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Georgia Air Branch
Attn: Eric Cornwell
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March 23, 2012

Facility Name: North Star Jefferson Renewable Energy
Application No: 20770
Facility Address: Wadley Road, Wadley, 30477 (Jefferson County)
EPD Notice Type: Permit – Application
Description of Operation: Power Generation

Dear Mr. Cornwell,

Please accept these comments on the draft air permit for the North Star Energy facility proposed for Wadley, Georgia. We find the permit to be completely inadequate to protect human health and the environment, and we hope you will revise it accordingly. These comments are submitted by:

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**Description of the North Star Energy facility**

- The applicant has proposed a 21 MW net, 25 MW gross fluidized bed biomass boiler project that will burn up to 20% tire-derived fuel (TDF) by weight. The boiler will also be capable of burning 100% wood. Heat input capacity is reported to be 320.6 mmbtu/hr for wood only; and 296.2 mmbtu/hr when wood and TDF are co-fired. The facility will burn a variety of agricultural wastes, pallets, and wood, including so-called "clean" construction and demolition debris.

- The facility will inject trona (hydrated sodium bicarbonate) into the flue gas to control HCl (at 90.2% removal efficiency) and SO2 (at 16.6% removal efficiency).

- The facility will employ a selective catalytic reduction unit (SCR) to control NOx at 35.9% removal efficiency.

- The facility will not employ an oxidation catalyst for control of CO and VOCs, instead relying on use of fluidized bed combustion technology.

- Particulate matter emissions will be controlled with an electrostatic precipitator (ESP); control efficiency is 95.75% for filterable PM, PM10, and PM2.5.

The facility has requested synthetic minor status for both criteria pollutants and HAPs.

**Table 3.1**
**Emissions Summary**

| Pollutant | Emissions (tons/yr) | |
|---|---|---|
| | Projected Max Actual | Potential |
| CO | 107 | 249* |
| $NO_x$ | 214 | 249* |
| $SO_2$ | 214 | 249* |
| $PM/PM_{10}/PM_{2.5}$ | 59 | 67 |
| VOC | 15 | 17 |
| $CO_2e$*** | 93,459 | 99,999* |
| Highest Individual HAP (HCl) | 9 | <10** |
| Total HAP | 22 | <25** |

*Requested PSD Minor limits
**Requested Synthetic Minor limits
*** Greenhouse Gases measured as Carbon Dioxide equivalent, $CO_2e$

As an observation on the permit that may influence other issues to be discussed, tire energy content appears to be overestimated in the permit. The permit application claims that the energy content of the TDF is 16,000 btu/lb. However, an overview document from a scrap tire conference estimates TDF energy content as 14,000 - 15,5000 btu/lb; [1] the application for the Crawford Renewable Energy facility in Pennsylvania, which the North Star application cites, estimates TDF energy content at 14,000 btu/lb[2], and the average of higher heating values for TDF in EPA's database of emissions and fuel data compiled for the "boiler rule" is 15,286 btu/lb.[3] Overestimation of heat content could lead to underestimation of the amount of fuel needed by the facility, which could have a variety of knock-on effects for the amount of emissions generated by the facility.

[1] Gray, T. 2004. Tire derived fuel: environmental characteristics and performance. Talk presented to First Northeast Regional Scrap Tire Conference, Albany, NY. June 15, 2004 (page 2)
[2] page 3, section 6.1 of Crawford Renewable Energy application
[3] Emissions Database for Boilers and Process Heaters Containing Stack Test, CEM, & Fuel Analysis Data Reported Under ICR No. 2286.01 and ICR No. 2286.03 (Version 6).mdb. Available at http://www.epa.gov/ttn/atw/boiler/boilerpg.html

**The North Star facility represents a significant source of pollution in an already impacted area**

The facility has made a large point of avoiding Prevention of Significant Determination permitting, and in doing so has avoided requirements to use Best Available Control Technology. As a synthetic minor source for both criteria pollutants and HAPs, the North Star facility will emit more pollution than if it were held to more rigorous emission standards. Despite the variety of extremely dirty fuels the facility will be permitted to combust, the facility does not use emissions control technology that is routinely used even on other synthetic minor sources. Further, the facility is located in an environmental justice area that already has a concentration of polluting industries.

*The PM limit in the permit is not protective*

The PM emission limit of 0.03 lb/mmbtu is unacceptably high for a facility that is permitted to burn everything from animal manure to wood to tires. The facility should use a baghouse instead of an electrostatic precipitator (ESP), as this would provide a higher level of particulate matter control, which in turn would reduce emissions of metals and the extremely toxic compounds that are emitted from combustion of tires and other wastes. The following table uses the manufacturer's specification for the pre-controls PM emissions rate[4] of 0.6357 lb/mmbtu, and compares emissions of filterable PM from the North Star facility using an ESP, versus a more effective baghouse (baghouse removal efficiencies are routinely guaranteed above 99.8% and even 99.9%). These estimates are for filterable PM, only, but show that installing a baghouse instead of an ESP would reduce PM emissions (and heavy metals and other PM-associated HAPs) dramatically.

| Raw filterable PM emissions rate (lb/mmbtu) | Wood input (tons/yr) | Wood fuel heat input (mmbtu/yr) | Pre-controls filterable PM (tons) | Filterable PM emissions at 95.75% control efficiency (ESP) | Filterable PM emissions at 99.8% control efficiency (fabric filter) | Difference (tons PM/yr) |
|---|---|---|---|---|---|---|
| 0.6357 | 297,317 | 2,808,456 | 892.7 | 37.9 | 1.8 | 36 |

<u>Among other metals, emissions of zinc will be unacceptably high</u>

Zinc oxide is added to tires as part of the rubber vulcanization process at levels approaching 1.0 - 1.5 % by weight. Therefore, zinc levels in tires are much higher than coal. Applications using tires must be able to control zinc emission to avoid a negative environmental impact.[5] The EPA considers controlling particulate matter as a primary means for controlling metals emissions. Yet this facility will have PM levels that are much higher than those from coal plants. For instance, the coal plant operated by the Public Service Company of Colorado (RBLC ID - CO-0057) in EPA's BACT Clearinghouse has a total PM limit of 0.022 lb/mmbtu and a filterable PM limit of 0.013 lb/mmbtu.[6]

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4 The manufacturer's guarantee, on Page 13 of Appendix E, states: PARTICULATE: The proposed equipment, when operating at design conditions and at an inlet load of 0.6357 lbs. of particulate per MMBTU is guaranteed to emit not more than 0.0270 lbs. of particulate per MMBTU or to remove 95.75% by weight of the inlet particulate load. If the inlet particulate load is greater than the design basis the efficiency of 95.75% is guaranteed; if it is equal or less than the design basis a residual of 0.0270 lbs. of particulate per MMBTU is guaranteed.

5 Gray, T. 2004. Tire derived fuel: environmental characteristics and performance. Talk presented to First Northeast Regional Scrap Tire Conference, Albany, NY. June 15, 2004 (page 2)

6 http://cfpub.epa.gov/rblc/index.cfm?action=PermitDetail.PollutantInfo&Facility_ID=26447&Process_ID=104787&Pollutant_ID=229&Per_Control_Equipment_Id=141239

*The facility should employ an oxidation catalyst to increase destruction of organic HAPs*
The North Star facility will burn a variety of potentially very contaminated fuels, including agricultural and animal wastes and tires. While the permit says that treated and glued wood are "not considered biomass", there is no prohibition on burning this material nor any fuel testing program at the plant to ensure contaminated materials are not burned. Therefore, the potential for emissions of organic hazardous air pollutants is very high. However, the facility is not proposing to install an oxidation catalyst, relying instead simply on the fluidized bed technology to control CO and presumably other products of incomplete combustion. The facility is likely to emit much more organic HAPs than claimed, and is likely actually a major source for HAPs, as explained below, but the absence of any meaningful monitoring program will ensure that violations go undetected. If the Georgia EPD is serious about controlling emissions of air toxics from this facility, it will require installation of an oxidation catalyst.

**Facility is located in an environmental justice area**

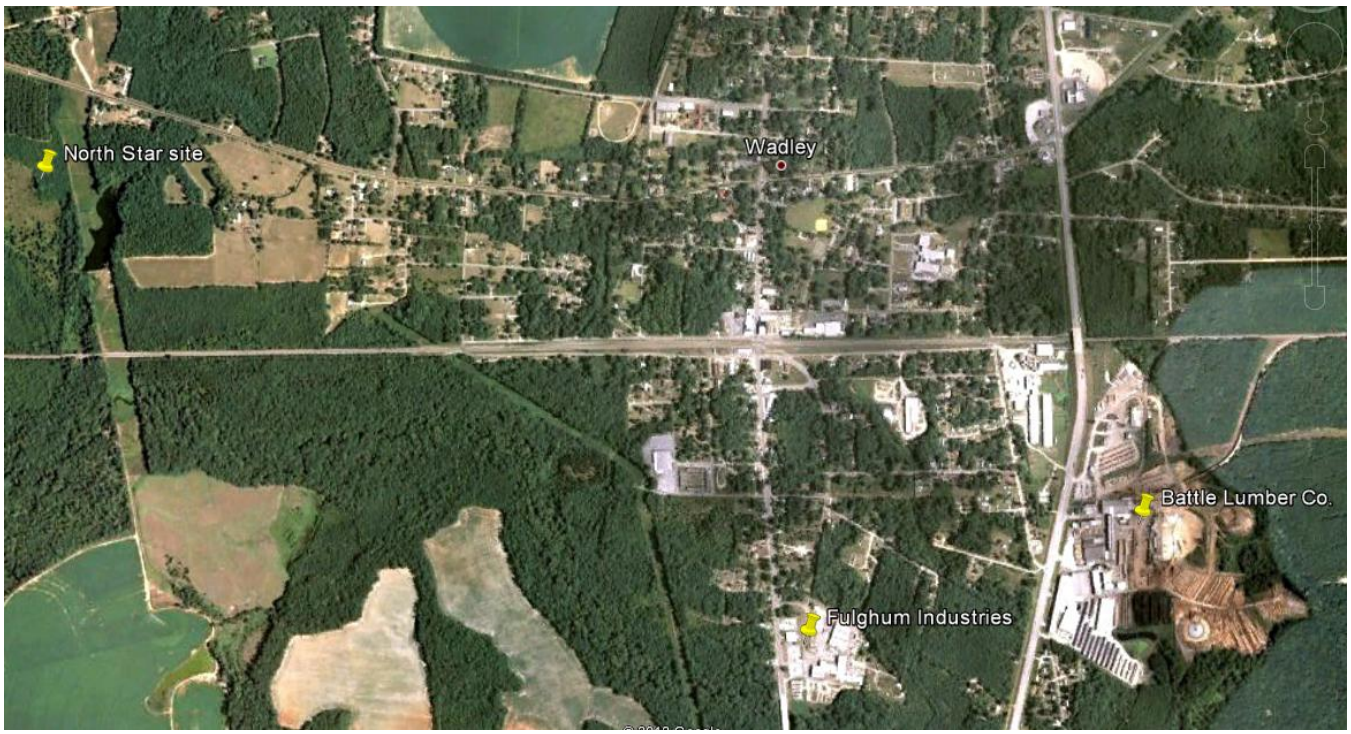
The North Star facility is located in an environmental justice area. Speaking of Jefferson County, a co-developer on the project, Carlton Owen of the U.S. Endowments observes

> *" It is a majority-minority county with fully 56% of the population being African-American. Poverty and unemployment are all-too-common with both far exceeding the national average. Families living below the poverty line are half-again more common than the rest of the nation and unemployment, anticipating another plant closure that has already been announced, will double that of the nation – expected to surpass 17% in the next few months.*
>
> *.. Some have questioned the Endowment's plans to partner with for-profit alternative energy developer, North Star Renewable Power. The most cynical say that the county was targeted because its population is poor and heavily minority. The odd thing is the critics are right. The difference is intent. We, indeed, "targeted" Jefferson County, but not to "take advantage" of its people and its plight; rather, our hope is to try some tangible things designed to help reverse the downward trend."*[7]

We do not disparage or doubt Mr. Owen's desire to improve the economy in Jefferson County, but no matter how good his intentions, the fact is that these very dirty facilities do usually get placed in the areas where the people have the least resources to oppose them.

*The facility is located in an area that already has a high toxic burden*
For a fairly rural area, Wadley already experiences large emissions of air toxics and particulates, because it contains facilities that are large sources of air pollution.

[7] Carlton N. Owen. U.S. Endowment Blog. http://www.usendowmentblog.blogspot.com/. Accessed March 22, 2012.




1. The Battle Lumber Company. This an especially filthy emitter for such a small facility. The mill has three boilers with a combined capacity of 67 mmbtu/hr, none of which use anything more than a cyclone system for PM control. As the Georgia EPD's permit narrative states, the burners are rated less than 30 MMBtu/hour, are thus not subject to the opacity and PM emission limits in the New Source Performance Standard. EPD's estimates for PM10 emissions from the three burners are 82.6 tons per year, and the permit narrative states

   *Since the nine drying kilns are used to dry only hardwood lumber, as indicated above, VOC emissions from the hardwood kilns are considerably lower than that for softwood kilns. Therefore, the condensable PM emissions from these kilns can also be assumed to be low. So EPD believes that $PM_{10}$ PTE from the drying kilns is certainly less than 17 tpy. Therefore total $PM_{10}$ PTE is less than 100 tpy.*

   Staying under 100 tons of emissions is important for this facility to avoid Title V permitting requirements. Likewise, combined permitted CO emissions from the facility are estimated at 98.1 tons per year. Georgia EPD's permit narrative for this facility estimates, but has not tested, the VOC emission rate from the facility. Again making assumptions that presuppose a low rate of emissions, the permit narrative estimates that total VOC emissions from the facility are 30 tons per year. The facility emits 59 tons of NOx per year. EPA records show that this facility failed several visible emissions stack tests in 2011.[8] This facility is about two miles from the North Star site.

[8] EPA's records are are available at http://oaspub.epa.gov/enviro/afs_reports.detail_plt_view?p_state_county_compliance_src=1316300012&p_plant_id=

2. Fulghum Industries. This manufacturing company has a Synthetic Minor Permit in order to avoid being considered a major source under Title V. The facility is required to keep its emissions of VOCs to less than 100 tons in a 12-month period, and its emissions of Hazardous Air Pollutants to less than 25 tons total and less than 10 tons for a single HAP. This facility is therefore a very significant source of air pollution, located 1.6 miles from the North Star site.

*Because actual ambient air toxics levels are not known, toxic impacts assessment is meaningless*
The facility has included a "Toxic Impact Assessment" in Appendix C, which compares the emissions of some of the toxics that will be emitted from the facility with the "Acceptable Ambient Concentration".

However, the conclusion that emissions from the facility do not represent a health threat is completely unsupported. Because the emission factors that the applicant has used to estimate toxics are too low, or non-existent, as described below, their emissions are underrepresented. Further, the modeling for the impact of these toxics on air quality is conducted assuming that the ambient air contains zero concentrations of the toxics. Given the large emissions from just two facilities in the Wadley area, to say nothing of air toxics from other regions, and from sources such as transportation and agriculture, modeling toxics from the North Star facility as if they are emitted into a pristine atmosphere renders the results meaningless. If Georgia EPD is interested in determining the real health impact of emissions from North Star, they should conduct some ambient air quality monitoring and assess the real background concentrations of air toxics.

**The facility should be regulated as an incinerator**

The variety of fuels to be burned in the North Star boiler makes it clear that the facility will actually serve as a waste incinerator. For these materials to be considered fuels and not wastes, they must meet EPA's legitimacy criteria. Page 23 of the application states:

> *Biomass means any biomass-based solid fuel that is not a solid waste. This includes, but is not limited to, wood residue and wood products (e.g., trees, tree stumps, tree limbs, bark, lumber, sawdust, sander dust, chips, scraps, slabs, millings, and shavings); animal manure, including litter and other bedding materials; vegetative agricultural and silvicultural materials, such as logging residues (slash), nut and grain hulls and chaff (e.g., almond, walnut, peanut, rice, and wheat), bagasse, orchard prunings, corn stalks, coffee bean hulls and grounds. This definition of biomass is not intended to suggest that these materials are or are not solid waste.*

To be considered a non-waste, EPA requires[9] that

> *"the applicant must demonstrate that the NHSM that is to be burned as a fuel has not been discarded, is a legitimate product fuel (per § 241.3(d)(1)), considering the five criteria identified in § 241.3(c)(1)(i)–(v):*
> *(1) Whether market participants treat the non-hazardous secondary material as a product rather than as a solid waste;*

[9] Environmental Protection Agency. 40 CFR Parts 60 and 241 [EPA–HQ–OAR–2003–0119 and EPA–HQ–RCRA 2008–0329; FRL–9503–7] RIN 2060–AR15 and 2050–AG44 Commercial and Industrial Solid Waste Incineration Units: Reconsideration and Proposed Amendments; Non-Hazardous Secondary Materials That Are Solid Waste .Federal Register Vol. 76, No. 247. Friday, December 23, 2011 (page 80473)

*(2) Whether the chemical and physical identity of the non-hazardous secondary material is comparable to commercial fuels;*
*(3) Whether the non-hazardous secondary material will be used in a reasonable time frame given the state of the market;*
*(4) Whether the constituents in the non-hazardous secondary material are released to the air, water or land from the point of generation to the point just prior to combustion of the secondary material at levels comparable to what would otherwise be released from traditional fuels; and*
*(5) Other relevant factors."*

Without demonstration that all fuels meet the legitimacy criteria, the facility should be regulated as an incinerator. As such, its emissions would be more controlled, and therefore more protective of public health.

*The air permit does not protect against use of contaminated wood as fuel*
The qualification that chemically treated, painted and glued woods do not constitute "biomass" in condition 2.9 of the draft permit is not sufficient to prevent these materials from being burned. If Georgia EPD is serious about ensuring that only truly "clean" wood is burned, the permit conditions should contain an absolute prohibition that states clearly that ***no*** chemically treated, painted, or glued wood can be burned in the boiler.

**The facility should not be permitted to burn tires**

If the facility is not to be regulated as an incinerator, then it should not be allowed to burn tires. The facility's use of tires represents a threat to health, and furthermore is not justified under the very EPA rules that applicant cites.

*Burning tires emits carcinogens and mutagens that harm human health*
We here quote directly from EPA's document on tire-burning emissions[10] for a description of the toxicity of emissions from tire burning.

*A follow-up study to the open-burning study examined the mutagenicity of emissions. "The mutagenic emission factor for open tire burning is the greatest of any other combustion emission studied previously. For example, it is 3-4 orders of magnitude greater than the mutagenic emission factors for the combustion of oil, coal, or wood in utility boilers" (Lemieux and DeMarini, 1992). A mutagen is defined as a substance that causes mutations. A mutation is a change in the genetic material in a body cell. These mutations can lead to birth defects, miscarriages, or cancer (ATSDR, 1990). Mutagens are of concern because "the induction of genetic damage may cause an increased incidence of genetic disease in future generations and contribute to somatic cell diseases, including cancer, in the present generation" (Amdur, 1991).*

*The authors concluded that open burning of tires, wood, and plastic results in exceptionally high mutagenic emission factors and that "open burning, regardless of the feed stock or fuel, results in greater mutagenic emission factors than does controlled combustion provided by various types of incinerators or boilers" (Lemieux and DeMarini, 1992).*

*The authors found similar mutagenic emission factors of semi-volatile organics produced by the large (chunk) and small (shred) tire pieces. They also found that the mutagenic emission factors for the particulate organics were much greater than those for organics.*

[10] U.S. EPA. Air emissions from scrap tire combustion. EPA-600/R-97-115. Washington, DC. October, 1997.

*The report's final conclusion serves as a potentially serious warning: "Considering the (a) relatively high mutagenic potency of the particulate organics, (b) high mutagenic emission factors, and (c) presence of many mutagens/carcinogens, especially PAHs, in the effluent from the open burning of tires, such burns pose a genuine environmental and health hazard" (Lemieux and DeMarini, 1992).*

It is important to note that although controlled incineration does produce better burn conditions than open burning, and thus (presumably) greater destruction of air toxics, the North Star facility is not employing any special equipment, such as an oxidation catalyst, that will assist in destruction of toxic compounds emitted by combusting tires. Further, the PM controls employed by the facility are far from being the most effective available, thereby ensuring that a great deal more toxics-bearing particulates escape the facility that would occur if more effective emissions controls were used.

*Tires do not meet EPA's legitimacy criteria*

The application references EPA's rule on use of non-hazardous secondary materials as fuel (at page 10):

(iii) The non-hazardous secondary material must contain contaminants at levels comparable in concentration to or lower than those in traditional fuels which the combustion unit is designed to burn. Such comparison is to be based on a direct comparison of the contaminant levels in the non-hazardous secondary material to the traditional fuel itself.

*Note: TDF contains contaminants that are comparable to traditional fuels, specifically coal. Table 16 (excerpted below) of the U.S. EPA Document Air Emissions from Scrap Tire Combustion[3] provides a direct comparison of TDF with coal, a traditional fuel.*

**TABLE 16. COMPARATIVE FUEL ANALYSIS BY WEIGHT (JONES, 1990)**

| Fuel | Composition (percent) | | | | | | | Heating Value | |
|---|---|---|---|---|---|---|---|---|---|
| | Carbon | Hydrogen | Oxygen | Nitrogen | Sulfur | Ash | Moisture | kJ/kg | Btu/lb |
| TDF | 83.87 | 7.09 | 2.17 | 0.24 | 1.23 | 4.78 | 0.62 | 36,023 | 15,500 |
| Coal | 73.92 | 4.85 | 6.41 | 1.76 | 1.59 | 6.23 | 5.24 | 31,017 | 13,346 |

However, there are at least two significant reasons why tires do not meet EPA's legitimacy criteria.

<u>Comparison of contaminant levels in tires and coal has not been conducted for contaminants of interest</u>

EPA's most recent revision of the "waste rule"[11] defines contaminant as

*Contaminants means all pollutants listed in Clean Air Act sections 112(b) and 129(a)(4), with modifications outlined in this definition to reflect constituents found in non- hazardous secondary materials prior to combustion. The definition includes the following elemental contaminants that commonly form Clean Air Act section 112(b) and 129(a)(4) pollutants:*

[11] Environmental Protection Agency. 40 CFR Parts 60 and 241 [EPA–HQ–OAR–2003–0119 and EPA–HQ–RCRA 2008–0329; FRL–9503–7] RIN 2060–AR15 and 2050–AG44 Commercial and Industrial Solid Waste Incineration Units: Reconsideration and Proposed Amendments; Non-Hazardous Secondary Materials That Are Solid Waste .Federal Register Vol. 76, No. 247. Friday, December 23, 2011 (page 80471)

*Antimony, arsenic, beryllium, cadmium, chlorine, chromium, cobalt, fluorine, lead, manganese, mercury, nickel, nitrogen, selenium, and sulfur.*

EPA's reference document on contaminant levels in traditional fuels[12] that was issued in conjunction with the proposed rules on non-hazardous secondary materials additionally provides data on coal for chlorine, fluorine, benzene, ethyl benzene, polycyclic aromatic hydrocarbons, styrene, toluene, and xylenes.

By comparing the composition of tires to that of coal in terms of C, H, O, N, S, Ash, Moisture, and energy content, the applicant has thus omitted to compare the levels of the contaminants EPA is most concerned about. The only documentation that North Star has provided of actual contaminant levels in tires is a list in Appendix D, which the applicant appears to have copied off the internet. The data are from 1986.

Tires do not meet the legitimacy criteria because the facility is not "designed to burn coal"

The EPA regulations state that when comparing contaminants in an alternative fuel to those in a traditional fuel, the traditional fuel used for comparison must be one that the facility is "designed to burn". [13] The North Star facility is not designed to burn coal – it is designed to burn biomass. Appendix D of the December application contains a letter from Rick Cashatt, Chief Executive Officer of North Star Energy, that makes it clear this plant is designed to burn wood:

*Please inform the design engineer to use the following fuel composition for the North Star Louisville Project" - then goes on to describe specifications of wood fuel. The letter further states, "Please note that though the facility must be capable of burning 100% wood, we intend to operate at 20% TDF by weight. Accordingly, the design must allow for full load at 100% wood, as well as wood and TDF (max. 20% by weight).*

There is nothing in this statement to indicate that the facility is "designed to burn" coal - in fact, it is highly specific that it is designed to burn wood. Accordingly, the traditional fuel to which tires should be compared is wood. Tires contain far more contaminants than wood, and do not qualify to be burned in this facility under EPA's rule. Particularly given the minimal nature of emissions controls (no oxidation catalyst) and lax permit limits on this facility (PM controlled with an ESP at 0.03 lb/mmbtu, rather than a baghouse with a more stringent limit), it is important that only the lowest-emitting fuels be used.

**The North Star is a major source for HAPs and should be regulated as such**

There are many reasons to believe that the North Star facility will actually be a major source for HAPs, and should be regulated as such.

[12] Environmental Protection Agency. Contaminant concentrations in traditional fuels: Tables for comparison. November 29, 2011.

[13] Environmental Protection Agency. 40 CFR Parts 60 and 241 [EPA–HQ–OAR–2003–0119 and EPA–HQ–RCRA 2008–0329; FRL–9503–7] RIN 2060–AR15 and 2050–AG44 Commercial and Industrial Solid Waste Incineration Units: Reconsideration and Proposed Amendments; Non-Hazardous Secondary Materials That Are Solid Waste .Federal Register Vol. 76, No. 247. Friday, December 23, 2011 (page 80471)

*The permit does not continue practically enforceable PTE limits as required by EPA*
EPA requires that when a source takes synthetic minor limits, those limits be practically enforceable. We quote here from a letter sent by the Region 9 EPA office to the proposed Hu Honua bioenergy facility in Hawaii on June 30, 2011:

> *EPA's longstanding guidance to permitting authorities and the regulated community has been that to effectively limit a source's Potential To Emit (PTE), permit conditions must be practically enforceable. For example, EPA's June 13, 1989 memorandum, "Guidance on Limiting Potential to Emit in New source Permitting" and EPA's January 25, 1995 memorandum, "Options for Limiting the Potential to Emit (PTE) of a Stationary Source Under Section 112 and Title V or the Clean Air Act," elaborated upon the Agency's criteria for practically enforceable PTE limits by stating that such limits should specify (1) a technically accurate limitation and the portions of the source subject to the limitation; (2) the time period for the limitation (hourly, daily, monthly, and annual limits such as rolling annual limits); and (3) the method to determine compliance including appropriate monitoring, recordkeeping, and reporting. Our guidance specifies that the averaging time for all limits must be practicably enforceable to readily allow for determination of compliance. Short term limits, generally daily but not to exceed one month. are preferred. Operational and/or production limits are also required.*

For both HAPs and criteria pollutants, the synthetic minor limits for the North Star facility are neither practically enforceable nor likely to be achieved, for the reasons detailed below. The draft permit's enforcement is practically impossible given the deficiencies in the permit.

*The applicant has omitted omission factors and used incorrect emission factors to estimate HAPs*
Because the applicant has not provided TDF emissions factors for many HAPs in Table B-3a of Appendix B, total HAPs emissions are calculated based solely on emissions from the 80% wood burned in the co-firing scenario. However, EPA's reference document on scrap tire burning provides an abundance of data on the kinds of HAPs that are emitted when tires are open-burned (we reproduced the table from the EPA document in the Appendix of this document). The applicant should include emissions factors for these toxics, which are clearly emitted when TDF is burned.

The following is a list of some of the compounds emitted by open burning of tires that have significant emissions, yet have either *no* emissions factor included in the North Star HAPs estimates Table (Table B-3a), or an emission factor that appears to be too low. [14] These compounds have emissions in the 100's to more than 1,000 ppm (mg emissions per kg of fuel) from open burning of TDF (the full Table 1 from EPA's TDF emissions document is reproduced in the Appendix of this letter). It is true that more complete combustion in the controlled conditions of a fluidized bed boiler will reduce emissions compared to open burning, but this is not an excuse for dramatically under-representing or completely omitting emissions factors. The open burning data show that these compounds are emitted from TDF in very large quantities, and they should be accounted for. When they are accounted for, the HAPs emissions from the facility (which are now estimated as miraculously skimming just under the 25 ton major source threshold for HAPs) will considerably exceed 25 tons.

1. The benzene emission factor for TDF is too low, as discussed in detail below. For benzene emissions from wood combustion, the applicant has used the NCASI emissions factor of 0.0033 lb/mmbtu, rather than the

[14] In some cases, where an emission factor is shown for wood, the applicant has used lower values from the NCASI list of emissions factors, rather than the EPA emission factor from the AP-42 document.

AP-42 factor of 0.0042 lb/mmbtu (this AP-42 factor was given a rating of "A" for reliability). Simply using the AP-42 emissions factor would increase estimated benzene emissions by 1.26 tons per year, putting estimated emissions at the facility very close to 25 tons per year. EPA generally requires that applicants explain why they have chosen to use particular emissions factors other than the AP-42 factors. No explanations are given in the North Star application, and we can only assume that the applicant's eagerness to remain below the major source threshold has led to them consistently choosing the lower emissions factor whenever possible.

2. 1,3-Butadiene – no emission factor for wood or tires, despite being emitted in substantial amounts by open-burning of tires.
3. Dimethyl benzene - no emission factor for wood or tires, despite being emitted in substantial amounts by open-burning of tires.
4. Ethenyl benzene - no emission factor for wood or tires, despite being emitted in substantial amounts by open-burning of tires.
5. Ethyl benzene - emission factor shown for wood, but not tires. The applicant uses a factor of 6.8E-06, which they say is from AP-42, but in fact, the AP-42 factor for this compound is 3.1E - 05. The applicant has actually used the NCASI emission factor for ethyl benzene.
7. Ethyl methyl benzene - no emission factor for wood or tires, despite being emitted in substantial amounts by open-burning of tires
8. Ethynyl methyl benzene - no emission factor for wood or tires, despite being emitted in substantial amounts by open-burning of tires.
8. Methyl benzene, aka "Toluene"[15] - no emissions factor for tires, but there is one for wood. The application uses the NCASI factor of 2.9E-05. The AP-42 factor is 9.2E-04.
9. Naphthalene – the applicant does provide an emissions factor for this compound, but it is from "Facility A" in EPA's tire emissions document, and is quite low, compared to the large emissions from uncontrolled tire burning (the problem with the applicant using "Facility A" is discussed below).
10. Styrene - no emission factor for tires. The applicant uses the NCASI factor for wood.
11. Phenol. There is an emission factor for wood (they use NCASI) but none for tires.

12. The emissions factor for hydrogen fluoride (HF) deserve special mention. The applicant does not include an emissions factor for HF for wood. However, other facilities have estimated HF emissions from wood to be substantial. The technical analysis[16] for the proposed 100 MW Gainesville Renewable Energy Center (GREC) in Florida, which will burn only forestry wood, makes the following statement about hydrogen fluoride emissions: *"Fluorine (F) is a naturally occurring constituent of vegetative matter. The F can be released as HF and or it can be bound to the ash. F can also condense in the form of alkali salts (NaF, KF, alkali fluorosilicates, etc.)."* The GREC permit requires a continuous emissions monitoring system for HF, along with CEMS for CO, SO2, NOx, and HCl. [17] The emissions of HF from the GREC facility are estimated as equivalent to the emissions of HCl, at 9.72 tons per year each. Just counting HF emissions from wood combustion at the North Star facility alone would be enough to put the facility well over the 25 ton HAPs limit.

[15] From: http://iaspub.epa.gov/sor_internet/registry/substreg/home/whatisasubstance/: Substances, particularly chemicals, often have multiple valid names. For example, the scientific name for one chemical is Benzene, methyl. Other names for this chemical include Toluene, Toluol, Phenylmethane, and Methyl benzene.

[16] Florida Department of Environmental Protection.. Technical Evaluation and Preliminary Determination for Gainesville Renewable Energy Center 100 MW Woody Biomass Power Plant. July 14, 2010. (page 27).

[17] Florida Department of Environmental Protection.. Final air construction permit for Gainesville Renewable Energy Center 100 MW Woody Biomass Power Plant. Dec 28, 2010. (page 3).

*The applicant has chosen an inappropriate models to establish emission factors*
The North Star application establishes emission factors for HAPs using a combination of data from other permits (the permit for the proposed Crawford Renewable Energy facility in Pennsylvania, which is a dedicated TDF energy plant) and also data found in the EPA publication, "Air Emissions from Scrap Tire Combustion", which contains test results and emission factors from both open burning of tires and facilities that have burned tires for energy and used some kinds of emissions controls. Not surprisingly, the applicant has cherry-picked emissions factors to represent HAPs emissions as being as low as possible.

<u>The applicant uses favorable data and ignores higher emission factors from a comparable facility</u>
The application states that "emission factors for TDF combustion in the boiler are selected from EPA Clean Air Technology Center Publication No. EPA-600/R97-115 - Air Emissions from Scrap Tire Combustion (October 1997), Table A-1b – Facility A – Dedicated Tires-to-Energy Power Plant".

However, deriving emission factors from this facility's test results is not legitimate. The "Facility A" referenced in this document in Table A-1b is a dedicated tires to energy plant (burning 100% tires), which means its combustion temperatures are likely higher than those of a boiler that burns 80% wood and just 20% tires by mass as the North Star facility would. Further, the facility in the EPA document utilized a baghouse with Gore Tex bags for particulate control, therefore its control of particulates is greater than the North Star plant, which controls PM at 95.75%. Because PM is less well controlled at the North Star plant, emissions of hazardous air pollutants are likely to be higher. "Facility A" also used SNCR to control NOx, involving different processes and flue gas temperatures than the SCR system to be employed by North Star, and a wet scrubber with lime injection rather than the dry scrubber with trona to be employed at North Star.

<u>The applicant inappropriately relies on emissions factors from a dedicated tire-burning facility</u>
The North Star application also relies on emissions factors from the Crawford Renewable Energy (CRE) air permit. Aside from the fact that the CRE facility is to burn nothing but tires, and will thus have different combustion conditions than the North Star facility, where tires will be co-fired with wet wood, the CRE emissions factors are themselves of dubious provenance. The CRE application[18] states that in developing emissions factors, they considered "an EPA study conducted in 1997 in which natural gas and TDF were fired in a test unit. This study indicates that organic HAP emissions are similar to or slightly greater than during combustion of natural gas" – however, this is the same old EPA document that the North Star application cites. The CRE facility also utilizes some untraceable data from the Northampton generating station in Pennsylvania to estimate emissions factors. This circular referencing of unsubstantiated and unjustified emissions factors is nothing more than leveraged misinformation.

In fact, the statement in the CRE application that emissions from TDF and natural gas are similar fails to observe that emissions of some contaminants increased dramatically when TDF was co-fired with natural gas. Here are data from the EPA document:

[18] Crawford Renewable Energy air permit application, Section 3, page 3.

**Table A-11b. Facility K - Lime Kiln**

| Pollutant | 100% Gas Fired | | 85% Gas, 15% TDF | | % Change |
|---|---|---|---|---|---|
| | $10^{-6}$g /MJ | $10^{-6}$ lb/MMBtu | $10^{-6}$g /MJ | $10^{-6}$ lb/MMBtu | |
| Organics[a] | | | | | |
| Anthracene | 1.6 | 3.7 | 0.77 | 1.8 | -51 |
| Phenanthrene | 22.3 | 51.9 | 12.5 | 29.1 | -44 |
| Fluoranthene | 3.7 | 8.6 | 3.8 | 8.8 | +2 |
| Pyrene | 2.8 | 6.6 | 2.7 | 6.2 | -6 |
| Benzo(a)anthracene | 0.47 | 1.1 | 0.47 | 1.1 | 0 |
| Chrysene | 0.47 | 1.1 | 0.47 | 1.1 | 0 |
| Benzo(b)fluoranthene | 0.3 | 0.8 | 0.3 | 0.8 | 0 |
| Benzo(k)fluoranthene | 0.1 | 0.3 | 0.2 | 0.4 | +33 |
| Metals | | | | | |
| Arsenic | 0.82 | 1.9 | 1.5 | 3.5 | +84 |
| Copper | 1.4 | 3.2 | 1.3 | 2.9 | -9 |
| Zinc | 98.5 | 28.8 | 183.9 | 427.7 | +1,385 |
| Iron | 99.63 | 231.7 | 72.37 | 168.3 | -27 |
| Nickel | 2.4 | 5.6 | 1.5 | 3.5 | -38 |
| Chromium | 35.8 | 83.3 | 137.0 | 318.6 | +282 |

One would expect combustion to be hotter, cleaner, and more complete when co-firing TDF with natural gas; whereas co-firing TDF with wood could easily degrade the temperature of the burn and the quality of combustion, leading to increased emissions of organic HAPs. It is interesting to note that in Appendix D-3 the applicant cites a reference on tire combustion that states that tire carbon is completely burnt at 1202 degrees F. Are such temperatures commonly achieved when co-firing TDF with 80% green wood, as North Star will do? In fact, as referenced, the same EPA document that the applicant cites also shows test data (*not* presented by the applicant) where co-firing TDF with wood led to dramatic increases in benzene and particulate matter at a fluidized bed biomass facility:

**Table A-5b. Facility E - Wood-Fired Power Plant**

| Pollutant | 100% Wood-Waste | | | | 9% Rubber Buffings | | | | 7% TDF | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/hr | lb/hr | g/MJ | lb/ MMBtu | kg/hr | lb/hr | g/MJ | lb/ MMBtu | kg/hr | lb/hr | g/MJ | lb/ MMBtu |
| Particulate | NT | NT | 0.036 | 0.083 | NT | NT | 0.11[a] | 0.25[a] | NT | NT | 0.13[a] | 0.31[a] |
| $SO_2$ | 3 | 7 | 0.086 | 0.020 | NT | NT | NT | NT | 23 | 50 | 0.032 | 0.074 |
| $NO_x$ | 41 | 90 | 0.082 | 0.19 | NT | NT | NT | NT | 22 | 48 | 0.0538 | 0.125 |
| CO | 1,050 | 2,300 | NT | NT | 1,200 | 2,700 | NT | NT | 1,000 | 2,200 | NT | NT |
| Aldehydes | 30.3 | 66.6 | NT | NT | 6.4 | 14 | NT | NT | 5.5 | 12 | NT | NT |
| Benzene | 8.2 | 18 | NT | NT | NT | NT | NT | NT | 11 | 25 | NT | NT |
| Phenols | 28 | 61 | NT | NT | NT | NT | NT | NT | 6.4 | 14 | NT | NT |
| Polyaromatic hydrocarbons | 59.1 | 130 | NT | NT | NT | NT | NT | NT | 77.3 | 170 | NT | NT |

The implications of this discrepancy should be clear. In Appendix B of the North Star application, Table B3a (Boiler Potential Emissions Calculation) the applicant uses a benzene emission factor for wood of 3.30E-03 lb/mmbtu, and a benzene emissions factor for TDF of 4.36E-08 lb/mmbtu, thus assuming that benzene emissions from TDF are several orders of magnitude smaller than emissions from wood. But this is not what the above results show – in fact, adding just 7% TDF to a waste wood boiler *increased* emissions by about 40%. It is also important to note that particulate matter emissions increased substantially – by 373% – when just TDF was co-fired with the wood waste.

*Fuel contamination of C&D is not adequately controlled by the permit*

The North Star facility will be permitted to burn "clean" construction and demolition waste (C&D). However, it is virtually impossible to generate a truly uncontaminated fuel stream from C&D. Painted, glued, pressure-treated, and PCP-treated wood inevitably makes its way into the fuel. Pressure-treated wood contains arsenic and chromium, which are deadly heavy metals that are poorly controlled by the minimal PM emissions controls employed at the North Star facility. Permit provision 7.26 states that "*Verification shall consist of fuel receipts obtained from the fuel supplier certifying that the fuel meets Conditions 2.9 and 2.10 definitions for Biomass and TDF, respectively".* However, this is a deeply unserious approach to determining contamination levels in fuel. The facility should not burn C&D wood at all, but if it does, it should design a statistically valid and robust sampling methodology to assess toxics associated with this fuel source.

*HAPs testing provisions in the permit are inadequate and will not ensure compliance*

<u>6.6 HCl emission tests</u>

This requirement is inadequate. HCl emissions should be tested over all fuel mixes burned in the boiler, including the 100% wood scenario, not just the wood/tire mix.

<u>6.7 Initial performance tests specified for acrolein, benzene, chromium, and formaldehyde.</u>

a) This requirement does not specify the fuel mix to be tested. The facility should be required to be tested under full operating conditions using 20% TDF as fuel, and full operating conditions using 100% wood as fuel. The testing should also be conducted specifically to test HAPs emissions when the facility is

burning construction and demolition waste. This material is never completely "clean" and always contains heavy metals, dioxins, and excessive chlorine concentrations that can lead to dioxin emissions.

b) This requirement is inadequate. A single initial performance test, which will likely be conducted under optimal conditions, is not predictive of HAPs emissions from the facility on an ongoing basis. Particularly given that the results of HAPs testing are to be used as emission factors for calculating yearly emissions, the frequency of testing must be increased, and testing requirements should not diminish.
c) This requirement does not test for enough compounds. EPA's emissions document (Appendix of this document) shows that a number of extremely toxic compounds are emitted by burning tires. The testing conditions should require testing for more of these compounds.

7.24 Calculation of monthly HCl and Total HAPs emissions from boiler

Calculating a monthly emission value using HAPs emissions factors that are tested once, probably under optimal conditions and with fuel mix not specified, is not statistically valid or defensible.

*Characterizations of fuels and emissions are inadequate and will not ensure compliance*

6.8 Determination of heat content

The applicant is actually going to burn several types of biomass, and should be required to test heat content of construction and demolition debris, forest wood, and any agricultural wastes, along with TDF.

6.9 Random sampling once quarterly for sulfur and chlorine content of TDF

A single "random" sample conducted quarterly is completely inadequate to determine contamination levels in fuel. The applicant should be required to develop a testing program that generates statistically valid and robust results.

6.10 Triennial testing of PM

Testing once every three years for PM emissions is completely inadequate. The applicant should be required to install a continuous emissions monitor for PM.

6.11 Frequency of testing

This condition does not make sense. The previous condition specifies testing every three years; this condition specifies that testing can be conducted less often if tests in at least "3 consecutive years" show emissions are at or below the emissions limit.

**Other deficiencies in the permit**

*Disposal of ash is not sufficiently described or regulated in the permit*

The air permit specifies no disposal plan for the ash generated by the boiler and the ESP, which is likely to be quite toxic. It further contains no special provisions to ensure this ash does not become a source of toxic airborne particulates.

*Fuel storage provisions are inadequate*

The application states that TDF will be stored in outside piles. The permit contains virtually no conditions on the sourcing, delivery, constitution, or storage of this material. What precautions are being taken to ensure this material does not contaminate soils and groundwater? The permit application (page 9) claims that wood chips

are the "analogous fuel" to which tire chips are compared, and that therefore the fuel can be managed in the same way. The application claims the material will be "fenced" and that there will be a water cannon on hand for fire suppression. These conditions, and the conditions in Section 2.10 governing TDF storage, are completely inadequate to protect water resources and avoid fuel fires.

We observed the following conditions for tire storage in a permit for the Cedar Bay facility in Florida,[19] which provide a more detailed model of what responsible fuel storage would look like:

A.61. Solid Waste Conditions. The permittee shall comply with the following solid waste conditions for TDF:
a. The tire derived fuel (i.e., the processed tires) shall conform to nominal one-inch processed tire chip standards in which less than 10% by weight are retained on a 2-inch square sieve and less than 5% total by weight will pass through a #4 sieve as determined by testing method ASTM D 422-63.
b. The tire derived fuel (TDF) shall conform to nominal one-inch processed tire chip standards in which they shall be less than 1% free wire by weight and less than 3% of the particles contain bead wire.
c. Documentation of the conformance of the TDF with the nominal one-inch processed tire chip standards shall be maintained onsite and be readily available for inspection at all times.
d. The operator shall maintain records of the quantity of TDF received at the site, stored at the site, and shipped from the site.
e. No operations involving the use of open flames shall be conducted within 25 feet of the TDF.
f. TDF piles shall not be constructed, maintained or operated in or within 200 feet of any natural or artificial body of water, including wetlands within the jurisdiction of the Department, except for bodies of water contained completely within the property boundaries of the facility and which do not ordinarily discharge from the site to surface waters.
g. Stormwater control methods for the TDF piles site shall meet the requirements of Chapters 62-25 and 62-330, F.A.C. and shall be managed in such a way as to divert stormwater or flood waters around and away from the storage piles.
h. TDF piles shall be no larger than 50 feet in width, 10,000 square feet in area and 10 feet in height.
i. A 50-foot wide fire lane shall be placed around the perimeter of each TDF pile.
j. The TDF piles site shall be bermed or given other Department approved protection if necessary to keep liquid runoff from a potential TDF fire from entering water bodies.
k. The TDF piles shall be kept free of grass, underbrush, and other potentially flammable vegetation at all times.
l. The TDF inventory shall be no more than one month's projected usage, based on the design capacity for the first six months, and no more than two times the average actual monthly usage during the preceding six months at all times thereafter.
m. Only a registered waste tire collector shall transport the TDF to or from the facility.

[19] http://www.dep.state.fl.us/siting/files/certification/pa88_24_append/Appendix%20I_0310337_016_AV.pdf

**Appendix: Reproduction of Table 1, Table 2, and Table 3 of "Air Emissions from Scrap Tire Combustion"[20]**

Description of how the data in Tables 1 – 4 were generated:

2.1 LABORATORY EMISSIONS TESTING A controlled simulation test program designed to identify and quantify organic and inorganic emission products during the simulated open combustion of scrap tires was conducted by EPA (Ryan, 1989) and further documented in an Air and Waste Management Association Paper [(AWMA) Lemieux and Ryan, 1993].

This important study is summarized in detail below. Small quantities of 4.5 to 9 kilograms {kg [10 to 20 pounds (lb)]} of scrap tire material were burned under two controlled conditions in a 2.4 x 2.4 x 2.4 m [8 x 8 x 8 foot (ft)] ventilated, instrumented burn hut. Two sizes of tire material were burned: "chunk," about 1/6 to 1/4 of an entire tire and "shred", where the tire pieces were 5 x 5 centimeters {cm [2 x 2 inches (in)]}. EPA's Hazardous Air Pollutants Mobile Laboratory was used to monitor fixed combustion gases. Organics were collected using the volatile organic sampling train and a semi-volatile collection system using XAD-2 resin and particulate filters. Particulate was also collected to assess airborne metals and to measure the amount of particulate less than 10 microns (μm) in aerodynamic diameter (PM ). The organic 10 constituents were analyzed using gas chromatography/mass spectroscopy (GC/MS), gas chromatography/flame ionization detection, and high pressure liquid chromatography (HPLC).

The results of the test program are presented in Tables 1 through 4. Table 1 presents an averaging of the three sets of volatile organic sampling train (VOST) samples taken at each run condition, each taken at different periods during the burn. Benzene is emitted in large quantities under both conditions. The majority of the volatile organic emissions are aliphatic-, olefinic-, or acetylenic-substituted aromatics. Cyclic alkanes, alkenes, and dienes were also present. Butadiene, a major constituent of the tire fabrication process was also present. The estimated emissions were calculated assuming that dilution air was added at a constant volume flow and the amount of air entering equaled the amount exiting the burn hut. A well-mixed condition is also assumed (i.e., the sample collected at the duct is representative of the gas mixture in the hut).

Semi-volatile organic emissions data are presented in Table 2. Substituted mono- and polyaromatics were also the predominant products of incomplete combustion (PICs). The data represent an average of three samples taken over the entire course of the day's run. The organic emissions summary is presented in Table 3.

PAH emissions data are presented in Table 4. The 16-PAHs include several compounds known to be carcinogenic. In particular, the presence and magnitude of benzo(a)pyrene (BaP) is of major concern. BaP is often a highly-scrutinized compound during evaluations of combustion processes, due to its high cancer potency.

[20] U.S. EPA. Air emissions from scrap tire combustion. EPA-600/R-97-115. Washington, DC. October, 1997.

**TABLE 1. OPEN BURNING EMISSIONS: VOLATILE ORGANICS[a,b] (LABORATORY SIMULATION)**

| Compound | Chunk | | | Shred | | |
|---|---|---|---|---|---|---|
| | Exhaust Conc. ($mg/m^3$) | Emission Factor (mass/mass tire) | | Exhaust Conc. ($mg/m^3$) | Emission Factor (mass/mass tire) | |
| | | mg/kg | lb/ton | | mg/kg | lb/ton |
| Benzaldehyde | 0.260 | 299.2 | 0.5984 | 0.215 | 330 | 0.660 |
| Benzene | 1.910 | 2,156.3 | 4.3126 | 1.40 | 2,205 | 4.410 |
| Benzodiazine | 0.017 | 13.7 | 0.0274 | 0.014 | 17.4 | 0.0348 |
| Benzofuran | 0.049 | 25.1 | 0.0502 | ND | ND | ND |
| Benzothiophene | 0.014 | 26.3 | 0.0526 | 0.011 | 14.7 | 0.0294 |
| 1,3-Butadiene | 0.152 | 308.4 | 0.6168 | 0.096 | 160 | 0.320 |
| Cyclopentadiene | 0.081 | 48.6 | 0.0972 | ND | ND | ND |
| Dihydroindene | 0.013 | 40.6 | 0.0812 | 0.021 | 42.8 | 0.0856 |
| Dimethyl benzene | 0.413 | 779.7 | 1.559 | 0.629 | 1,078 | 2.156 |
| Dimethyl hexadiene | 0.008 | 28.3 | 0.0566 | 0.049 | 90.9 | 0.182 |
| Dimethyl methyl propyl benzene | ND | ND | ND | 0.008 | 14.9 | 0.298 |
| Dimethyl dihydroindene | 0.007 | 22.0 | 0.0440 | 0.008 | 17.7 | 0.0354 |
| Ethenyl benzene | 0.678 | 941.8 | 1.88 | 0.395 | 611.4 | 1.223 |
| Ethenyl cyclohexane | 0.006 | 26.2 | 0.0524 | 0.060 | 107.6 | 0.2152 |
| Ethenyl dimethyl benzene | 0.014 | 7.2 | 0.014 | 0.014 | 23.7 | 0.0474 |
| Ethenyl methyl benzene | 0.016 | 14.1 | 0.0282 | 0.014 | 19.5 | 0.0390 |
| Ethenyl dimethyl cyclohexane | ND | ND | ND | 0.193 | 350.4 | 0.7008 |
| Ethenyl methyl benzene | 0.129 | 221.6 | 0.4432 | 0.028 | 40.9 | 0.0818 |
| Ethyl benzene | 0.182 | 460.8 | 0.9216 | 0.164 | 295.1 | 0.5902 |
| Ethyl methyl benzene | 0.120 | 334.5 | 0.6690 | 0.262 | 475.8 | 0.9516 |
| Ethynyl benzene | 0.322 | 190.0 | 0.3800 | 0.110 | 131.5 | 0.2630 |
| Ethynyl methyl benzene | 0.562 | 530.6 | 1.061 | 0.226 | 258.7 | 0.5174 |
| Heptadiene | 0.009 | 25.4 | 0.051 | 0.028 | 51.4 | 0.103 |

| Compound | Chunk | | | Shred | | |
|---|---|---|---|---|---|---|
| | Exhaust Conc. ($mg/m^3$) | Emission Factor (mass/mass tire) | | Exhaust Conc. ($mg/m^3$) | Emission Factor (mass/mass tire) | |
| | | mg/kg | lb/ton | | mg/kg | lb/ton |
| Isocyanobenzene | 0.341 | 348 | 0.696 | 0.191 | 290 | 0.580 |
| Limonene | 0.011 | 27.5 | 0.055 | 0.513 | 893 | 1.79 |
| Methyl benzene | 0.976 | 1,606 | 3.21 | 0.714 | 1,129 | 2.26 |
| Methyl cyclohexane | 0.005 | 21.1 | 0.420 | 0.023 | 40.1 | 0.080 |
| Methyl hexadiene | 0.021 | 71.3 | 0.143 | 0.068 | 127 | 0.254 |
| Methyl indene | 0.138 | 316 | 0.632 | 0.087 | 140 | 0.280 |
| Methyl naphthalene | 0.287 | 312 | 0.624 | 0.135 | 197 | 0.394 |
| Methyl thiophene | 0.006 | 5.5 | 0.011 | 0.007 | 12.6 | 0.025 |
| Methyl ethenyl benzene | 0.027 | 55.7 | 0.111 | 0.045 | 76.6 | 0.153 |
| Methyl methylethenyl benzene | 0.046 | 98.0 | 0.196 | 0.373 | 683 | 1.37 |
| Methyl methylethyl benzene | 0.041 | 111 | 0.222 | 0.165 | 283 | 0.566 |
| Methyl methylethyl cyclohexane | ND | ND | ND | 0.086 | 170 | 0.340 |
| Methyl propyl benzene | ND | ND | ND | 0.020 | 41.6 | 0.083 |
| Methylene indene | 0.038 | 48.5 | 0.097 | 0.022 | 34.4 | 0.069 |
| Methylethyl benzene | 0.045 | 135 | 0.270 | 0.092 | 169 | 0.338 |
| Naphthalene | 1.29 | 1,130 | 2.26 | 0.607 | 824 | 1.65 |
| Pentadiene | 0.077 | 164 | 0.388 | 0.680 | 1,163 | 2.33 |
| Phenol | 0.002 | 0.5 | 0.001 | 0.016 | 14.3 | 0.029 |
| Propyl benzene | 0.026 | 72.4 | 0.145 | 0.046 | 84.2 | 0.168 |
| Tetramethyl benzene | ND | ND | ND | 0.130 | 256 | 0.512 |
| Thiophene | 0.023 | 54.6 | 0.109 | 0.021 | 27.9 | 0.056 |
| Trichlorofluoromethane | 0.158 | 57.6 | 0.115 | ND | ND | ND |
| Trimethyl benzene | 0.022 | 46.9 | 0.0938 | 0.042 | 74.9 | 0.150 |
| **TOTALS** | **8.53** | **11,182** | **22.364** | **8.03** | **13,068** | **26.136** |

**TABLE 2. OPEN BURNING EMISSIONS: SEMI-VOLATILE ORGANICS (LABORATORY SIMULATION)**

| Compound | Chunk | | | Shred | | |
|---|---|---|---|---|---|---|
| | Exhaust Conc. ($mg/m^3$) | Emission Factor (mass/mass tire) | | Exhaust Conc. ($mg/m^3$) | Emission Factor (mass/mass tire) | |
| | | mg/kg | lb/ton | | mg/kg | lb/ton |
| 1-Methyl naphthalene | 0.292 | 330.7 | 0.6614 | 0.133 | 227.6 | 0.4552 |
| 1,1' Biphenyl,methyl | 0.013 | 11.1 | 0.0222 | ND | ND | ND |
| 1H fluorene | 0.187 | 210.3 | 0.4206 | 0.183 | 308.4 | 0.6168 |
| 2-Methyl naphthalene | 0.314 | 350.7 | 0.7014 | 0.255 | 429.2 | 0.8584 |
| Acenaphthylene | 0.580 | 633.8 | 1.267 | 0.318 | 531.1 | 1.062 |
| Benzaldehyde | 0.218 | 244.1 | 0.4482 | 0.180 | 333.9 | 0.6678 |
| Benzisothiazole | ND | ND | ND | 0.094 | 173.9 | 0.3478 |
| Benz(b)thiophene | 0.050 | 44.2 | 0.0884 | ND | ND | ND |
| Biphenyl | 0.186 | 209.5 | 0.4190 | 0.193 | 330.1 | 0.6602 |
| Cyanobenzene | 0.199 | 223.7 | 0.4474 | 0.300 | 516.8 | 1.034 |
| Dimethyl benzene | 0.254 | 305.0 | 0.6100 | 0.544 | 935.1 | 1.870 |
| Dimethyl-naphthalene | 0.034 | 41.1 | 0.082 | 0.096 | 178.1 | 0.3562 |
| Ethyl benzene | 0.181 | 205.2 | 0.4104 | 0.197 | 337.6 | 0.6752 |
| Ethyl dimethyl benzene | ND | ND | ND | 0.158 | 272.4 | 0.5448 |
| Ethynyl benzene | 0.254 | 275.8 | 0.5516 | 0.112 | 187.4 | 0.3748 |
| Hexahydro-azepinone | 0.062 | 75.1 | 0.150 | 0.445 | 748.5 | 1.497 |
| Indene | 0.462 | 503.4 | 1.007 | 0.201 | 339.2 | 0.6784 |
| Isocyano- naphthalene | 0.011 | 9.4 | 0.019 | ND | ND | ND |
| Limonene | 0.047 | 56.1 | 0.112 | 1.361 | 2,345.5 | 4.6910 |
| Methyl benzaldehyde | ND | ND | ND | 0.047 | 86.6 | 0.173 |
| Methyl benzene | 1.105 | 1,212.2 | 2.4244 | 0.816 | 1,390.1 | 2.7802 |
| Methyl indene | 0.093 | 111.8 | 0.02360 | 0.234 | 400.7 | 0.8014 |

| Compound | Chunk | | | Shred | | |
|---|---|---|---|---|---|---|
| | Exhaust Conc. ($mg/m^3$) | Emission Factor (mass/mass tire) | | Exhaust Conc. ($mg/m^3$) | Emission Factor (mass/mass tire) | |
| | | mg/kg | lb/ton | | mg/kg | lb/ton |
| Methyl methylethyl benzene | 0.107 | 127.9 | 0.2558 | 0.821 | 1,426.1 | 2.8522 |
| Methylethyl benzene | 0.040 | 48.3 | 0.0966 | 0.133 | 229.1 | 0.4582 |
| Naphthalene | 1.578 | 1,697.9 | 3.3958 | 0.671 | 1,130.7 | 2.2614 |
| Phenanthrene | 0.173 | 183.7 | 0.3674 | 0.119 | 187.0 | 0.3740 |
| Phenol | 0.330 | 365.9 | 0.7318 | 0.412 | 700.2 | 1.400 |
| Propenyl naphthalene | 0.027 | 23.5 | 0.0470 | ND | ND | ND |
| Propenyl methyl benzene | ND | ND | ND | 0.282 | 523.6 | 1.047 |
| Propyl benzene | ND | ND | ND | 0.127 | 219.6 | 0.4392 |
| Styrene | 0.605 | 659.9 | 1.320 | 0.380 | 645.5 | 1.291 |
| Tetramethyl benzene | ND | ND | ND | 0.049 | 91.9 | 0.184 |
| Trimethyl benzene | ND | 209.4 | 0.4188 | 0.446 | 751.4 | 1.502 |
| Trimethyl naphthalene | ND | ND | ND | 0.185 | 315.8 | 0.6316 |
| **TOTALS** | **7.593** | **8,369.7** | **16.739** | **9.492** | **16,293.1** | **32.5862** |

**TABLE 3. OPEN BURNING: TOTAL ORGANICS EMISSION SUMMARY (LABORATORY SIMULATION)**

| Organic Component | Chunk | | | Shred | | |
|---|---|---|---|---|---|---|
| | Exhaust Conc. ($mg/m^3$) | Emission Factor (mass/mass tire) | | Exhaust Conc. ($mg/m^3$) | Emission Factor (mass/mass tire) | |
| | | mg/kg | lb/ton | | mg/kg | lb/ton |
| Volatile | 8.53 | 11,182 | 22.364 | 8.03 | 13,068 | 26.136 |
| Semi-Volatile | 3,514.6 | 9,792.0 | 19.584 | 8,473.0 | 31,686.0 | 63.3720 |
| Particulate | 4,048.0 | 11,223.5 | 22.4470 | 4,151.9 | 14,888.0 | 29.7760 |
| **TOTALS** | **7,571.1** | **32,197.5** | **64.3950** | **12,632.93** | **59,642.0** | **119.284** |