USDA Forest Service
Wood Education and Resource Center
301 Hardwood Lane
Princeton, WV 24740
(304) 487-1510

PRELIMINARY ANALYSIS MEMORANDUM

DATE: **December 31, 2009**

TO: **Lew McCreery, WERC**

FROM: **Tom Wilson, WES; Brandi Johnston, WES**

CC: **John Tuttle, Missouri Department of Conservation**

RE: **Gainesville High School**

1.0 MEMORANDUM PURPOSE

The Wood Education and Resource Center (WERC) is providing preliminary analysis of the potential for a wood utilization project at each of the schools responding to the Missouri Fuels For Schools grant opportunity. The preliminary analysis provides the following information for each school:

- A description of the school's heating system, heat distribution system, and controls;
- An estimate of annual fuel usage based on fuel bills and information provided by the school;
- A preliminary design of one potential option for a wood utilization project at the school
    - Recommended biomass heating system sizing, fuel storage sizing, and interconnection and/or modification to the schools internal heating distribution system;
    - An estimate of the annual fuel offset by wood utilization and the associated cost savings; and
    - A site plan showing the wood utilization system, fuel storage, and any distribution piping;
- A conceptual estimate of the costs for installation of the potential biomass system.

The potential option and conceptual costs outlined in this memorandum are based on WERC's initial assessment of the school's opportunity for utilization of wood as a fuel. Modifications to this option or additional options may be developed following additional more detailed evaluation.

2.0 DESCRIPTION OF EXISTING HEATING SYSTEM AND FACILITY

Gainesville Jr/Sr High School operates from mid-August to mid-May and consists of 5 buildings: the Jr/Sr High School, 63,000 ft²; the Shop/Music building, ~8,000 ft²; the Greenhouse, 2,370 ft²; the Field House, 2,400 ft² and the Bus Barn 3,000 ft². There is no central heating system in any building and multiple types of systems throughout. The Field House is heated with electric only and is a small load several hundred feet from the rest of the buildings; it is not practical to connect to a district heating system and is therefore excluded from this analysis. Table 1 provides a description of each of the buildings considered and their salient features.

Table 1 - Description of Buildings

Building/Section	Heat Sources	Year Built	Square Footage	Heat Distribution
Jr. Sr. High School	Propane/electric	1962	63,000	non central/varied
Shop/Music Building	Propane	unknown	8,000	non central/varied
Greenhouse	Propane	1982	2,300	forced air
Bus Barn	Propane	unknown	2,400	forced air
Field house	Electric	unknown	3,000	radiant and baseboard

In the main High School Building there are rooftop units that serve the cafeteria and a computer lab. The cafeteria is also served by electric resistance baseboard units along the windows. In the same corner of the facility is an industrial arts shop heated by hanging propane furnaces with a 140,000 Btu/hr output and a 175,000 Btu/hr input. Additional classroom space in this corner is heated by electric baseboard heaters and cooled by window DX units. A storage room adjacent to the art room and library contains two propane ducted forced air furnaces which serve these rooms. Each unit has a 160,000 Btu/hr output and a 200,000 Btu/hr input. A second storage room in the Junior High wing contains another propane forced air furnace (125,000 Btu/hr input, 100,000 Btu/hr output) which only provides heat to the hallway. The gymnasium is heated by two hanging propane furnaces. The main lobby is heated by one electric resistance unit; in addition, 14 other rooms are also heated by electric resistance baseboard units. Eleven rooms are heated and cooled by window units that contain electric resistance heating. There are seven units that heat at 16,000 Btu/hr and cool at 18,000 Btu/hr; while there are seven units that heat at 18,000 Btu/hr and cool at 24,000 BTU/hr.

In the Shop/Music building, the shop is serviced by two hanging propane heaters with 75,000 Btu/hr input and 60,000 Btu/hr output. The social studies room and LD room, located on the other side of the shop, are heated with a propane ducted furnace with a 125,000 Btu/hr output. The music room has an approximate 50,000 Btu/hr output ducted propane furnace.

The greenhouse is heated by two hanging propane units with an 80,000 Btu/hr output and a 100,000 BTU/hr input. The greenhouse classroom contains a propane ducted forced air unit with 125,000 Btu/hr input and 96,000 Btu/hr output. The Bus Barn is heated by one propane hanging furnace unit estimated at 175,000 Btu/hr output; while the office area is heated by a small propane heater with a 10,000 Btu/hr output.

In general the buildings have no planned air exchange other than the roof top units. Original design in the Jr. High wing used unit ventilators that are no longer functional. Significant overall improvement in the environment and energy savings in the main High School building could be achieved with a central, two pipe heating and cooling system. This would require installing unit ventilators in all rooms located on exterior walls and running supply and return pipes to service the heating and cooling needs of the facility.

3.0 CURRENT FUEL USEAGE AND COST

The total average annual energy output of the heating units in the buildings evaluated is estimated to be 2,000 mmBtu/yr. It is assumed that a biomass energy system would replace 85% of the energy currently needed for heating. To realize additional energy savings, a central chiller could be installed to use the same two pipe system for cooling; a central chiller will reduce electric costs for cooling by approximately 50%. An analysis of current cooling costs and potential cooling energy savings from a central system was not part of this report.

Table 2 -Current Average Annual Fuel Usage

Building/Section	Square Footage	Heat Load mmBtu	Propane Gallons	Propane Cost $	Electric for Heat kWh	Electric Cost $	Output, Btu/sf	Total heating cost
Jr./Sr. High School	63,000	1575	13,622	$27,243	184,642	$15,141	25,000	$42,384
Shop/Music	8,000	240	3,459	$6,919			30,000	$6,919
Bus Garage	3,000	90	1,297	$2,595			30,000	$2,595
Greenhouse	2,370	95	1,366	$2,733			40,000	$2,733
Totals	**76,370**	**2,000**	**19,745**	**$39,490**		**$15,141**		**$54,630**

Gainesville School District utilizes electric and propane as the fuels for heating. The price paid for propane has varied from $1.09 to $1.99 per gallon over the last 18 months. To make comparison between projects to be evaluated for the grants a price of $2.00 per gallon was used for propane in analysis of all projects. Actual propane usage assumes that the tank was initially filled on the first delivery information provided. Electricity use was estimated based on type of structure and expected energy use per square foot as no separate metered value is available. The price for electric used was based on energy cost supplied in utility bills. Table 3 presents assumptions regarding fuel prices and heating values used in this analysis. In addition, Gainesville receives a credit of $1,273 per month for having standby diesel generation that is independent of energy use.

Table 3 – Fuel Heating Values and Unit Costs

Fuel, Unit	Heating Value, Btu/unit	Unit Cost, $/unit
Propane, gal	92,500	$2.00
Electric, kWh	3,412	$0.08
Wood, ton	10,000,000	$40.00

4.0 PROPOSED WOOD UTILIZATION PROJECT

In order to convert the Gainesville High School Campus to a biomass system, the heating distribution system within the High School will have to be converted to a central system. The current HVAC system in the main building does not provide adequate planned ventilation and is inefficient due to relying on individual DX cooling units with lower efficiencies than are available from central chillers. The project

outlined will include the renovations required to connect the buildings listed in Table 2 to the biomass system.

4.1 Wood System Sizing

Weather data for Southern Missouri shows that the month of January contains on average 25 – 30% of annual heating degree days using 55^{o}F as the basis. Using 25%, an average hourly energy output for the month of January is 0.7 mmBtu/hr. Based on this estimate a 1.0 mmBtu boiler and 1,000 gallon thermal storage would meet the majority of the heating requirements and operate efficiently. If the project moves forward further modeling and refining of the heat load profile is required to properly size the system.

4.2 Boiler Housing and Chip Storage

The design described by this memorandum is for a wood chip boiler and chip storage that is housed in a building located adjacent to the Greenhouse just off of the driveway. Several good sites with easy access exist and if this project goes forward additional sites for the system should be considered. The building would be approximately 1,500 square feet to house both the chip storage and boiler room. Chip storage should be sized to accept full van trailer deliveries of chips, approximately 150 cubic yards.

4.3 HVAC Upgrades

A two pipe system sized to allow heating and cooling and accompanying heat exchange devices are outlined in the project cost and metrics evaluation. A dramatic improvement in the internal environmental conditions of the High School Building can be realized by implementing these measures. These insulated supply and return pipes circulate water powered by variable frequency drive pumps and operated by a controller that uses outside temperature and energy demand to vary flow rate. Additional energy cost savings would be realized on cooling; however, for this project these additional savings have not been evaluated. If favorable financing can be obtained, reduced energy costs, avoided future capital expenses and reduced maintenance costs will offset this additional investment. Attachment C provides a breakdown of the conceptual cost estimate for the proposed HVAC system upgrades.

4.4 Potential Energy and Cost Savings

Current annual costs for heating and domestic hot water are about $55,000 (Table 2). Table 4 provides the heating fuel usage and costs associated with the proposed biomass system. Total annual fuel costs with the proposed system (Table 4) would be about $18,000. Thus, the potential annual savings achievable by replacing the existing heating system with biomass heat are approximately $37,000.

Table 4 - Proposed Biomass System Energy Usage and Fuel Costs

Facility	Propane Usage, gal	Propane Cost	Electric Usage, kWh	Electric Cost	Wood Tonnage	Wood Cost	Total Fuel Cost
Jr./Sr. High School	2,043	$4,086	27696	$2,271	191	$7,650	$14,008
Shop/Music	519	$1,038	0	$0	29	$1,166	$2,204
Bus Barn	195	$389	0	$0	11	$437	$826
Greenhouse	205	$410	0	$0	12	$460	$870
Totals	**2,962**	**$5,124**	**27,696**	**$2,271**	**243**	**$9,713**	**$17,908**

Note: An efficiency of 70% is used for the biomass system in order to calculate the wood tonnage needs. This efficiency is assumed to include biomass boiler room and distribution losses between the biomass boiler room and the interconnection to the various buildings.

5.0 CONCEPTUAL COST ESTIMATE

The estimated capital cost to install the biomass system described in Section 4 is $1,560,000. Attachment B provides a breakdown of the conceptual cost estimate for the overall system. Further investigation and scoping of the proposed biomass project are required to refine this conceptual estimate if this project is awarded the grant.

Table 5 provides a list of metrics by which this project may be compared to other potential projects that are also competing for the Missouri Fuels for Schools grant funding.

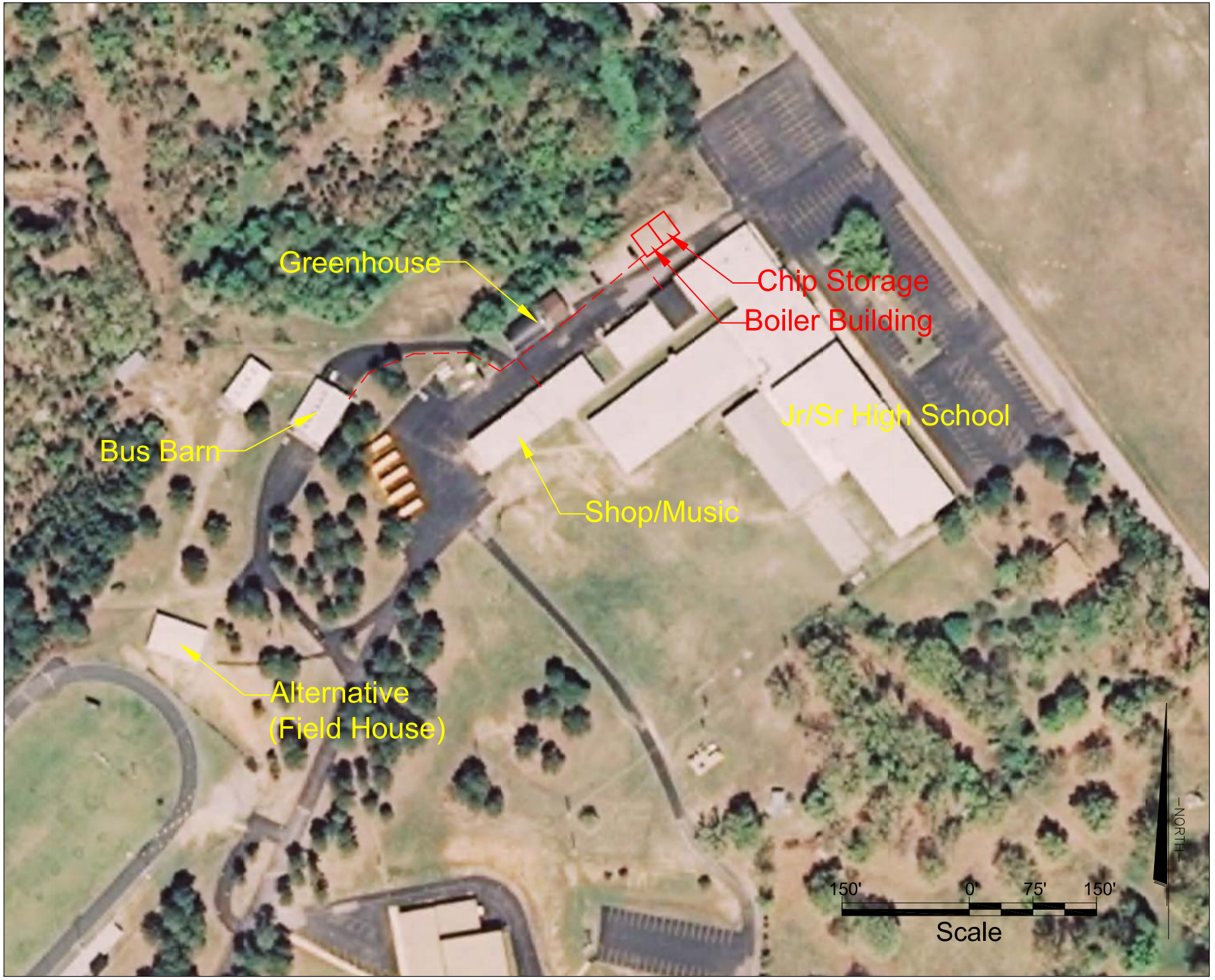
Table 5 - Grant Funding Metrics

Metric	Value
System cost per annual mmBtu of wood usage ($/mmBtu)	$642
System cost per dollar of estimated annual savings ($/$ savings)	$42

The grant funding metrics presented above provide a means to compare the ability of the competing projects to leverage grant dollars to utilize low-use wood and realize fuel cost savings.

ATTACHMENT A

Proposed Wood Utilization Project Plan View



Gainesville R-V School District
Gainesville, Missouri

Site Plan

Designed	THW	12-17-09
Drawn	BEJ	12-17-09
Checked	THW	12-17-09

Approved _____ Date _____
Title _____ Job Class _____

WERC
Wood Education and Resource Center
United States Forest Service
United States Department of Agriculture

REVISIONS

Date	Description	Approved

Attachment A

Attachment B

Gainesville Schools
12/31/2009

Preliminary, Conceptual Cost Estimate

Line Item	Value	Units	$/Unit		Cost[1]
1.0 mmBtu/hr biomass boiler & chip handling system	-	-	-	$	230,000
Stack and Breeching	-	-	-	$	10,000
Boiler housing	720	sf	$ 50	$	36,000
150 cy chip storage building and bunker	720	sf	$ 150	$	108,000
Site preparation	-	-	-	$	25,000
Thermal storage 1,000 gal	-	-	-	$	10,000
Biomass boiler room equipment / installation	-	-	-	$	50,000
Pex Pipe (2" supply and return)	514	lf	$ 150	$	77,100
Interconnection to 4 buildings	-	-	-	$	27,000
HVAC system upgrades[2]	-	-	-	$	527,800
Sub-Total				$	1,100,900
Contractor Profit	*10%*			*$*	*110,090*
Sub-Total				*$*	*1,210,990*
Contingency	*15%*			*$*	*181,649*
Sub-Total				*$*	*1,392,639*
Professional Services	*12%*			*$*	*167,117*
Total				**$**	**1,559,755**

Notes:
1 - Overhead and bid bond are factored into the estimated item costs and are not broken out.
2 - Existing equipment and plumbing have not been evaluated in detail. Cost is preliminary and subject and subject to change pending mored detailed analysis.
3 - All costs are installed costs.
4 - Geotechnical investigations and surveys have not been conducted. Soil and grade dependent items are subject to large changes in cost pending site investigation.

Attachment C

*Preliminary, Conceptual Cost Estimate
HVAC and Interconnection to Buildings

Line Item	Value	Units	$/Unit	Cost[1]
High School	-	-	-	$ -
**Classroom unit ventilators		26	$ 2,500	$ 65,000
**Unit Controls		26	$ 1,100	$ 28,600
**Installation (Internal piping)				$ 385,200
**Fan coil units	12	-	$ 750	$ 9,000
Water to Air heat exchangers (RTU)	2		$ 2,500	$ 5,000
Direct connection to HW Distribution System	1			$ 1,000
**Mechanical Room pumps and piping				$ 40,000
Wall penetration and repair for supply and return pipe	1		$ 1,000	$ 1,000
Sub-Total				**$ 534,800**
Shop and Music Building	-	-	-	
Water to Air heat exchangers (music room furnace)	2		$ 1,000	$ 2,000
Fan coil heat exchange units (locker rooms and hallway)	2	-	$ 1,250	$ 2,500
Internal piping (supply and return)				$ 3,000
Wall penetration and repair for supply and return pipe				$ 1,000
Misc. Labor and Materials	-	-	-	$ 2,000
Sub-Total				**$ 10,500**
Green House				
Fan coil heat exchange units	2	-	$ 1,250	$ 2,500
Internal pipe between AHUs				$ 250
Water to Air heat exchangers (classroom furnace)	1		$ 750	$ 750
Misc. Labor and Materials				$ 500
Wall penetration and repair for supply and return pipe				*$ 1,000*
Sub-Total				***$ 5,000***
Bus Barn				
Fan coil heat exchange units	2	-	$ 1,250	$ 2,500
Internal pipe between AHUs				$ 500
Misc. Labor and Materials				$ 500
Wall penetration and repair for supply and return pipe				*$ 1,000*
Sub-Total				**$ 4,500**
Total				**$ 554,800**
Building Interconnection Total				**$ 27,000**
HVAC Total				**$ 527,800**

* Costs have not been quoted for this project. Estimates are based on site visit with cursory investigation into HVAC system needs. Costs are preliminary and subject to change.
** HVAC cost