0 Executive Summary 1
2.0 Introduction 2
3.0 Existing Building Systems 2
4.0 Energy Use 2
5.0 Biomass Boiler Size 3
6.0 Wood Fuel Use 3
7.0 Boiler Plant Location and Site Access 4
8.0 Integration with Existing Heating Systems 4
9.0 Air Quality Permits 5
10.0 Wood Heating Options 5
11.0 Estimated Costs 5
12.0 Economic Analysis Assumptions 5
13.0 Results of Evaluation 6
14.0 Project Funding 6
15.0 Summary 7
16.0 Recommended Action 7

Appendixes

Appendix A: Preliminary Estimates of Probable Cost 1 page
Appendix B: Cash Flow Analysis 2 pages
Appendix C: Site Plan 1 page
Appendix D: Air Quality Report 11 pages
Appendix E: Wood Fired Heating Technologies 3 pages

1.0 Executive Summary

The following assessment was commissioned to determine the preliminary technical and economic feasibility of integrating a wood fired heating system in the Emmonak Corporation store and office building in Emmonak, 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
Corporation Store	Fuel Oil	8,250	\$6.34	\$52,280

Table 1.2 - Annual Wood Fuel Use Summary				
	Fuel Oil (Gallons)	Cord Wood (Cords)	Wood Pellets (Tons)	Chipped/Ground Wood (Tons)
Emmonak Corp. Store	8,250	84.4	77.3	126.5

The wood heating system options reviewed were:

Small Wood Chip Boiler Option:

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

Small Wood Pellet Boiler Option:

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

Cord Wood Boiler Options:

C.1.A: A freestanding building with interior cordwood storage, 70% fuel oil offset.

C.1.B: A freestanding building with interior cordwood storage, 50% fuel oil offset.

Table 1.3 - Economic Evaluation Summary									
Emmonak Corporation Biomass Heating System									
	Project Cost	Year 1 Operating Savings	NPV 20 yr at 3%	NPV 30 yr at 3%	20 Yr B/C Ratio	30 Yr B/C Ratio	ACF YR 20	ACF YR 30	YR ACF=PC
A.1	\$305,000	\$17,397	\$550,628	\$1,002,509	1.81	3.29	\$790,915	\$1,761,647	12
B.1	\$268,000	\$4,344	\$294,471	\$616,328	1.10	2.30	\$436,065	\$1,129,443	16
C.1.A	\$270,000	\$5,316	\$297,911	\$602,960	1.10	2.23	\$438,274	\$1,094,957	16
C.1.B	\$270,000	\$3,122	\$207,666	\$423,436	0.77	1.57	\$306,256	\$770,790	19

A cord wood boiler serving the Emmonak Corporation store and office building appears to be a fair candidate for a wood fired heating system with the current economic assumptions. Currently cord wood is the only viable fuel choice and if the boiler system

can be tended to very regularly, it is estimated that approximately 70% of the heating fuel could be offset with wood, which yields a 20 year B/C ratio of 1.10. However, if only 50% of the fuel oil use can be offset with wood, the 20 year B/C ratio is only 0.77. Additional sensitivity analysis was performed and if the delivered cord wood price was \$220/cord, then the 50% fuel oil offset would have a 20 year B/C ratio of 1.01.

Pellet and chipped wood options were also explored because of their potential future availability. If the fuel could be produced and delivered at the prices indicated in the economic analysis, then both system types have 20 year B/C ratios over 1.0, with the chip system at 1.81 (at \$200 per ton) and the pellet system at 1.10 (at \$550 per ton).

All wood fuel sources (cord wood, chips, and pellets) would benefit the community because the fuel is a renewable resource and has a lower energy cost. Cord wood and locally chipped wood provide one large additional benefit – the money paid for the fuel would remain in the local community and economy.

2.0 Introduction

The following assessment was commissioned to determine the preliminary technical and economic feasibility of integrating a wood fired heating system in the Emmonak Corporation store and office building in Emmonak, Alaska.

3.0 Existing Building Systems

The Emmonak Corporation store and office building is a single story metal building constructed in 2001. Because of poor soil conditions, the building is supported by piles and is elevated approximately four feet above native grade. The facility is approximately 11,200 square feet and is heated by two 212,000 Btu/hr output hot water boilers. The grocery store has refrigerated cases and coolers and it appeared that refrigerant piping served a fan coil which used the waste heat from the refrigeration system to help heat the store. Domestic hot water is provided by a 41 gallon indirect water heater using the boiler water as a heating source. The existing boilers are original to the building and appear to be in good condition. The heating system infrastructure is original to the building and in fair condition. There were some indications that some of the offices on the south side do not receive enough heat during cold temperatures and this may be due to lack of flow in the baseboard heating elements, possibly due to lack of pump head in the main circulating pumps. There have also been occasional leaks in the heating water piping at the unit heaters in the grocery store. A heat recovery ventilator is used to exhaust air from the toilet rooms and provide ventilation air to the building.

4.0 Current Heating Energy Use

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

Facility Name	Fuel Type	Avg. Use (Gallons)	Current Cost/Gal	Annual Cost
Corporation Store	Fuel Oil	8,250	\$6.34	\$52,280

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
Corp Store	Boiler 2	Fuel Oil	212	1.00	212
	Boiler 2	Fuel Oil	212	1.00	212
Total			424		424

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
Corp. Store	424	0.6	254

6.0 Wood Fuel Use and Cost

The only type of wood fuel currently available in the area is cord wood. Much is driftwood that comes from upriver and is deposited along the river banks during the spring river break up. There are no commercial logging operations in the area, although Yukon River Towing does collect and mill logs to use in their log home kits. Most wood is collected and cut up by private individuals for use in residential wood stoves. Typically alder is used for wood stoves, but there are also cottonwood and willows in the area. The driftwood is collected stacked by the City of Emmonak during post break up cleanup activities.

Although cord wood is the only fuel type currently available in the area, there are discussions within the community about purchasing a wood chipper and producing ground wood fuel. There are also projects in the Bethel area planning to use wood pellets. Because of this, these fuel types will be also be considered because they potentially could be available in the future.

The estimated amount of wood fuel needed of each wood fuel type for the building was calculated and is listed below:

Table 6.1 - Annual Wood Fuel Use Summary				
	Fuel Oil (Gallons)	Cord Wood (Cords)	Wood Pellets (Tons)	Chipped/ Ground Wood (Tons)
Emmonak Corp. Store	8,250	84.4	77.3	126.5

The amount of wood fuel shown in the table is for supplanting the entire amount of fuel oil and is for comparison purposes only. It is extremely unlikely that wood fuel will be able to completely replace the entire amount of 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. Cord wood was assumed to be 20% moisture content (MC) with a system efficiency of 65%. Wood pellets were assumed to be 7% MC with a system efficiency of 70%. Chipped/ground fuel was assumed to be 30% MC with a system efficiency of 65%.

The unit fuel costs for fuel oil and the different wood 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	134500	0.8	107600	\$6.00	\$55.76	\$44.61
					\$6.34	\$58.92	\$47.14
					\$7.00	\$65.06	\$52.04
Cord Wood	cords	16173800	0.65	10512970	\$300.00	\$28.54	\$18.55
					\$350.00	\$33.29	\$21.64
					\$400.00	\$38.05	\$24.73
Pellets	tons	16400000	0.7	11480000	\$500.00	\$43.55	\$30.49
					\$550.00	\$47.91	\$33.54
					\$600.00	\$52.26	\$36.59
Chips	tons	10800000	0.65	7020000	\$100.00	\$14.25	\$9.26
					\$150.00	\$21.37	\$13.89
					\$200.00	\$28.49	\$18.52

7.0 Boiler Plant Location and Site Access

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 east of the building adjacent to the existing loading dock and vehicle ramp. See Appendix C for a site plan of this building.

Any type of biomass boiler plant will require access by delivery vehicles. For cord wood systems this would likely be pick-up trucks and trucks with trailers. For pellet and chip systems, this would likely be 40 foot long vans or some similar type of trailer. Access to the plant would be from the southeast side of the property. The existing loading dock ramp and the road to the building is large enough to accommodate any type of delivery vehicle that would be used for wood delivery.

8.0 Integration with Existing Heating System

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 likely be run above ground under the building in arctic pipe and extend up to 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 the existing pumping systems within the building. The wood heating system would inject heat into the existing heating hot water system.

The existing hot water heating system appears to be designed for a heating supply water temperature of 180 deg. F. Perimeter finned tube heating elements are the primary devices used to heat the spaces. Heat emanates from these elements via radiation and natural convection. Because of this, the performance of the heating elements is greatly influenced by heating water supply temperature. At 140 deg. F heating water supply temperature, the heat output of these elements is approximately 50% of their output at 180 deg F. Wood chip and wood pellet boilers can consistently produce and maintain 180 deg. F water because the fuel is automatically and mechanically fed into the boiler. However, it can be difficult for manually fed cord wood systems to maintain this temperature unless they are continuously tended to and wood is constantly fed into the boiler. For this reason, cord wood boilers should be coupled with thermal storage tanks, so the boiler can be loaded, it can burn the wood hot and fast, and the water can be heated and "stored" in the tank. In this scenario as long as the boiler is checked and tended to regularly (3 to 5 times a day depending on heating load) a consistent 140 deg. F supply temperature generally can be maintained. A very basic and preliminary building heat load analysis was performed and it appears that a 140 deg. F heating water supply temperature could provide sufficient heat for the building down to approximately 22 deg. F outside air temperature, which would cover approximately 70% of the heating hours over the course of a year.

9.0 Air Quality Permits

Resource System Group (RSG) has done a preliminary review of potential air quality issues in the area and has found no significant concerns. The proposed boiler size at this location is small enough that the boiler is not likely to require any State or Federal permits.

See the air quality memo in Appendix D for more detailed information including design criteria that has been suggested to minimize emissions and maximize dispersion.

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 summaries on these types of systems.

A cord wood boiler system is the only viable option at this time in Emmonak, however, because of the community discussions about purchasing a chipper and because the Bethel area may be getting pellets, those options were also included in this report to see if there could be a potential benefit in the future. Two cord wood options were developed, one offsetting 70% of the current fuel oil usage and one offsetting 50% of the current fuel oil usage. Both cord wood options have the same capital costs.

The options reviewed were:

Small Wood Chip Boiler Option:

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

Small Wood Pellet Boiler Option:

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

Cord Wood Boiler Options:

C.1.A: A freestanding building with interior cordwood storage, 70% fuel oil offset.

C.1.B: A freestanding building with interior cordwood storage, 50% fuel oil offset.

11.0 Estimated Costs

The total project costs are at a preliminary level and are based on RS Means and recent biomass project construction cost data. The estimates are shown in Appendix A. 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 \$6.34/gal, electricity at \$0.34/kwh, cord wood delivered at \$300/cord, wood pellets delivered at \$550/ton, and ground wood fuel delivered at \$200/ton. The fuel oil and electricity costs are based on the costs reported by the facility. Cord wood and chipped/ground wood fuel costs are estimated based on other wood processing costs in Alaska. Pellet costs were estimated based an engineering study investigating using pellet boilers at a facility in Bethel.

Unless noted otherwise, 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 building. 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									
Emmonak Corporation Biomass Heating System									
	Project Cost	Year 1 Operating Savings	NPV 20 yr at 3%	NPV 30 yr at 3%	20 Yr B/C Ratio	30 Yr B/C Ratio	ACF YR 20	ACF YR 30	YR ACF=PC
A.1	\$305,000	\$17,397	\$550,628	\$1,002,509	1.81	3.29	\$790,915	\$1,761,647	12
B.1	\$268,000	\$4,344	\$294,471	\$616,328	1.10	2.30	\$436,065	\$1,129,443	16
C.1.A	\$270,000	\$5,316	\$297,911	\$602,960	1.10	2.23	\$438,274	\$1,094,957	16
C.1.B	\$270,000	\$3,122	\$207,666	\$423,436	0.77	1.57	\$306,256	\$770,790	19

The benefit to cost (B/C) ratio takes the net present value (NPV) of the net energy savings and divides it by the estimated 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.

See Appendix D for the full cash flow spread sheets for each option.

14.0 Project Funding

The Emmonak Corporation can pursue a biomass project grant from the Alaska Energy Authority. See the following website for more information:

<http://www.akenergyauthority.org/refund7.html>

The Emmonak Corporation 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. A performance contract was recently performed with some buildings owned by the City of Emmonak.

15.0 Summary

A cord wood boiler serving the Emmonak Corporation store and office building appears to be a fair candidate for a wood fired heating system with the current economic assumptions. Currently cord wood is the only viable fuel choice and if the boiler system can be tended to very regularly, it is estimated that approximately 70% of the heating fuel could be offset with wood, which yields a 20 year B/C ratio of 1.10. However, if only 50% of the fuel oil use can be offset with wood, the 20 year B/C ratio is only 0.77. Additional sensitivity analysis was performed and if the delivered cord wood price was \$220/cord, then the 50% fuel oil offset would have a 20 year B/C ratio of 1.01.

Pellet and chipped wood options were also explored because of their potential future availability. If the fuel could be produced and delivered at the prices indicated in the economic analysis, then both system types have 20 year B/C ratios over 1.0, with the chip system at 1.81 (at \$200 per ton) and the pellet system at 1.10 (at \$550 per ton).

All wood fuel sources (cord wood, chips, and pellets) would benefit the community because the fuel is a renewable resource and has a lower energy cost. Cord wood and locally chipped wood provide one large additional benefit – the money paid for the fuel would remain in the local community and economy.

16.0 Recommended Action

The amount of driftwood that is or can be collected should be measured and/or estimated to verify the building could be served by mostly driftwood (approximately 70 cords is needed for offsetting 70% of the current fuel oil use). The actual cost of processing the driftwood and other local wood sources into cord wood for use with a boiler system should be investigated further to determine what the actual delivered cost would be. Referencing cord wood boiler option C.1.B that offsets 50% of the current fuel oil use, if the cost of cord wood is \$220/cord or less, this option becomes economically viable and option C.1.A becomes even stronger.

A more detailed feasibility assessment is also recommended. A full assessment would provide more detail on the wood fuel resources and potential costs and a schematic design of the boiler systems and system integration to obtain more accurate construction costs.

APPENDIX A

Preliminary Estimates of Probable Cost

**Preliminary Estimates of Probable Cost
Biomass Heating Options
Emmonak Corporation Store, Emmonak, AK**

Option A.1 Small Wood Chip Boiler

Biomass Boiler Building Including Wood Storage Area:	\$55,000
Wood Heating and Wood Handling System:	\$55,000
Stack:	\$5,000
Mechanical/Electrical within Boiler Building:	\$25,000
Underground Piping	\$16,000
Integration in Store Boiler Room	\$8,500
Subtotal:	\$164,500
40% Remote Factor	\$65,800
Subtotal:	\$230,300
Design Fees, Building Permit, Miscellaneous Expenses 15%:	\$34,545
Subtotal:	\$264,845
15% Contingency:	\$39,727
Total Project Costs	\$ 304,572

Option B.1 Small Pellet Boiler

Biomass Boiler Building:	\$40,000
Pellet Boiler, Silo, and Thermal Storage Tank	\$50,000
Stack:	\$5,000
Mechanical/Electrical within Boiler Building:	\$25,000
Underground Piping	\$16,000
Integration in Store Boiler Room	\$8,500
Subtotal:	\$144,500
40% Remote Factor	\$57,800
Subtotal:	\$202,300
Design Fees, Building Permit, Miscellaneous Expenses 15%:	\$30,345
Subtotal:	\$232,645
15% Contingency:	\$34,897
Total Project Costs	\$ 267,542

Option C.1 Cord Wood Boiler

Biomass Boiler Building Including Wood Storage Area:	\$55,000
(2) Cord Wood Boilers and Thermal Storage Tank:	\$34,000
Stack:	\$8,000
Mechanical/Electrical within Boiler Building:	\$25,000
Underground Piping	\$16,000
Integration in Store Boiler Room	\$8,500
Subtotal:	\$146,500
40% Remote Factor	\$58,600
Subtotal:	\$205,100
Design Fees, Building Permit, Miscellaneous Expenses 15%:	\$30,765
Subtotal:	\$235,865
15% Contingency:	\$35,380
Total Project Costs	\$ 271,245

APPENDIX B

Cash Flow Analysis

Emmonak Corporation Store & Offices
Emmonak, Alaska

Option A.1
Wood Chip Boiler

Date: July 10, 2013
Analyst: CTA Architects Engineers - Nathan Ratz

EXISTING CONDITIONS

Existing Fuel Type:	Store	Fuel Oil	Fuel Oil	Fuel Oil	Total
Fuel Units:	Fuel Oil	gal	gal	gal	
Current Fuel Unit Cost:	\$6.34				
Estimated Average Annual Fuel Usage:	8,250				8,250
Annual Heating Costs:	\$52,305	\$0	\$0	\$0	\$52,305

ENERGY CONVERSION (to 1,000,000 Btu; or 1 dkt)

Fuel Heating Value (Btu/unit of fuel):	134500	134500	134500	134500	
Current Annual Fuel Volume (Btu):	1,109,625,000	0	0	0	
Assumed efficiency of existing heating system (%):	80%	80%	80%	80%	
Net Annual Energy Produced (Btu):	887,700,000	0	0	0	887,700,000

WOOD FUEL COST

\$/ton:
Assumed efficiency of wood heating system (%):

Wood Chips
\$200.00
65%
5400
126
107
4

PROJECTED WOOD FUEL USAGE

Estimated Btu content of wood fuel (Btu/lb) - **Assumed 40% MC**
Tons of wood fuel to supplant net equivalent of 100% annual heating load.
Tons of wood fuel to supplant net equivalent of 85% annual heating load.
25 ton chip van loads to supplant net equivalent of 85% annual heating load.

Project Capital Cost	-\$305,000
-----------------------------	-------------------

Project Financing Information	
Percent Financed	0.0%
Amount Financed	\$0
Amount of Grants	\$305,000
Interest Rate	5.00%
Term	10
Annual Finance Cost (years)	\$0

Additional Power Use	
Est. Pwr Use	2250 kWh
Elec Rate	\$0.340 /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

Simple Payback: Total Project Cost/Year One Operating Cost Savings:	17.5 years	Net Benefit	B/C Ratio
Net Present Value (30 year analysis):	\$1,002,509	\$697,509	3.29
Net Present Value (20 year analysis):	\$550,628	\$245,628	1.81
Year Accumulated Cash Flow > 0	#N/A		
Year Accumulated Cash Flow > Project Capital Cost	12		

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	\$6.34		8250 gal		\$52,305	\$54,920	\$57,666	\$60,550	\$63,577	\$66,756	\$70,094	\$73,598	\$77,278	\$81,142	\$85,199	\$89,459	\$93,932	\$98,629	\$103,560	\$132,172	\$168,689	\$215,294
Displaced heating costs	\$0.00		0 gal		\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Displaced heating costs	\$0.00		0 gal		\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Displaced heating costs	\$0.00		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)	\$200.00	85%	107 tons		\$21,497	\$22,142	\$22,806	\$23,490	\$24,195	\$24,921	\$25,669	\$26,439	\$27,232	\$28,049	\$28,890	\$29,757	\$30,650	\$31,569	\$32,516	\$37,695	\$43,699	\$50,659
Small load existing fuel	\$6.34	15%	1238 gal		\$7,846	\$8,238	\$8,650	\$9,082	\$9,537	\$10,013	\$10,514	\$11,040	\$11,592	\$12,171	\$12,780	\$13,419	\$14,090	\$14,794	\$15,534	\$19,826	\$25,303	\$32,294
Small load existing fuel	\$0.00	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	\$0.00	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	\$0.00	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	\$1,600				\$1,632																	
Additional Electrical Cost	\$0.340				\$765	\$788	\$812	\$836	\$861	\$887	\$913	\$941	\$969	\$998	\$1,028	\$1,059	\$1,091	\$1,123	\$1,157	\$1,341	\$1,555	\$1,803
Annual Operating Cost Savings					\$17,397	\$18,856	\$22,069	\$23,745	\$25,521	\$27,402	\$29,394	\$31,503	\$33,736	\$36,100	\$38,600	\$41,246	\$44,044	\$47,002	\$50,131	\$68,648	\$92,984	\$124,856
Financed Project Costs - Principal and Interest					0																	
Displaced System Replacement Costs (year one only)					0																	
Net Annual Cash Flow					17,397	18,856	22,069	23,745	25,521	27,402	29,394	31,503	33,736	36,100	38,600	41,246	44,044	47,002	50,131	68,648	92,984	124,856
Accumulated Cash Flow					17,397	36,254	58,323	82,068	107,588	134,990	164,384	195,887	229,624	265,724	304,324	345,570	389,613	436,616	486,747	790,915	1,204,526	1,761,647

Emmonak Corporation Store & Offices
Emmonak, Alaska

Option B.1
Wood Pellet Boiler

Date: July 10, 2013
Analyst: CTA Architects Engineers - Nathan Ratz

EXISTING CONDITIONS

Existing Fuel Type:	Store	Fuel Oil	Fuel Oil	Fuel Oil	Total
Fuel Units:	Fuel Oil	gal	gal	gal	gal
Current Fuel Unit Cost:	\$6.34				
Estimated Average Annual Fuel Usage:	8,250				8,250
Annual Heating Costs:	\$52,305	\$0	\$0	\$0	\$52,305

ENERGY CONVERSION (to 1,000,000 Btu; or 1 dkt)

Fuel Heating Value (Btu/unit of fuel):	134500	134500	134500	134500	
Current Annual Fuel Volume (Btu):	1,109,625,000	0	0	0	
Assumed efficiency of existing heating system (%):	80%	80%	80%	80%	
Net Annual Energy Produced (Btu):	887,700,000	0	0	0	887,700,000

WOOD FUEL COST

\$/ton:
Assumed efficiency of wood heating system (%):

Wood Pellets
\$550.00
70%
8200
77
66
3

PROJECTED WOOD FUEL USAGE

Estimated Btu content of wood fuel (Btu/lb) - Assumed 7% MC
Tons of wood fuel to supplant net equivalent of 100% annual heating load.
Tons of wood fuel to supplant net equivalent of 85% annual heating load.
25 ton chip van loads to supplant net equivalent of 85% annual heating load.

Project Capital Cost	-\$268,000
-----------------------------	-------------------

Project Financing Information	
Percent Financed	0.0%
Amount Financed	\$0
Amount of Grants	\$268,000
Interest Rate	5.00%
Term	10
Annual Finance Cost (years)	\$0

Additional Power Use	
Est. Pwr Use	2250 kWh
Elec Rate	\$0.340 /kWh

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

Simple Payback: Total Project Cost/Year One Operating Cost Savings:	61.7 years	Net Benefit	B/C Ratio
Net Present Value (30 year analysis):	\$616,328	\$348,328	2.30
Net Present Value (20 year analysis):	\$294,471	\$26,471	1.10
Year Accumulated Cash Flow > 0	#N/A		
Year Accumulated Cash Flow > Project Capital Cost	16		

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	\$6.34		8250 gal		\$52,305	\$54,920	\$57,666	\$60,550	\$63,577	\$66,756	\$70,094	\$73,598	\$77,278	\$81,142	\$85,199	\$89,459	\$93,932	\$98,629	\$103,560	\$132,172	\$168,689	\$215,294
Displaced heating costs	\$0.00		0 gal		\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Displaced heating costs	\$0.00		0 gal		\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Displaced heating costs	\$0.00		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)	\$550.00	85%	66 tons		\$36,150	\$37,234	\$38,351	\$39,502	\$40,687	\$41,908	\$43,165	\$44,460	\$45,793	\$47,167	\$48,582	\$50,040	\$51,541	\$53,087	\$54,680	\$63,389	\$73,485	\$85,189
Small load existing fuel	\$6.34	15%	1238 gal		\$7,846	\$8,238	\$8,650	\$9,082	\$9,537	\$10,013	\$10,514	\$11,040	\$11,592	\$12,171	\$12,780	\$13,419	\$14,090	\$14,794	\$15,534	\$19,826	\$25,303	\$32,294
Small load existing fuel	\$0.00	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	\$0.00	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	\$0.00	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					\$1,600	\$1,632	\$1,665	\$1,698	\$1,732	\$1,767	\$1,802	\$1,838	\$1,875	\$1,912	\$1,950	\$1,989	\$2,029	\$2,070	\$2,111	\$2,331	\$2,573	\$2,841
Additional Operation and Maintenance Costs First 2 years					\$1,600	\$1,632																
Additional Electrical Cost	\$0.340				\$765	\$788	\$812	\$836	\$861	\$887	\$913	\$941	\$969	\$998	\$1,028	\$1,059	\$1,091	\$1,123	\$1,157	\$1,341	\$1,555	\$1,803
Annual Operating Cost Savings					\$4,344	\$5,396	\$8,189	\$9,431	\$10,761	\$12,182	\$13,700	\$15,320	\$17,049	\$18,893	\$20,859	\$22,952	\$25,182	\$27,554	\$30,078	\$45,285	\$65,772	\$93,167
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					4,344	5,396	8,189	9,431	10,761	12,182	13,700	15,320	17,049	18,893	20,859	22,952	25,182	27,554	30,078	45,285	65,772	93,167
Accumulated Cash Flow					4,344	9,740	17,929	27,361	38,121	50,303	64,002	79,323	96,372	115,265	136,124	159,076	184,258	211,812	241,890	436,065	721,544	1,129,443

Emmonak Corporation Store & Offices

Emmonak, Alaska

Option C.1.A

Cord Wood Boiler
70% Offset

Date: July 10, 2013
Analyst: CTA Architects Engineers - Nathan Ratz

EXISTING CONDITIONS

Existing Fuel Type:
Fuel Units:
Current Fuel Unit Cost:
Estimated Average Annual Fuel Usage:
Annual Heating Costs:

Store	Fuel Oil	Fuel Oil	Fuel Oil	Total
Fuel Oil	gal	gal	gal	
	\$6.34			
8,250				8,250
\$52,305	\$0	\$0	\$0	\$52,305
134500	134500	134500	134500	
1,109,625,000	0	0	0	
80%	80%	80%	80%	
887,700,000	0	0	0	887,700,000

ENERGY CONVERSION (to 1,000,000 Btu; or 1 dkt)

Fuel Heating Value (Btu/unit of fuel):
Current Annual Fuel Volume (Btu):
Assumed efficiency of existing heating system (%):
Net Annual Energy Produced (Btu):

WOOD FUEL COST

\$/cord:
Assumed efficiency of wood heating system (%):

Cord Wood
\$300.00
65%
16,173,800
84
72
N/A

PROJECTED WOOD FUEL USAGE

Estimated Btu content of wood fuel (Btu/cord) - **Assumed 20% MC, 6,700 Btu/lb x 28.4 lb/cf x 85 cf**
Cords of wood fuel to supplant net equivalent of 100% annual heating load.
Cords of wood fuel to supplant net equivalent of 85% annual heating load.
25 ton chip van loads to supplant net equivalent of 85% annual heating load.

Project Capital Cost	-\$270,000
-----------------------------	-------------------

Project Financing Information	
Percent Financed	0.0%
Amount Financed	\$0
Amount of Grants	\$270,000
Interest Rate	5.00%
Term	10
Annual Finance Cost (years)	\$0

Additional Power Use	
Est. Pwr Use	2250 kWh
Elec Rate	\$0.340 /kWh

Additional Maintenance					
Type	Hr/Wk	Wk/Yr	Total Hr	Wage/Hr	Total
Biomass System	14.0	40	560	\$20.00	\$11,200
Other	0.0	40	0	\$20.00	\$0
1st 2 Year Learning	2.0	40	80	\$20.00	\$1,600

Simple Payback: Total Project Cost/Year One Operating Cost Savings:	50.8 years	Net Benefit	B/C Ratio
Net Present Value (30 year analysis):	\$602,960	\$332,960	2.23
Net Present Value (20 year analysis):	\$297,911	\$27,911	1.10
Year Accumulated Cash Flow > 0	#N/A		
Year Accumulated Cash Flow > Project Capital Cost	16		

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	\$6.34		8250 gal		\$52,305	\$54,920	\$57,666	\$60,550	\$63,577	\$66,756	\$70,094	\$73,598	\$77,278	\$81,142	\$85,199	\$89,459	\$93,932	\$98,629	\$103,560	\$132,172	\$168,689	\$215,294
Displaced heating costs	\$0.00		0 gal		\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Displaced heating costs	\$0.00		0 gal		\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Displaced heating costs	\$0.00		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)	\$300.00	70%	59 cords		\$17,732	\$18,264	\$18,812	\$19,376	\$19,958	\$20,556	\$21,173	\$21,808	\$22,462	\$23,136	\$23,830	\$24,545	\$25,282	\$26,040	\$26,821	\$31,093	\$36,046	\$41,787
Small load existing fuel	\$6.34	30%	2475 gal		\$15,692	\$16,476	\$17,300	\$18,165	\$19,073	\$19,927	\$20,828	\$21,772	\$22,760	\$23,793	\$24,871	\$25,994	\$27,162	\$28,375	\$29,634	\$33,652	\$39,607	\$46,588
Small load existing fuel	\$0.00	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	\$0.00	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	\$0.00	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					\$11,200	\$11,424	\$11,652	\$11,886	\$12,123	\$12,366	\$12,613	\$12,865	\$13,123	\$13,385	\$13,653	\$13,926	\$14,204	\$14,488	\$14,778	\$16,316	\$18,014	\$19,889
Additional Operation and Maintenance Costs First 2 years	\$1,600				\$1,600	\$1,632																
Additional Electrical Cost	\$0.340				\$765	\$788	\$812	\$836	\$861	\$887	\$913	\$941	\$969	\$998	\$1,028	\$1,059	\$1,091	\$1,123	\$1,157	\$1,341	\$1,555	\$1,803
Annual Operating Cost Savings					\$5,316	\$6,336	\$9,090	\$10,287	\$11,562	\$12,920	\$14,366	\$15,904	\$17,541	\$19,280	\$21,128	\$23,091	\$25,176	\$27,388	\$29,736	\$43,769	\$62,467	\$87,227
Financed Project Costs - Principal and Interest					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Displaced System Replacement Costs (year one only)					0																	
Net Annual Cash Flow					5,316	6,336	9,090	10,287	11,562	12,920	14,366	15,904	17,541	19,280	21,128	23,091	25,176	27,388	29,736	43,769	62,467	87,227
Accumulated Cash Flow					5,316	11,653	20,743	31,030	42,592	55,512	69,878	85,783	103,323	122,603	143,732	166,823	191,999	219,387	249,123	438,274	711,094	1,094,957

Emmonak Corporation Store & Offices

Emmonak, Alaska

Option C.1.B

Cord Wood Boiler
50% Offset

Date: July 10, 2013
Analyst: CTA Architects Engineers - Nathan Ratz

EXISTING CONDITIONS

Existing Fuel Type:
Fuel Units:
Current Fuel Unit Cost:
Estimated Average Annual Fuel Usage:
Annual Heating Costs:

Store	Fuel Oil	Fuel Oil	Fuel Oil	Total
Fuel Oil	gal	gal	gal	
gal				
\$6.34				
8,250				8,250
\$52,305	\$0	\$0	\$0	\$52,305
134500	134500	134500	134500	
1,109,625,000	0	0	0	
80%	80%	80%	80%	
887,700,000	0	0	0	887,700,000

ENERGY CONVERSION (to 1,000,000 Btu; or 1 dkt)

Fuel Heating Value (Btu/unit of fuel):
Current Annual Fuel Volume (Btu):
Assumed efficiency of existing heating system (%):
Net Annual Energy Produced (Btu):

WOOD FUEL COST

\$/cord:
Assumed efficiency of wood heating system (%):

Cord Wood
\$300.00
65%
16,173,800
84
72
N/A

PROJECTED WOOD FUEL USAGE

Estimated Btu content of wood fuel (Btu/cord) - Assumed 20% MC, 6,700 Btu/lb x 28.4 lb/cf x 85 cf
Cords of wood fuel to supplant net equivalent of 100% annual heating load.
Cords of wood fuel to supplant net equivalent of 85% annual heating load.
25 ton chip van loads to supplant net equivalent of 85% annual heating load.

Project Capital Cost	-\$270,000
-----------------------------	-------------------

Project Financing Information	
Percent Financed	0.0%
Amount Financed	\$0
Amount of Grants	\$270,000
Interest Rate	5.00%
Term	10
Annual Finance Cost (years)	\$0

Additional Power Use	
Est. Pwr Use	2250 kWh
Elec Rate	\$0.340 /kWh

Additional Maintenance					
Type	Hr/Wk	Wk/Yr	Total Hr	Wage/Hr	Total
Biomass System	10.0	40	400	\$20.00	\$8,000
Other	0.0	40	0	\$20.00	\$0
1st 2 Year Learning	2.0	40	80	\$20.00	\$1,600

Simple Payback: Total Project Cost/Year One Operating Cost Savings:	86.5 years	Net Benefit	B/C Ratio
Net Present Value (30 year analysis):	\$423,436	\$153,436	1.57
Net Present Value (20 year analysis):	\$207,666	-\$62,334	0.77
Year Accumulated Cash Flow > 0	#N/A		
Year Accumulated Cash Flow > Project Capital Cost	19		

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	\$6.34		8250 gal		\$52,305	\$54,920	\$57,666	\$60,550	\$63,577	\$66,756	\$70,094	\$73,598	\$77,278	\$81,142	\$85,199	\$89,459	\$93,932	\$98,629	\$103,560	\$132,172	\$168,689	\$215,294
Displaced heating costs	\$0.00		0 gal		\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Displaced heating costs	\$0.00		0 gal		\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Displaced heating costs	\$0.00		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)	\$300.00	50%	42 cords		\$12,666	\$13,046	\$13,437	\$13,840	\$14,255	\$14,683	\$15,124	\$15,577	\$16,045	\$16,526	\$17,022	\$17,532	\$18,058	\$18,600	\$19,158	\$22,210	\$25,747	\$29,848
Small load existing fuel	\$6.34	50%	4125 gal		\$26,153	\$27,460	\$28,833	\$30,275	\$31,789	\$33,378	\$35,047	\$36,799	\$38,639	\$40,571	\$42,600	\$44,730	\$46,966	\$49,314	\$51,780	\$66,086	\$84,344	\$107,647
Small load existing fuel	\$0.00	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	\$0.00	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	\$0.00	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					\$8,000	\$8,160	\$8,323	\$8,490	\$8,659	\$8,833	\$9,009	\$9,189	\$9,373	\$9,561	\$9,752	\$9,947	\$10,146	\$10,349	\$10,556	\$11,654	\$12,867	\$14,207
Additional Operation and Maintenance Costs First 2 years					\$1,600	\$1,632																
Additional Electrical Cost	\$0.340				\$765	\$788	\$812	\$836	\$861	\$887	\$913	\$941	\$969	\$998	\$1,028	\$1,059	\$1,091	\$1,123	\$1,157	\$1,341	\$1,555	\$1,803
Annual Operating Cost Savings					\$3,122	\$3,834	\$6,261	\$7,109	\$8,013	\$8,975	\$10,000	\$11,092	\$12,252	\$13,486	\$14,798	\$16,191	\$17,671	\$19,242	\$20,909	\$30,881	\$44,175	\$61,790
Financed Project Costs - Principal and Interest					0	0	0	0														
Displaced System Replacement Costs (year one only)					0																	
Net Annual Cash Flow					3,122	3,834	6,261	7,109	8,013	8,975	10,000	11,092	12,252	13,486	14,798	16,191	17,671	19,242	20,909	30,881	44,175	61,790
Accumulated Cash Flow					3,122	6,956	13,217	20,326	28,339	37,314	47,315	58,406	70,658	84,145	98,943	115,134	132,805	152,047	172,956	306,256	499,032	770,790

APPENDIX C

Site Plan



Drawn By TW
 Checked By NHR
 Date 06/27/2013
 CTA # FEDC
 Cad File: EMMONAK.DWG

BIOMASS PRE-FEASIBILITY ASSESSMENT
 EMMONAK CORPORATION
 EMMONAK, AK



SITE PLAN

APPENDIX D

Air Quality Report



R | S | G INC.
RESOURCE SYSTEMS GROUP, INC.

Transportation &
Environment Practice

**Air Quality Feasibility Report
For the:
FEDC Pre-Feasibility Studies
on Wood-Fired Heating
Projects**



Prepared for:

**CTA Architects Engineers
Missoula, MT**

July, 2013

Prepared by:
RSG, Inc.

Resource Systems Group, Inc.
55 Railroad Row
White River Junction, VT 05001
TEL 802.295.4999 | FAX 802.295.1006
www.rsginc.com

TABLE OF CONTENTS

1.0	INTRODUCTION	1
2.0	EQUIPMENT DESCRIPTION.....	1
3.0	SITE DESCRIPTIONS	2
3.1	Emmonak	2
3.2	Koyuk.....	2
3.3	Lower Kalskag.....	2
3.4	Tuntutuliak.....	2
4.0	METEOROLOGICAL CONDITIONS	3
5.0	REGULATORY CONSIDERATIONS.....	4
6.0	DESIGN & OPERATION RECOMMENDATIONS	4

LIST OF FIGURES

Figure 1: Wind Speed Data from Bethel, AK	3
Figure 2: Wind Speed Data from Nome, AK	3



1.0 INTRODUCTION

At the request of CTA, RSG has completed an air quality pre-feasibility study of implementing biomass energy systems in Emmonak, Koyuk, Lower Kalskag, and Tuntutuliak, Alaska. These systems will displace fossil fuel used in these locations and therefore displace fossil fuel-related emissions.

This report is broken into the following sections:

- Equipment description
- Site descriptions
- Meteorological conditions
- Regulatory considerations
- Design and operation recommendations

2.0 EQUIPMENT DESCRIPTION

The following details were provided for the boilers being considered. Equipment vendors have not been selected.

- Emmonak
 - Fuel: cord wood likely, wood chips also possible.
 - Heating capacity: 250,000 Btu/hr output.
- Koyuk
 - Fuel: cord wood.
 - Heating capacity: 150,000 Btu/hr output.
- Lower Kalskag
 - Fuel: cord wood.
 - Heating capacity.
 - Alternative A: one boiler at 625,000 Btu/hr output.
 - Alternative B: one boiler at 250,000 Btu/hr output coupled with several high efficiency wood stoves.
- Tuntutuliak
 - Fuel: cord wood
 - Heating capacity: 125,000 Btu/hr



3.0 SITE DESCRIPTIONS

Descriptions of each site are provided below. USGS maps, aerial photography, and site maps are provided in the Appendix.

3.1 Emmonak

Emmonak is a small village located near the west coast of Alaska, on the north bank of the Kwiguk Pass of the Yukon River. The area is relatively flat. No significant air pollution sources were identified in the review for this site. One biomass plant is being considered for this site at the Emmonak Corporate Store and Offices Building.

3.2 Koyuk

Koyuk is a small village located near the west coast of Alaska. It is situated on the north bank of the Koyuk River at Koyuk Inlet. The village is bordered by hills to the north and flat terrain to the south. The land slopes downhill from north to south, with ground elevation ranging from approximately 100 feet to 15 feet. No significant air pollution sources were identified in the review for this site. One Biomass plant is being considered for this site at the Kiniaq Building.

3.3 Lower Kalskag

Lower Kalskag is a small inland village located on the western bank of the Kuskowim River. The site is relatively flat. No significant air pollution sources were identified in the review for this site. Two biomass plants are considered for this site. One at the school and one near the clinic.

3.4 Tuntutuliak

Tuntutuliak is a relatively small inland village located on the northern bank of the Kinak River. The site is relatively flat. No significant air pollution sources were identified in the review for this site. One biomass plant is being considered for this site at the Community Hall.



4.0 METEOROLOGICAL CONDITIONS

Meteorological data from Bethel and Nome, AK, were reviewed to develop an understanding of weather conditions which will affect the dispersion of emissions. Bethel is the closest weather station approximating climactic conditions in the Emmonak, Lower Kalskag, and Tuntutuliak. Nome is the closest weather data approximating Koyuk. The data indicates calm winds occur approximately only 10% of the year. This suggests there will be minimal time periods when thermal inversions and therefore poor emission dispersion conditions can occur.¹

Figure 1: Wind Speed Data from Bethel, AK

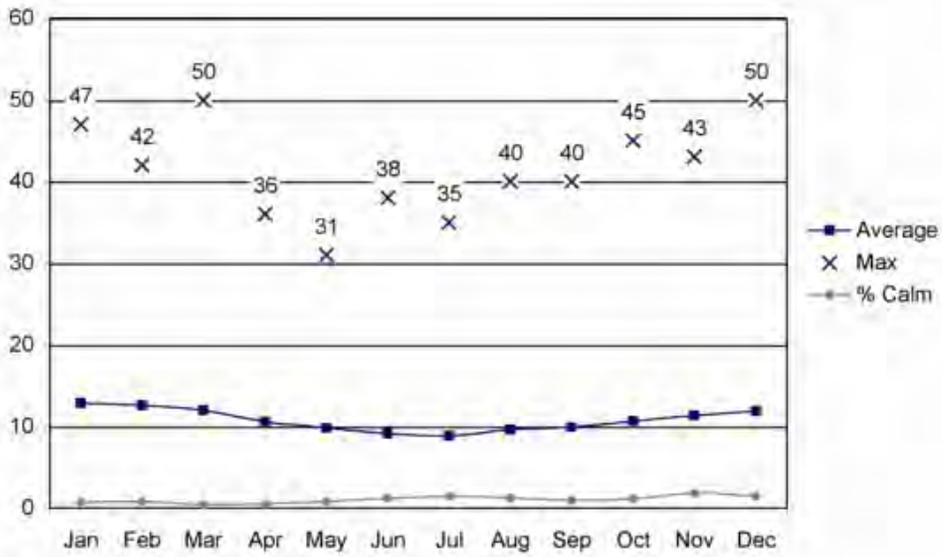
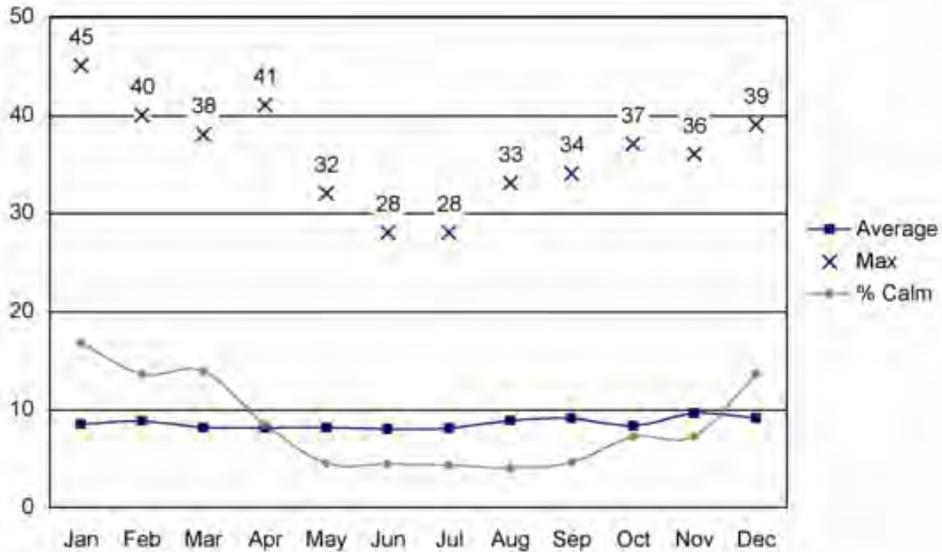


Figure 2: Wind Speed Data from Nome, AK



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



5.0 REGULATORY CONSIDERATIONS

The size of the proposed boilers will not trigger state or federal permitting requirements. Hot water boilers burning wood which are less than 1.6 MMBtu/hr heat input are below the threshold for EPA boiler requirements. More information about EPA boiler requirements can be obtained here:

<http://www.epa.gov/boilercompliance/>

6.0 DESIGN & OPERATION RECOMMENDATIONS

These design and operation recommendations are based on the assumption that state-of-the-art combustion equipment is installed. The following are suggested for designing this project:

- Burn natural wood, whose characteristics (bark content, species, geometry) optimizes combustion in the equipment selected for the project.
- Burn seasoned cord wood. Burning wet wood generates excess emissions.
- Do not install a rain cap above the stack. Rain caps obstruct vertical airflow and reduce dispersion of emissions.
- In situations where there are clusters of buildings, consider constructing 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. *Special attention should be given to this in Koyuk due to the moderate 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.
- Conduct regular observations of stack emissions. If emissions are not characteristic of good boiler operation, make corrective actions.

More information can be found about controlling wood boiler emissions can be obtained in a report written by RSG called "Emission Controls for Small Wood-Fired Boilers". The report can be downloaded here: http://www.wflcenter.org/news_pdf/361_pdf.pdf.

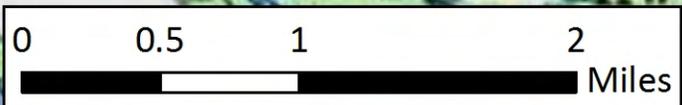
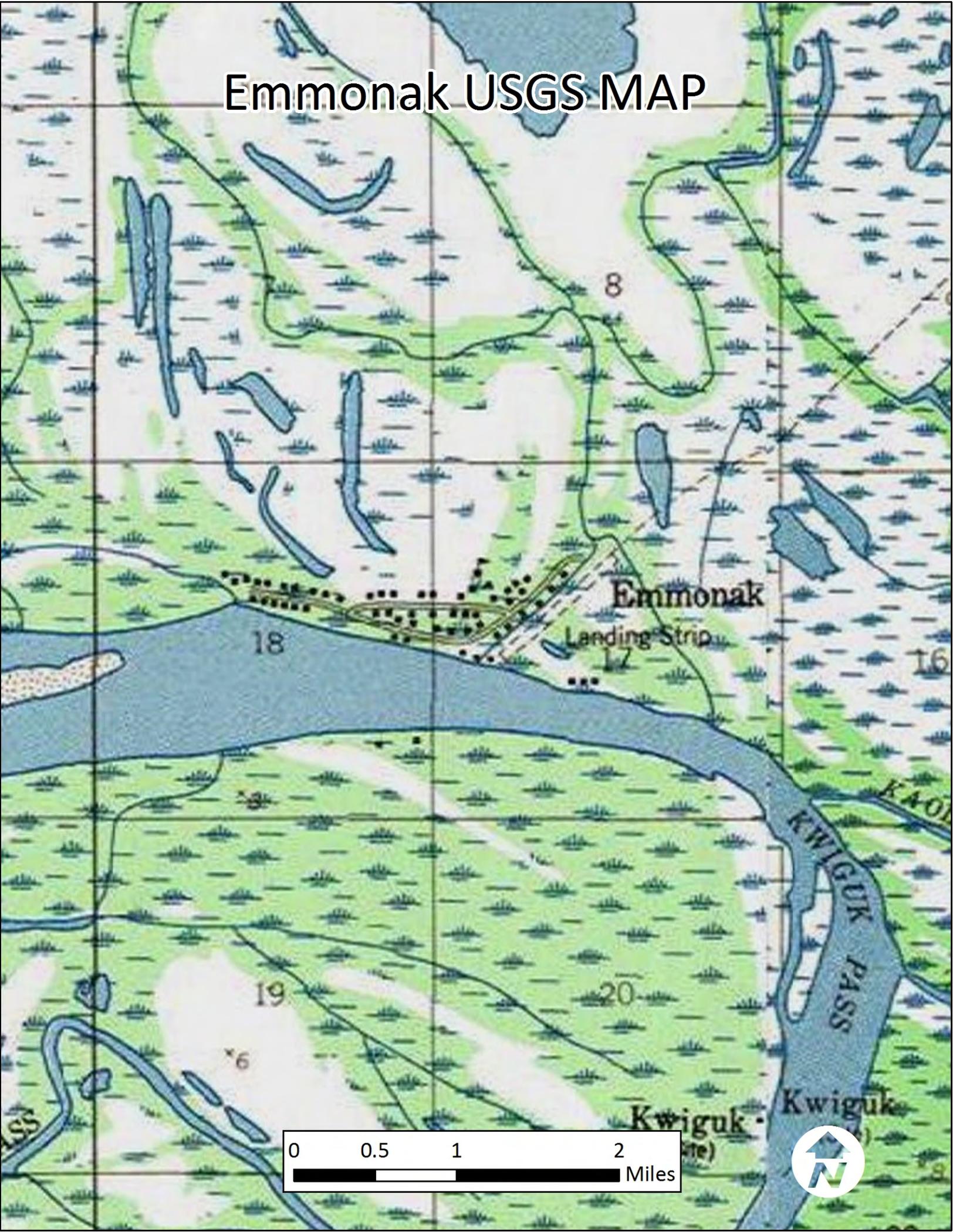


APPENDIX A

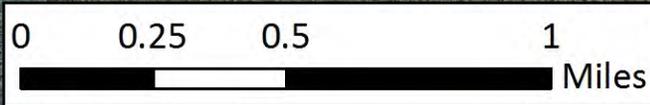
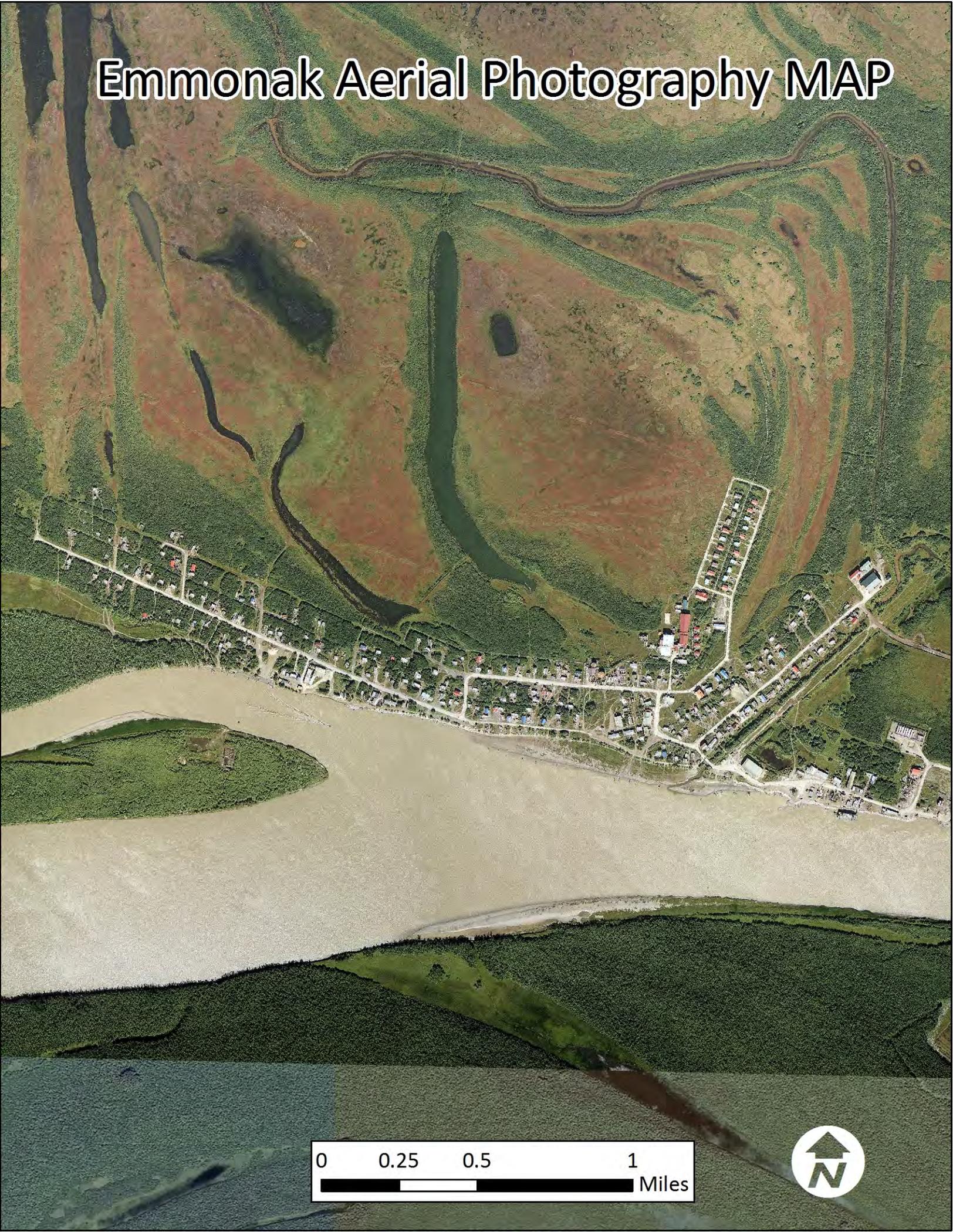
EMMONAK SITE INFORMATION

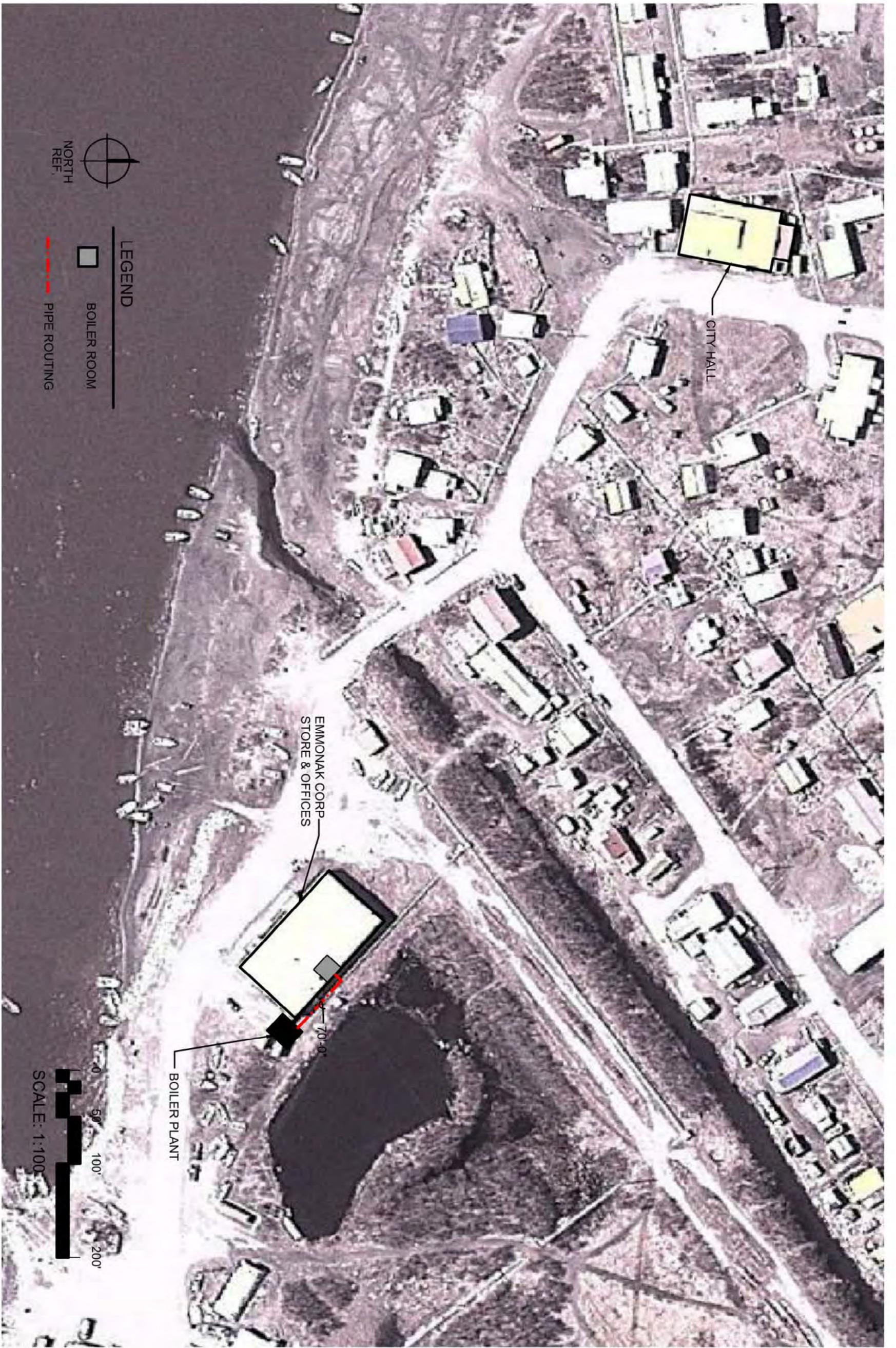


Emmonak USGS MAP



Emmonak Aerial Photography MAP





BIOMASS PRE-FEASIBILITY ASSESSMENT
 EMMONAK CORPORATION
 EMMONAK, AK



SITE PLAN

Drawn By _____ TW
 Checked By _____ NHR
 Date _____ 06/27/2013
 CTA # _____ FEDC
 Cad File: _____ EMMONAK.DWG

APPENDIX B

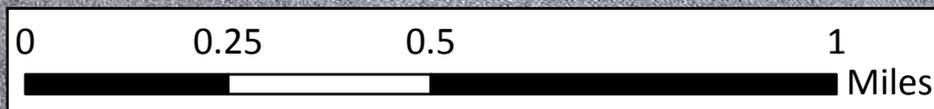
KOYUK SITE INFORMATION

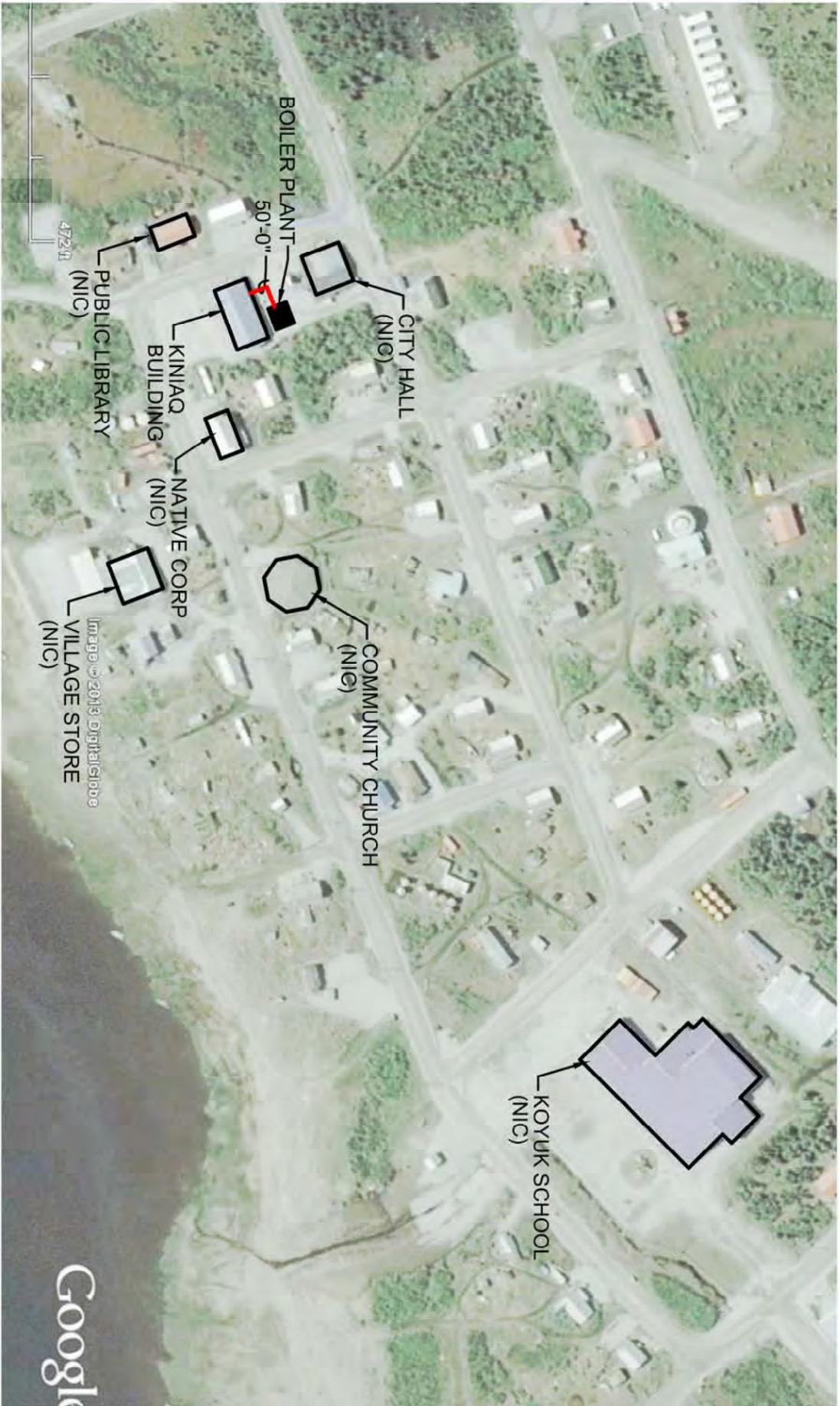


Koyuk USGS MAP



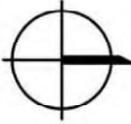
Koyuk Aerial Photography MAP

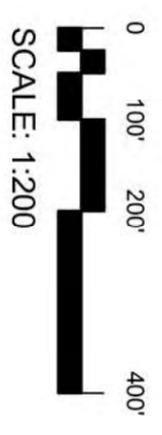




LEGEND

 BOILER ROOM
 PIPE ROUTING
 (NIC) NOT IN CONTRACT

 NORTH REF.



SITE PLAN



BIOMASS PRE-FEASIBILITY ASSESSMENT
 KINIAQ BUILDING
 KOYUK, AK

Drawn By TW
 Checked By NHR
 Date 06/27/2013
 CTA # FEDC
 Cad File: KOYUK.DWG

APPENDIX C

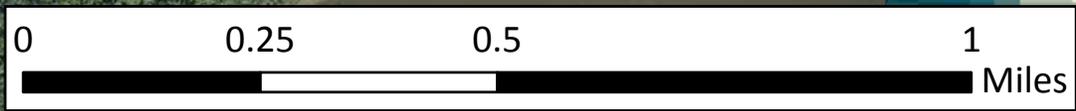
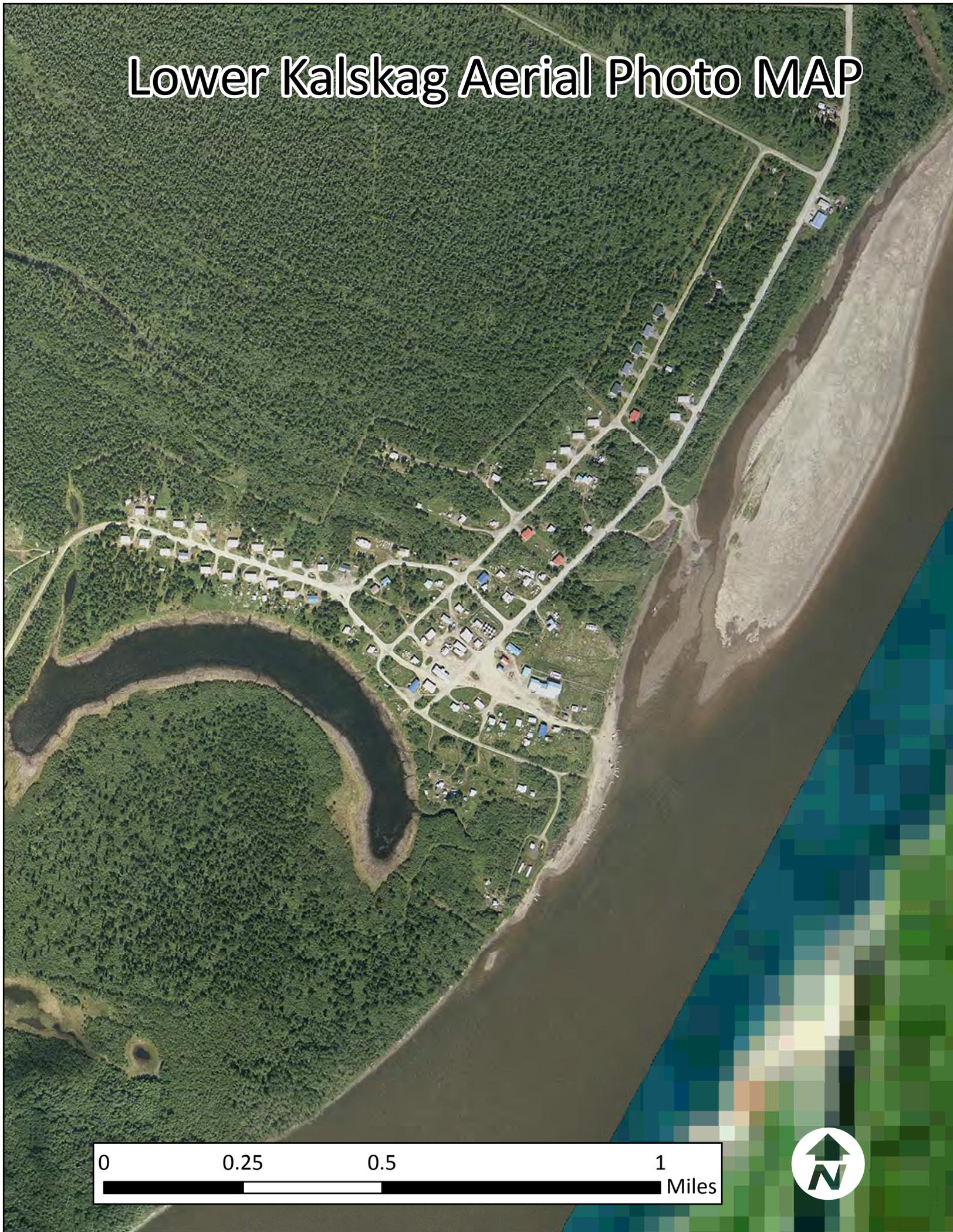
LOWER KALSKAG SITE INFORMATION

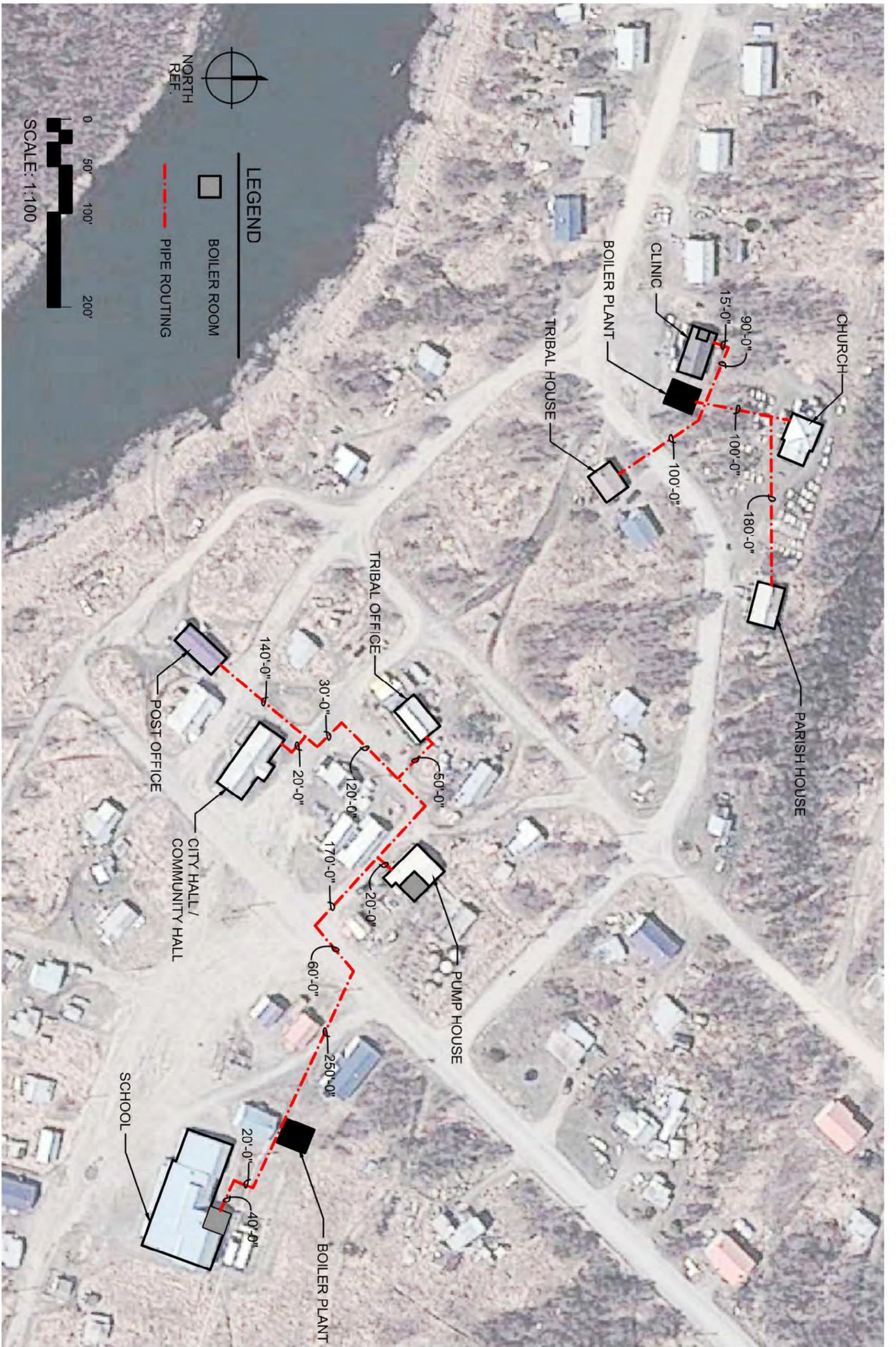


Lower Kalskag USGS MAP



Lower Kalskag Aerial Photo MAP





BIOMASS PRE-FEASIBILITY ASSESSMENT
 LOWER KALASKAG CLUSTER
 LOWER KALASKAG, AK

Drawn By TW
 Checked By NHR
 Date 06/27/2013
 CTA # FEDC
 Cad File: KALASKAG.DWG

SITE PLAN

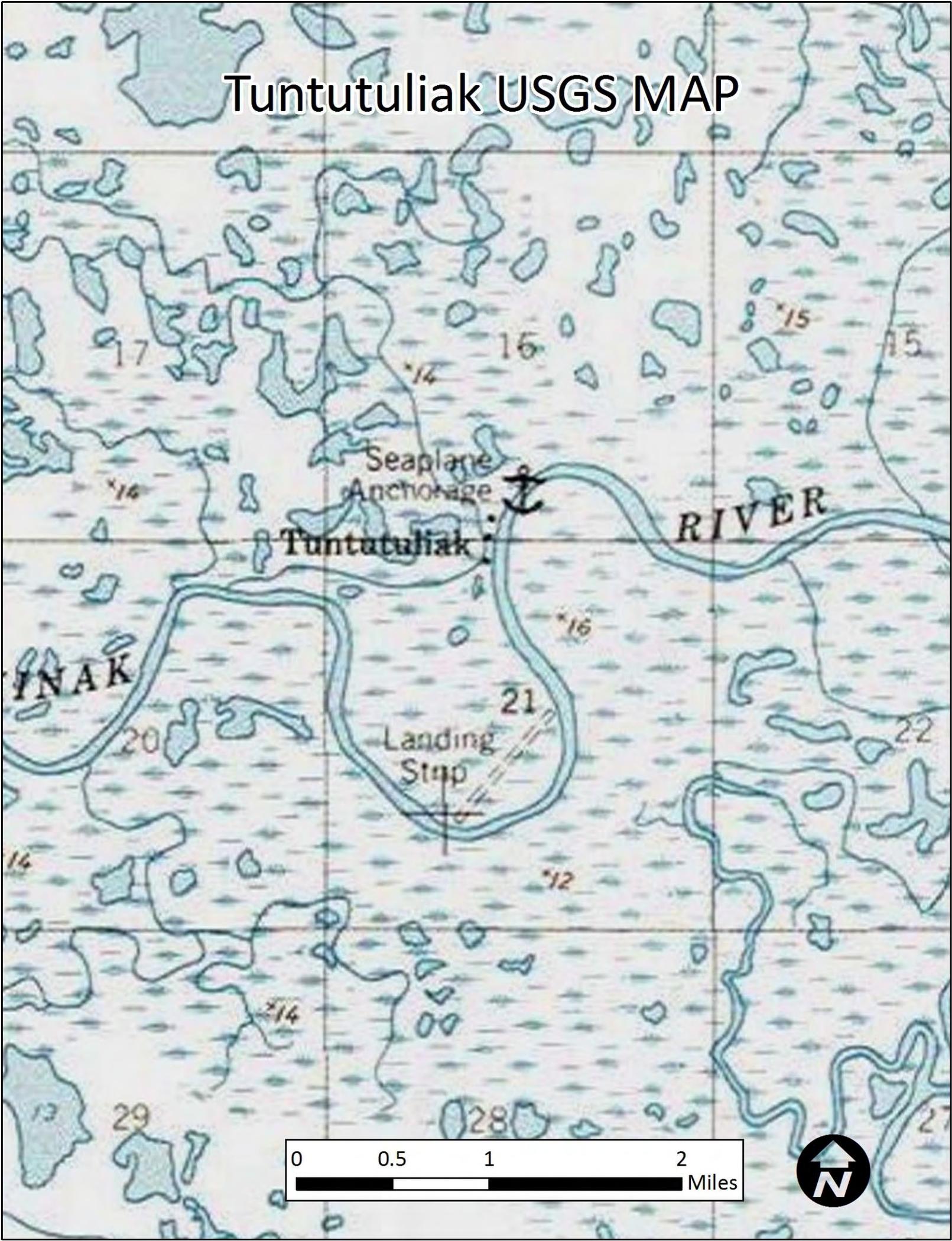


APPENDIX D

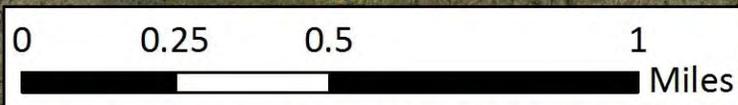
TUNTUTULIAK SITE INFORMATION



Tuntutuliak USGS MAP



Tuntutuliak Aerial Photo





SITE PLAN



BIOMASS PRE-FEASIBILITY ASSESSMENT
 TUNTUTULIAK COMMUNITY HALL
 TUNTUTULIAK, AK

Drawn By TW
 Checked By NHR
 Date 06/27/2013
 CTA # FEDC
 Cad File: TUNTUTULIAK.DWG

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 boiler 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